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Comparison and Discrimination of Aged and Laundered Fibers by UV-Vis Microspectrophotometry and Colorimetry

Sushana S. Wiliams
West Virginia University

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Sushana S. Williams

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Suzanne Bell, Ph.D., Chair
Patrick Buzzini, Ph.D.
Keith Morris, Ph.D.

Department of Forensic & Investigative Science

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Abstract

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Fibers are commonly encountered trace evidence materials that are observed and analyzed in forensic science. The analysis of fibers currently relies upon chromatography, microscopy, spectroscopy, and mass spectrometry (1, 2). While most features of fibers are easily established, the determination and comparison of one important attribute, color, is complex(3, 4). Factors such as environmental conditions may play an important role when identifying, analyzing and comparing color between questions and known fiber samples.

While color can be evaluated subjectively, it can also be characterized instrumentally. This property may observe subtle or significant differences when fibers have been exposed to aging and laundering. These changes cannot be adequately characterized without instrumental analysis. To standardize and quantify these changes, the Commission Internationale de l'Eclairage (CIE) color characterization system was used in this project.

For the comparison of color, microscopical examination remains the key tool (5). The Microspectrophotometry (MSP) instrumentation has become a standard analytical method used for measuring color in trace evidence. It is the preferred and accepted method because it is non-destructive. In this study, ultraviolet-visible Microspectrophotometry (UV-Vis MSP or MSP) in transmittance measurement was used to analyze the kinetics of color on aged and laundered textile fibers. In transmittance microscopy, the transmittance curve of a colored sample is an objective description of its physical characteristics, free from the subjective influence that occurs with the human eye when it perceives color (6). Therefore, the purpose of this research is to objectively measure color change on aged and laundered textile fibers using colorimetry, and statistically evaluating the data obtained to determine how aging and laundering alter the colorimetric data.

Color changes were observed on fibers subjected to the process of aging and washing. Both treatments affected the degradation of color microscopically in fibers. The artificial aging of fibers was seen to affect the saturation of color more than the gloss of the color. The process treatment of washing and aging was seen to affect the gloss of fiber more than the saturation of color within the fiber. Using colorimetry, statistical methods were able to determined where the changes took place and by how much. Unfortunately, CIELab values were unequally affected between colors such that an overall pattern of degradation could not be calculated.

Dedication

I first give honor to God who has given me life to enjoy all things. He has been my encouragement and prosperity in completing this project. I would then like to thank my amazing and wonderful husband Matthew, who has continually supported and assisted me in unexplainable ways. And I am very grateful that he and my mom and dad, Marcia Woodhouse and Owen Fearon, believed in me and never allowed me to quit when the tasks became discouraging. The accomplishments achieved in this project are dedicated to you all.

Acknowledgement

I would sincerely like to thank everyone who has influenced and helped me to accomplish the challenges of this project. I am also very grateful to my committee members for joining and believing in this project. My advisor, Dr. Bell assisted in designing and organizing this project and was very supportive in numerous ways. Dr. Buzinni taught me in great depth the fundamentals of my instrument which truly gave me a better understanding of its operational concept. And lastly, Dr. Morris, who was not only there to help me with the maintenance of my instrument, but also gave me statistical advice on how to approach and gather information from my obtained data.

A great honor of gratitude goes to Dr. Jim Thorne, a prestigious engineer from Craic Technologies who virtually guided my hands in fixing and maintaining the primary instrument needed for this research. I will never forget the numerous contacts made through emails which all involved repairing the Microspectrophotometry. He is a very talented technician and I appreciate the time and attention he offered me during my difficulties.

Special thanks go to Vijay Manickam from the Mechanical and Aerospace Engineering department at WVU who assisted me with the Matlab software and with how to write and implement programs to help with the analysis of the data.

Lastly, I would like to give a substantial amount gratitude to Dr. Gerry Hobbs from the Statistics department at WVU, who provided statistical support which assisted me with the major portion of this project. He showed me how to disintegrate the data in order to extract and interpret the information necessary to answer the proposed research questions. Without his dedication and work, I would have tremendously struggled with the analysis of the data.

Without the support from each and everyone one of you, I would not have been able to surmount through this great and overwhelming challenge. Thank you all very much and God bless.

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List of Abbreviations

CCD	Charged couple device
CIE	Commission Internationale de l'Eclairage
df	degrees of freedom
HSD	Tukey honest significant difference test
IR	Infrared
K-S	Kolmogorov-Smirnov test
Matlab	Matrix laboratory
MSP	see UV-Vis MSP
NIST	National Institute of Standards
NOBS	nonanolyoxbenzene sulfate
OD	optical density
RGB	red, green and blue
RSD	relative standard deviation
S-W	Shapiro- Wilk test
TAED	tetra-acetylethylene diamine
UV-Vis MSP	Ultraviolet –visible Microspectrophotometry

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1. Research Questions

The goal of this project is to classify and discriminate fibers based on color, specifically on how aging and laundering affects color. Other research questions included:

- Does color change within fiber such that it can no longer be compared to its untreated source without concluding type I errors?
- Is it possible to differentiate fibers from different garments of similar color after the aging and laundering process?
- Are the results dependent on parameters such as the type of detergent used?
- How can statistical analysis assist in describing the characteristics of color that change as a result of aging and laundering?

2. Introduction

Textile fibers are natural or man-made substances which are the components of fabrics and textiles. Natural fibers are fibers derived from animals, minerals or plants. Since these are fibers in their natural state, they do not require fiber formation or reformation as manufactured or man-made fibers. Man-made fibers are those derived through a process of manufacturing from any substance that was not originally a fiber. They require the formation of fibers for synthetic materials and the reformation of fibers for polymer materials. This class is divided into categories based on the primary material used in its development. These materials include synthetic polymers, and natural polymers.

Table 1: Examples of natural and manufactured fibers

Type	**Fiber**	**Example**
Natural	Animal	Wool
Natural	Mineral	Asbestos
Natural	Plant	Cotton
Manufactured	Natural polymer	Rayon
Manufactured	Synthetic polymer	Polyester

Almost all manufacturing industries are concerned with its' product appearance. For that reason, color is often imparted to the end product of manufactured materials. The color of a fiber is dependent upon the dyes, pigments, and surface treatments used during manufacturing. Dyes are unsaturated organic molecules that are used to impart color on a substrate with some degree of permanence during the manufacturing process. They can be physically or chemically bound to fibers using forces such as hydrogen bonding, van der Waals forces, or covalent bonding(7). Dyes are usually classified by their chemical constituents that indicate the major chromophore present in the dye. Chromophores are the unsaturated conjugated groups of the dye that give the molecule its color. Additional information about the morphology of fiber formation and dye application is summarized elsewhere(7).

Pigments are small inorganic particles that are insoluble in water and most other solvents. Pigment particles are primarily used to deluster or color fibers and are either incorporated into the fiber at the time of production or are bonded to the surface of the fiber by a resin. Since pigments are unnaturally attracted to fibers, they must be modified to increase its affinity. Some fiber types that are not easily dyed are often pigmented.

A table is included that discusses dyes specifically encountered in the forensic examination of fibers, and is classified based on the method of application. The application and characteristics of each type of dye provides useful information about its washfastness. Fastness, i.e. the fibers resistant to fading, depends on how color changes over time under environmental conditions. Washfastness is then defined as the fibers' resiliency to retain its color during washing.

Table 2: List of dyes commonly encountered in forensic examination of fibers (8-10)

Dye class	**Bond type**	**Fiber type**	**Description/ application**	**Example**	**Characteristics/ Washfastness**
Acid dyes	Ionic bonding	Wool, silk, nylon, polyamide, protein,	Water-soluble anionic compounds; ionic bond between dye molecules and polymer.	Congo red	Bright color. May have poor fastness
Azoic dyes	Mechanical adhesion	Cotton, viscose	Consist of a coupling component between diazo salt and the coupling component such as naphthol which creates one large insoluble molecule	Tartrazine	Bright shades. Good to excellent fastness
Basic dyes	Ionic bonding	modified acrylic, polyester, polyamide	Water-soluble, applied in weakly acidic dye baths; negative charge fiber draws the dye cation	Malachite green	Very bright colors. Poor fastness
Direct dyes	Surface absorption	Cotton, viscose	Water soluble, anionic compounds; applied directly from aqueous medium that has an electrolyte;	Direct yellow 12	Poor to good fastness unless further treated

			positively charged ion is attracted to negatively charged fiber		
Disperse dyes	Surface absorption	Polyester, nylon, acetate, acrylic	Not water-soluble; applied from a hot aqueous dispersion; hydrogen and van der Waals forces are formed that hold the dye molecules in fiber.	Celliton	Fair to excellent fastness
Metalized dyes	Ionic bonding	Wool, nylon, polypropylene	Form colored metal complexes within fiber through a mordant (binding agent) such as chrome with a separate dye molecule	Acid violet 56	Good to excellent fastness
Reactive dyes	Covalent bonding	Cotton, wool, polyamide	Water-soluble; forms covalent bonds with the functional groups of the dye molecule; similar structure to acid dyes' similar application to direct dyes	C. I. Reactive Blue 19	Bright shades. Good fastness. Sensitive to bleach
Sulphur dyes	Mechanical adhesion	Cotton	Sulphur organic compound; requires reducing agent to make them soluble then undergo oxidation to its original form	CI Sulphur Red 14	Dull colors. Good fastness. Sensitive to bleach

Vat dyes	Mechanical adhesion	Cotton	Water-insoluble; requires reducing agent to make them soluble then undergo oxidation to create an insoluble dye	Indigo	Good to excellent fastness
Pigment*	Mechanical adhesion	Cotton, viscose, acrylic, polyamide, polyester	Pigments are finely ground solids that have no affinity for fibers and are generally added or bonded with a bonding agent	Luteolin, titanium oxide	Generally give bright colors. Good fastness
Ingrain	Mechanical adhesion	Cotton	Dye is synthesized directly into the fiber	Azo dyes	Good fastness

* Pigments are not dyes but are seen as colorants or delustrant in a variety of fiber types.

The application of the dye to the fiber will determine its fastness. When the dye molecules become a part of the fiber (e.g. reactive dyes), it is less likely to be removed by washing than dye molecules that adhere by adsorption (e.g. direct dyes). The location where the dye has penetrated the fiber, its bonding mechanism, and the stability of that molecule will influence the fastness of the dye. Physical factors and chemical reagents can alter the total dye absorbed by the fiber. To evaluate this nondestructively, MSP instrument was used and the data obtained was expressed quantitatively by the CIE system.

Since microscopical examination remains the key tool for color comparison, MSP was preferred because it objectively measures the degree of color change in a material(11). MSP is a type of spectroscopy method which studies the chemical interaction between light and matter. In spectroscopy, there are two main spectral regions of interest for the typical forensic spectroscopic applications: ultraviolet and visible (UV-Vis) region, and the infrared (IR) region.

With the MSP and color analysis, the region of interest is the UV-Vis region of the spectrum. This region is located on the electromagnetic radiation spectrum in the 200nm - 400nm range for near UV and 400nm - 800nm range for visible. It is in these regions that the electron excitation can be observed when light interacts with a molecule. The energy associated with the interaction of light to produce electronic excitation is due to the external or valence electrons found on the orbital of a molecule. MSP is based on the electronic molecular absorption as it measures the absorption of the electromagnetic radiation in the ultraviolet and visible region of the spectrum.

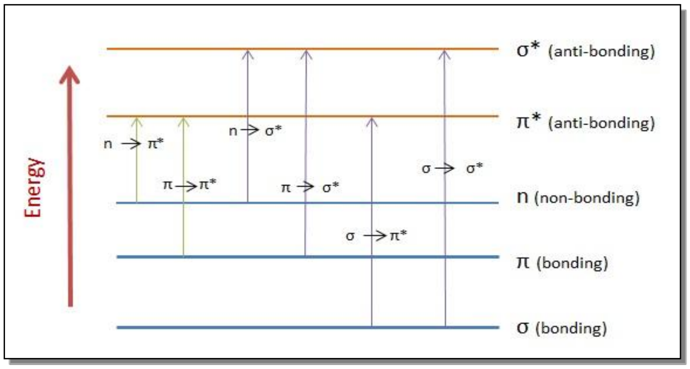
For absorption to occur, a molecule must first be excited by the frequency of that incident electromagnetic radiation. However, absorbance only occurs if the energy of the photon closely matches the difference in energy between two electronic states**.** During this excitation, an electronic transition occurs when the electron has enough energy to transition to a higher orbital state, the excited state. The electrons transits to a higher state when that photon of corresponding energy is absorbed. This process of electron jumping from ground state to an excited state is called absorbance.

After absorption, the molecule may release some of that stored energy in different ways. Since the excited state is unstable, the electron transition back to its original state (ground state) and the energy that is emitted between these transitions is dependent on the emission factor. One of the most common ways an electron returns to the ground state is by the release of energy to the surrounding molecule. An electron can return to the ground state by producing lesser energy with the emission of a photon (called fluorescence) or without this emission. It can also return to its ground state by internal conversion which occurs when the molecule releases its energy through vibration.

The electronic transitions between different energy levels of a molecule are dependent upon the electronic configuration of the molecule, the bonding of the atom, and the environment, as well as other parameters. Molecular orbital theory provides a model for the way electromagnetic radiation interacts with molecules. This interaction is based on the bonding mechanism of the electrons.

The different bonding that can occur at the external orbital of the atom requires different energy for absorption to occur. There are three types of valence electron bonding: the sigma-electrons of the molecular frame, the pi-electrons of the double and triple bonds and the non-binding pairs of electrons, also referred to as ion-pairs. These valence electrons require different energy levels in order for excitation to occur. As the electrons get excited, the atoms can rotate or vibrate with respect to each other. Absorption of UV-Vis radiation is limited to certain functional groups depending upon the valence electrons, and thus the type of bonding between the electrons. Among the three valence electron bonding, the sigma bonds are the strongest; they require the greatest amount energy for excitation to occur. The higher amount of energy required, the shorter the wavelength needed for excitation. This wavelength range is beyond the scope of the MSP. Pi-electrons are weaker and the bond structures are looser, so lesser energy is required for excitation to occur.

Figure 1: Electronic Excitation Levels

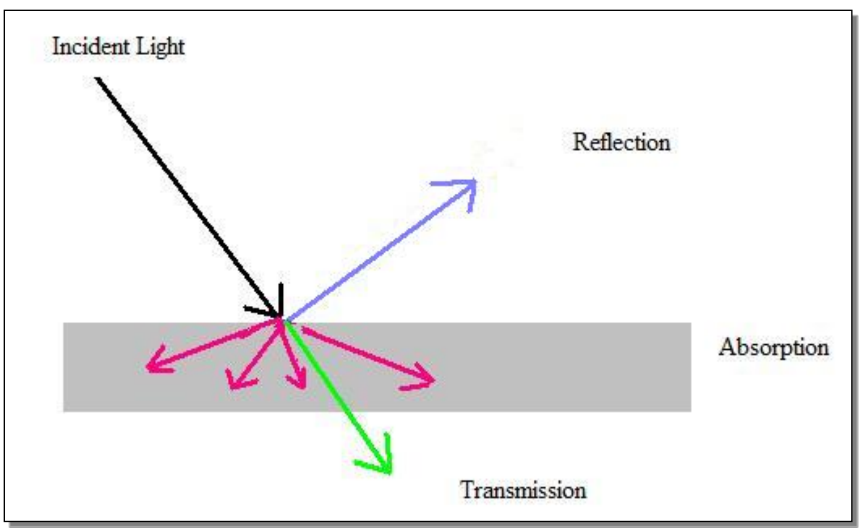


This diagram outlines the electron transitions that may occur in an organic molecule. Of the six illustrated, only the two lowest ones (left two) are achieved by the energy available in the UV-Vis region. Lesser energy is required to excite the pi and non-binding electrons in the visible region. These electrons are easily excited if the pi and non-binding electrons are conjugated. There is an inverse relationship between bonding and energy; the more conjugated bonds are found in a molecule, the lesser the energy necessary for those electrons to be excited. These conjugated bonding system found in the bonding of pi-electrons can absorb radiation in the visible region (the longer wavelengths) and therefore is responsible for the color that is observed.

The chemical theory of color states that absorption of radiation in the visible region of the spectrum may require the presence of some conjugated double bond groups. This will determine whether a molecule will absorb in the visible region, and describe where such absorption will occur. Knowledge of the number of double bonds and the different double bonds will help to understand the spectra of a molecule, but more importantly, to help predict the spectra if the chemical structure of the colored molecule is known. The part of the molecule responsible for absorption of UV-Vis radiation is the chromophore. Therefore, absorption of UV-Vis radiation is restricted to certain functional groups (chromophores) that contain valence electrons of low excitation energy.

For the comparison of color, microscopic examination remains the key tool because it is able to distinguish color in which the human eye cannot perceive (3, 5, 12). MSP has been the conventional tool for analyzing color without destroying the sample. It provides an objective method of microscopic analysis for color comparison. Microspectrophotometry uses a microscope to measure the absorption of the electromagnetic radiation from the chromophore after being excited in the visible and ultraviolet region of the spectrum (4). Since each molecule absorbs light at different wavelengths, the result is considered from the near UV to visible regions and is plotted in a graph called a spectrum. These results can be obtained in one of three modes: transmittance, reflectance and absorbance.

Figure 2: Interaction of Light with Matter



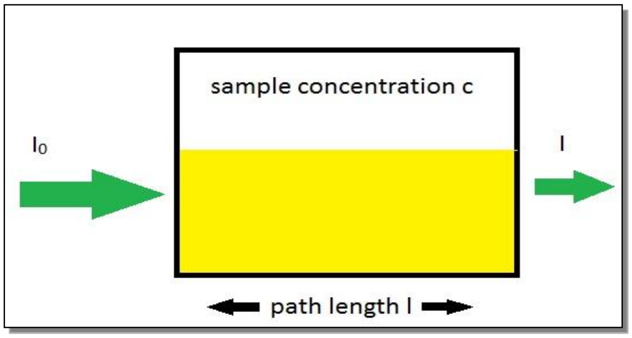
When light strikes an object, the light can react in a number of different ways (Figure 3). When a sample interacts with light, some of that light can be transmitted through, absorbed in or reflected by that sample. Each interaction provides specific details about the sample. While reflectance only measures the surface area, transmittance interrogates the whole sample. The result is a transmittance spectrum that details qualitative information about the interaction of the sample with the various wavelengths*(13)*. For example, when light strikes a blue colored fiber, the red, orange and yellow wavelengths are absorbed by the fiber and the violet-blue and green wavelengths are reflected. Therefore, the color observed on the fiber is based on the wavelength being reflected or transmitted through. The color of any object is largely due to the way that object interacts with light, and how it is reflected and transmitted to the observer. These interactions are expressed in Table 2 below.

Table 3: Color absorbed versus color observed by the eye (10)

Color Absorbed	**Color observed, by eye**	**Wavelength (nm)**
Violet	Yellow-green	380-430
Blue	Yellow	430-480
Green-blue	Orange	480-490
Blue-green	Red	490-500
Green	Purple	500-560
Yellow-green	Violet	560-580
Yellow	Blue	580-590
Orange	Green-blue	590-610
Red	Blue-green	610-750

In this project, transmittance mode was used for analyzing fibers because of the translucent properties of the fibers. In the transmittance mode, the light directed at the sample interacts with the sample as it passes through. The value of the transmitted light is then measured in comparison of the incident beam (I_0) and the attenuated or reduced beam (I).

Figure 3: Absorption of Light by a Sample



This result is also dependent on the thickness of the sample holder used (microscope slide and cover slip), the sample itself and the absorption coefficient of the sample. This absorption of energy in the visible range is governed by Beer's law given by the formula

$$A = \varepsilon_{\lambda}\, l\, c$$

where ε is the molar absorptivity, l is the path length and c is the concentration of the sample.

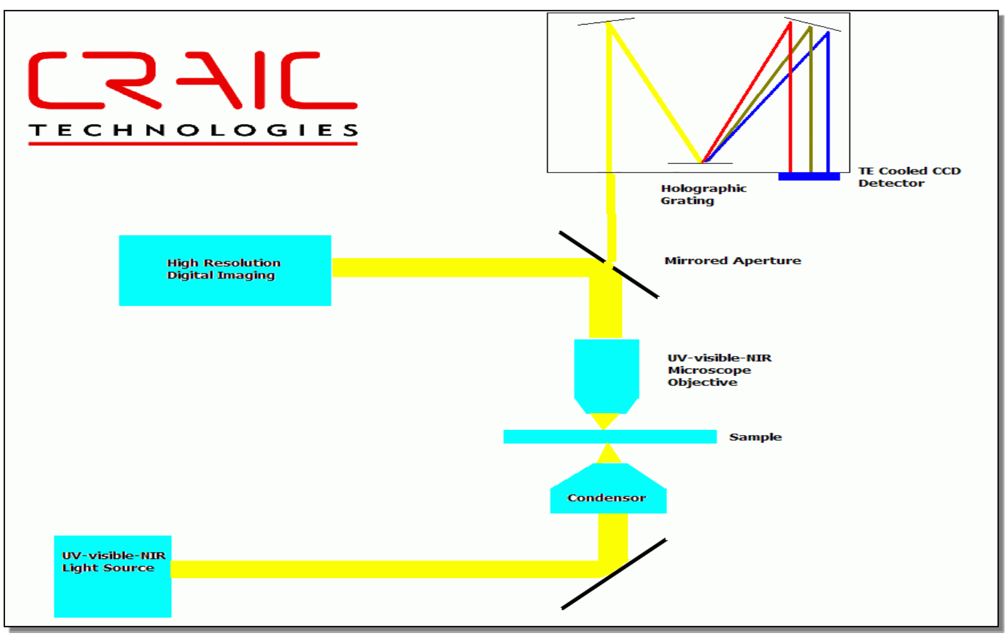
For a given absorber at a given wavelength, ε is constant. The absorbance varies linearly with the path length and the analyte concentration. Spectrometers are typically designed with a constant path length; therefore the absorption is directly related to the concentration of the solution.

3.2 Components of the UV-Vis MSP

The MSP is an integration of an optical microscope and a highly sensitive spectrophotometer. The objective of the microscope is to collect light from the sample using lenses and mirrors to produce a magnified image of the sample and focus that image on the spectrophotometer aperture. The spectrophotometer portion is an optical instrument for measuring the intensity of light relative to its wavelength.

The MSP is composed of the following components: light source, monochromator, microscope, detector and computer. The light source necessary for ultraviolet radiation will differ from visible radiation. Therefore it is necessary that the light source is able to emit all the wavelengths of the UV-Vis region. When light is emitted, the monochromator acts as a prism and splits the light into individual wavelengths. The microscope coupled to the spectrometer, helps to visualize the microscopic materials that is being analyzed. The detector is a charged couple device (CCD) that converts light into an electrical signal. The computer, which is attached to the instrument, controls the system, and parameters, and displays the data using specific software.

Figure 4: General diagram of the transmission MSP



The lamp emits light which is focused on the sample. The sample may absorb some of those wavelengths of light depending upon the chemical structure of the chromophore. Light that is not absorbed by the sample is collected by the MSP objective and focused on the entrance aperture of the spectrophotometer. Using a mirrored aperture, majority of the projected light is reflected to the digital imaging system. This system views the aperture and the sample simultaneously and presents the image showing what the spectrophotometer aperture is currently measuring. The remaining nonreflected light is directly sent to the head of the spectrophotometer and is separated by the monochromator into individual wavelength before reaching the detector. The CCD collects the incoming wavelengths and measures the intensity of each wavelength by the array of pixels. It then sends this information to a computer and the result is a spectrum which displays the intensity of each wavelength of light.

3.3 Colorimetry

Colorimetry is used to quantify descriptions of perceived color and its relationship to spectroscopic measurements(3). It may be used in trace evidence to classify objects such as fibers, paints and inks. Colorimetry was developed to replace the subjective occurrence of color vision in human observation. CIE is the standard colorimetric system used to quantify the color of objects. It is a mathematical model that attempts to express color as a linear combination of red, green and blue (RGB) receptors, which roughly stimulates how humans perceive color.

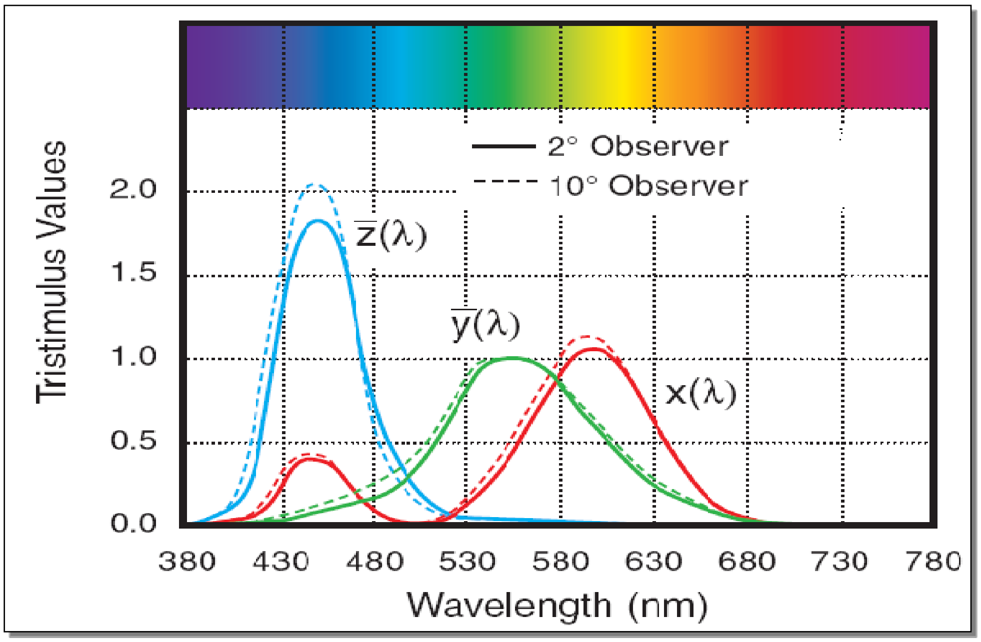
The human eye contains two types of photoreceptor cells called rods and cones where rods responds to the wavelengths of light and the cones respond to color by the reaction of light with pigments (14). The human eye can detect the light in the visible range of the spectrum. When it perceive light, the cones perceive the colors and the rods perceive tones, i.e., black, white and variations of gray. Within the cones, there are three sets of color receptors: red, green and blue. The red cones responds to wavelength around 560nm, the green around 530nm and the blue around 420nm. For this reason, the red cones are most stimulated by light in the red to yellow range, the green in the yellow to green range and the blue in the blue to violet range. Whenever an individual sees color, each cone is stimulated differently to produce that color. For instance, if a beam of light only stimulates the red cone, then the color observed is pure red; likewise for the green and blue cones. Combinations of strongly or weakly stimulated RGB cones will result in production of a variety of colors.

In principle, these three receptors are needed to describe color. Similarly, CIE is related to the sensitivity of these receptors because it is based on the response of the direct measurements of the human eye. The sensitivity of these receptors is used to calculate the tristimulus values and generate a color match. These values are the notation for the CIE system. The tristimulus system is based on the mechanism of human color vision. These cones contain three light sensitive pigment complexes that correlate with RGB of the tristimulus system. The average human response to wavelengths of light is considered the standard observer. The goal of the CIE and tristimulus system is to recreate the pattern of cone stimulation in the eye of a standard observer under controlled conditions of illumination and viewing angle.

Certain colors appear different under different illumination, a phenomena called metamerism. These metameric colors appear to match in one light setting, but differ under another. Because of this, the conditions of the illumination must be controlled to prevent metamerism. CIE also took into account that humans perceive colors most exactly in the eye if the colors impinge in the region of the fovea. Since this region deviates from the optical axis of the eye by approximately

2°, the angle under which a standard observer sees was defined to be exactly 2° (illustrated in Figure 5). This angle is considered the viewing angle. However, another viewing angle of 10° was created to consider the circumstances where the eye sees more distant objects under a different viewing angle. The main difference between 2° and the 10° viewing angle is the increase in the field of view (15).

Figure 5: The Standard Observer Curves



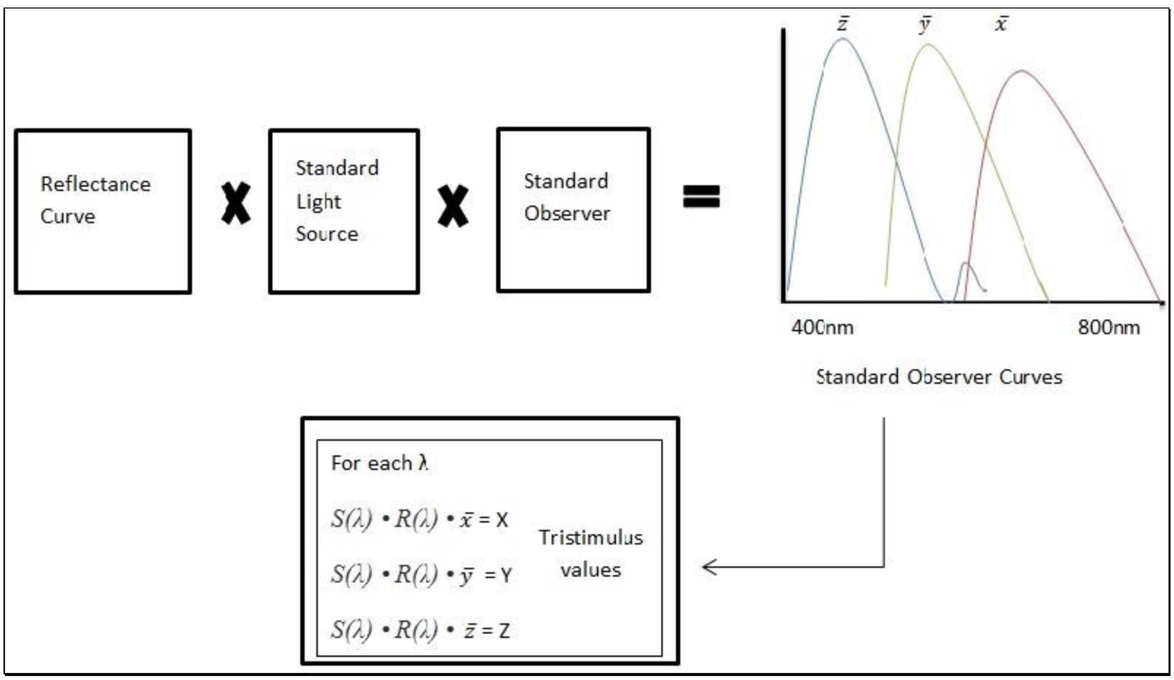
Reproduced with permission: Graphic courteous of PCI Magazine Feb 2003 by X-Rite titled 'Understanding Color Communication'

Color sensation depends on the wavelength content of the received light on the characteristics of the human observer's visual system from our three photoreceptors. While the human eye perceives color by mixtures of RGB, the CIE system employs a reflectance spectrum from the CIE's standard light source. To determine the quantity of RGB for any color, the quantities of these colors in each wavelength must be integrated(16):

$$R = \int_0^\infty I(\lambda)\bar{r}(\lambda)\mathrm{d}\lambda; \qquad G = \int_0^\infty I(\lambda)\bar{g}(\lambda)\mathrm{d}\lambda; \qquad B = \int_0^\infty I(\lambda)\bar{b}(\lambda)\mathrm{d}\lambda$$

Where I(λ) is the luminous intensity in each wavelength and $\bar{r}$ (λ), $\bar{g}$ (λ) and $\bar{b}$ (λ) curves expresses the amount of red, green and blue needed for a match to be made for each wavelength of the spectrum. The color matching functions r, g, b of the standard observer determines the relationship of the primary colors. If an object reflects light when irradiated, the luminous intensity is obtained by *I (λ) = S(λ) • R(λ),* where S(λ) is the spectral power distribution of the standard light source, and R(λ) is the spectral reflectance curve of the object. Thus, the light source, the object reflecting the light, and the standard observer receiving the light and producing the color sensation, reflects the three elements needed in producing color *(17)*. This is expressed in the equation below.

Figure 6: The Color Measurement process



The reflection value at each wavelength in the spectrum is expressed as a weighted contribution of RGB ($\bar{z}, \bar{y}, \bar{x}$). This spectrum representing the visible region is obtained by the MSP. Once the illumination and degree of observation has been applied, the standard observer curves are calculated. From this, the tristimulus value X, Y, Z, which represents the total component of each color, is summed over the spectral range. The three tristimulus values X (red), Y (green), and Z (blue), can be given for any color, which will model the color perceived by an individual *(18).* These coordinates define the color quality of the color stimulus. Each coordinate is then calculated by summing over the entire spectral region and multiplying the amount of light by the receptor sensitivity *(19)*.

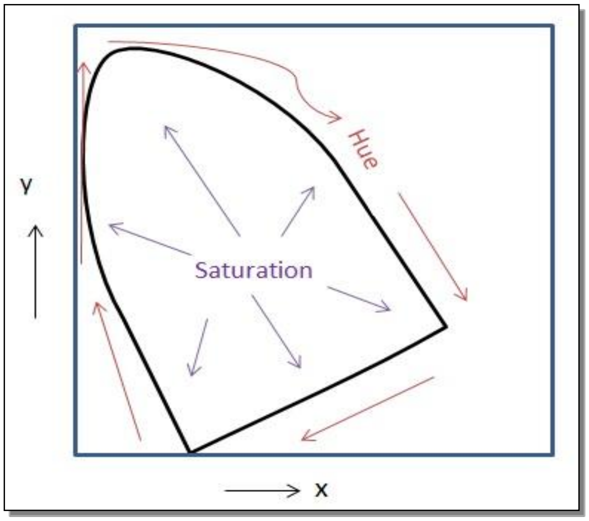
$$X = \sum_{\lambda=380}^{760} S\bar{x}(\lambda) \bullet R(\lambda); \quad Y = \sum_{\lambda=380}^{760} S\bar{y}(\lambda) \bullet R(\lambda); \quad Z = \sum_{\lambda=380}^{760} S\bar{z}(\lambda) \bullet R(\lambda);$$

The CIE tristimulus values do not directly correspond to the visual attributes of color, but are an approximation. For color to be readily understood, it must be defined in terms of hue and chroma. The hue refers to the spectral colors, and the chroma refers to the saturation or strength of the dominant wavelength or hue as the color deviates from gray. For this reason, CIE uses the XYZ tristimulus values to formulate a new set of values called the chromaticity coordinates denoted xyz:

$$x = \frac{X}{X + Y + Z}; \quad y = \frac{Y}{X + Y + Z}; \quad z = \frac{Z}{X + Y + Z}$$

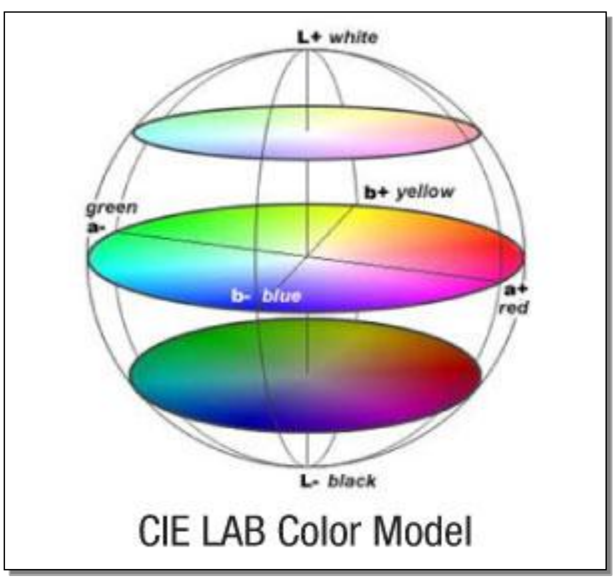
The sum of x, y, and z is always equal to one. Only the two coordinates, x and y, are necessary for color determination because they specify the hue and chromaticity of the color *(20).* This result in a single value which is plotted in a 2D chromaticity diagram to observed the location of the color. The Y tristimulus value is established as a direct measure of luminance or light which refers to the depth of the color. By normalizing the tristimulus values, the chromaticity coordinates can be calculated into a 2-D chart illustrated below.

Figure 7: The Chromaticity diagram



Chromaticity diagrams are limited by being asymmetric: therefore the calculations and comparisons of color differences are not uniform. To address this, a transformation must be applied. CIE later established a cyclindrical color model called Lab.

Figure 8: The CIELab Color Space



It is a uniformed color space version of CIE and has a larger color range. CIELAB describes color with three components (Table 4); ‘L’ for luminance or lightness, ‘a’ for chromatic components from green to red, and ‘b’ from blue to yellow (further derived from tristimulus values X, Y, Z). Using this model, a color difference can be calculated. The transformation used to convert the tristimulus values to CIELab equivalent are as follows

$$L^* = 116\ (Y/Y_n)^{1/3} - 16$$

$$a^* = 500\ [(X/X_n)^{1/3} - (Y/Y_n)^{1/3}]$$

$$b^* = 200\ [(Y/Y_n)^{1/3} - (Z/Z_n)^{1/3}]$$

Hence, the CIE values are defined in terms of the ratio of the tristimulus values, X, Y and Z (21). The difference of distance on the CIELAB plot can be stated as a single value, known as simple Euclidean distance.

There are also other color models known but CIELab was chosen as it is most frequently used to measure color (17, 21-24). The procedure for calculating color is based upon the illuminant used, the observer and the reflection spectral profile of the object. The recommended illuminant for forensic case work is illuminant A, which is an incandescent tungsten lamp with a color temperature of 2856K *(25)*. For this project, the illuminant and the observer remained constant; therefore any differences in color arose from the reflectance spectra of the fiber plus any associated variables.

Table 4: The CIE Color Space Notation

Notation	Description	Positive value	Negative value
L	Difference in lightness/ darkness value	Lighter- if the value = 0, the sample is white	Darker- if the value = 100, the sample is black

a	Difference on red/green axis	Redder or has red shading	Greener or has green shading
b	Difference on yellow/blue axis	yellower or has yellow shading	Bluer or has blue shading

3. Literature review

One of the most common questions asked of trace evidence examiners in court is "How common are these fibers?" (1)**.** To determine the commonness and rareness of fibers, the properties of the fiber type, the color, the cross section as well as other parameters, must be recorded and considered. Since color has high discriminatory characteristics and can be determined objectively, further experimenting of color in fibers was approached. The majority of the studies that have been completed thus far have been directed toward color fading of multi-cycle laundering processed on single fiber type such as cotton, polyester and wool *(26, 27).*

The study performed by Phillips et al attempted to develop a method to identify colored cotton fabrics susceptible to fading (26). One goal of this study was to predict the effect of bleached detergent on cotton batches after multiple laundered cycles. The activated bleach used was hydrogen peroxide with tetra-acetylethylene diamine (TAED). This oxygenated bleaching system is commonly found in laundry detergents in Western Europe where the research was performed. The author evaluated 39 commonly used reactive, sulfur and vat dyes, which were washed using four different detergents: two commercial detergent brands containing TAED and two reference detergents with only one containing the bleach system TAED. Prior to washing, the fabrics were screened by an existing standard to eliminate any bleeding and staining that may occur if the fabrics are washed collectively. Of the 64 fabrics, 11 were removed from the experiment as they were deemed unsuitable for washing because they would have caused high levels of bleeding and staining to adjacent fibers. These 11 direct dyes excluded from the study were all water soluble; hence, as the fiber was submerged in the liquid, high levels of bleeding and staining occurred as the dye was not retained in the fiber. The remaining 53 fabrics were washed 20 times in a washing machine set to the ‘main cotton’ washing cycle. The color change was recorded using a spectrophotometer and the results were compared to the unprocessed fabrics.

The results from the study showed that certain dyed fabrics were more sensitive to bleach than others. It was further concluded that even with the absence of the bleach, certain dyes observed a high fading, therefore estimating that the mechanism behind fading can be both a physical and chemical process. This result was limited to CI Vat Yellow 46 dye; the other vat dyes exhibited very little bleach sensitivity. This experiment has been validated by another study which took place in the United Kingdom.

Philips et. al. experimented on establishing a correlation between the fading of a fiber subjected to bleach in a single cycle versus multiple wash cycles. Sixty-four cotton substrates dyed with direct, reactive, sulfur and vat dyes were washed for a total of 20 times(28). The results were categorized into two groups: the sensitivity of the dye to the bleaching system, or those considered to be resistant or robust to bleaching. With direct dyes, fading is influenced by both the chemistry of the dye and the after treatment that followed. While reactive dyes varied in its sensitivity, sulfur was extremely sensitive to bleach. In agreement to the previous study, vat dyes did not exhibit a significant amount of bleach fading. In conclusion, bleaching systems can greatly influence fading of dye during their life-time of laundering.

Another study led to the conclusion that the degree of fading in domestic washing progressively increases with the number of wash cycles for different dyed fabrics (29). Although the study was limited to wool fibers, the change in temperature and the effect of water on wool altered the durability of the wool fiber to endure. This can also be assumed for other types of fibers under similar conditions.

There are obvious limitations observed throughout the studies performed. Since most of the research was done outside the United States, the European studies do not adequately represent the US laundry settings. In each case, the water temperature, the length cycle of washing, and the detergents, differ from the US conditions of water temperature, the purity of the water, the duration of the washing cycle and the detergents found in the US markets (30, 31).

Another limitation observed in the studies was the partial explanation of the dye fading in the fabrics. The conclusions did not explain the mechanism of dye fading and no studies have attempted to analyze what exactly occurs during washing. For instance, can it be assumed that only the dye fades, or does the fiber age when washed? Most studies have not adequately explained that the dye has faded because of the washing, and not that the fiber has aged. If the fiber does age after laundry, then it can be expected that the color would also look faded. To demonstrate that the dye has faded, the dye would need to be extracted from the fiber and analyzed separately before any further conclusions can be gathered.

Fortunately, the CIE coordinates for a dye solution will be the same regardless of the concentration so long as the solution obeys Beer’s law. This implies that it is not possible to distinguish between fibers lightly and heavily dyed with the same dye (1). The analysis of differentiating dyes is not of greater concern when attempting to determine whether two fibers are common or rare. It is the specific dye that was used to color the fiber that has the greater impact. The same dye solution used to color different fibers will not change because the substrate on which it is dyed is different. However, the concentration will be dependent on that substrate as each substrate might retain the dye solution differently. Therefore the necessity to know the washfastness of the dye over time, especially over aging and washing, is very important to aid in forensic comparison of color in fibers.

A recent attempt was made by Was-Gubala to determine the mechanism involving color change(32). This study evaluated a variety of textiles treated with different detergent solutions. The goal in this experiment was to assess various color related characteristics in fibers by subjecting the fiber to repeated long term laundry using different detergent solutions. Four different types of fibers and dyes were used: acrylic, cotton, polyester, and wool, dyed with basic, direct, dispersed and acid dyes, respectively. Three different colors for each type of fiber were analyzed: blue, dark grey and red. The detergents used were based on the brand name and compositional diversity found in Poland and other European markets. The fabrics were stored in separate plastic containers based on the recommended detergent solution over a 14 day period. Each detergent solution was changed and replaced with fresh solution on a daily basis. At the same time daily, small pieces were cut from each of the laundered sample, dried and analyzed by sensory analysis and fluorescence. Because visual examination is subjective, the necessity of objective results are preferred and therefore a second part of the same experiment was done using the MSP (33).

The MSP was used and the results confirmed the previous observational findings which indicated that the first detergent resulted in the most noticeable change in color. This was likely due to a potent, oxygen-based chemical whitener present in this formulation. And with the aid of fluorescence microscopy, the degradation of the color change could be readily observed. The greatest amount of color change was found in the red indirect dyes, which were used to dye cotton textiles.

Although there was substantial inter-variability of different types of fibers, there was limited mention of analysis for fiber intra-variability. The authors used four types of textiles and three different colors for inter-variability purposes, but they failed to reference the intra-variability within the textile and fiber. Observing intra-variability is also useful in monitoring the range of color change within a single fiber. Another noticeable limitation was the inadequate portrayal of a normal laundered cycle. The color change in the fibers might have been different due to the mere rubbing, turning and constant moving of clothes as it is being washed in an actual washing machine. Instead, the fibers were placed in separate containers and shaken regularly to depict physical movement. Lastly, the duration of the fabric being submerged in the detergent solution is not comparable to a normal cycle. Even with a heavy duty cycle which lasts approximately 35 to 40 minutes in the laundry, the fabrics were submerged for 24hours. Initially, a difference in color change was expected as a function of extensive detergent exposure. On the other hand, lack of physical contact of clothes in washing, could have also influenced that change to a lesser extent.

A more realistic approach of washing was done to compare dye fading due to different washing machines. Rohwer's project compared dye fading of 14 dyes in a multi-wash test between Linitest and a normal washing machine (34). Lintiest is a simple machine that rotates eight closed 500ml beakers in a temperature controlled water bath. Unlike a regular washing machine, Linitest is limited in its mechanical action of slipping, rubbing and tumbling of textiles through washing. For the washing cycle, three different detergents were used: non-bleach, high bleach and new bleach. The main ingredients of the bleaching systems were the same; however, the difference among them was the content of the bleach. While high bleach referred to the inclusion of TAED, new bleach referred to the addition of a catalyst with TAED. The bleach catalyst 'Clariant' was added to the high bleach solution to create the 'new bleach'. The 14 dyes were washed 20 times collectively based on the similar shade in color among the dyes to minimize any influence of dye transfer or bleed.

The results obtained were in collaboration from six independent laboratories. A poor correlation was observed between the washing machine and Linitest in the non-bleaching environment. There was significant fading in the washing machine of certain dyes than in the Linitest. This difference was only observed at lower washing temperatures. In contrast, the correlation in the high bleach system was better. A larger quantity of the dyes faded in the actual washing machine. In the new bleaching system, the only difference observed was the fading profile. Since a catalyst only increases the rate of the reaction without changing it, the fading profile of the bleaching system was unexpected. Even with a catalyst added to the system to influence the results, only one dye exhibited substantial fading. The mechanism behind this reaction requires further evaluation and study. Three factors were determined to predict dye fading in washing operations: bleach, temperature and mechanical action from the washing machine. While both instruments identified the same fading ranks of the dyes, the full extent of dye fading was more apparent in the actual washing machine than in Linitest.

The research showed that color fading gives a descriptive result when done as realistically as possible. Although fading was observed in the laboratory setting, it denies portraying truthful results as one would obtain outside the lab. One limitation apparent in this and the previous studies is the inadequate representation of the US laundry and the bleaching condition. There was also incomplete information about the fiber dyes. Knowing the dye and its bonding mechanism to the fiber will assist in understanding the intensity of the color change that will occur.

McLean's experiment focused on the interaction of textiles and bleach under North American conditions (31). To modify these conditions, the bleach activator TAED was replaced with nonanoyloxybenzene sulfonate (NOBS). Both bleaching systems attempt to perform similar results, but both are also influenced by temperature, duration of wash cycle, volume of water and concentration of detergent for cleaning performance. Seventeen commercial dyes were washed for a total of 50 cycles under normal US conditions with both bleaching systems. It was concluded that certain dyes reacted differently or are more sensitive to one bleaching system than the other and that the recommended US conditions of activated bleaching system NOBS is more favorable for the analysis of color fading in the US.

This gateway that allows for accurate analysis of color fading under the US conditions was only peer-reviewed but not published. No validation of the results have been presented and confirmed by the author. Other peer reviewed articles have agreed that NOBS appears more robust than TAED in industrial textile bleaching applications because of its excellent solubility in water, and that the minimal need to control the pH of the water its gives superior bleach performance (35).

Modern research has incorporated the modified COX conditions. This method is used to identify colored cotton fabrics susceptible to fading by laundering with detergents containing activated bleach(30). It focuses on comparing the two primary bleach activators, TAED and NOBS, and their effects on fibers. Seventeen dyes were chosen as a representative of the commercial dye class which ranged from acid, basic, direct, disperse, reactive, sulfur and vat dyes, and were subjected to 50 wash cycles using the two detergents. The results indicated that the dyes were affected by both bleaching systems; however, most were observed to be sensitive to the beach activator TAED. Thus, the modified version of COX, replacing TAED with NOBS, was recommended by the authors.

Other recent studies evaluated the reproducibility of washfastness in cotton and polyester fibers within six laboratories (36). The samples were washed under four different conditions to observe the range of washfastness of the dyes in the fabrics. These conditions varied in temperature, pH, and additions in the base detergent used. The results of the color change were recorded by a gray scale value that was visually determined. Although there were observed differences in the absolute values of color change, the results were consistent in the sensitivities of the dyes. Successfully, the reproducibility for the fibers averaged over the participating laboratories. Other studies focused on the population of fibers recovered from washing machines and evaluated their persistence, not necessarily their color change(37).

Scientists realized that the fading of colors (or dyes) due to washing is still an important issue (38). Because of this, it is important to accurately represent the family of textile fibers by subjecting them to similar aging, washing and storing conditions as an individual would and gathering objective discriminatory data that greater influence the analysis of fibers. It is important to further observe color fading in fibers, normal wear and tear, and aging of the fiber under environmental conditions.

Later studies have been concerned with the degradation of color in which environmental conditions, such as light and temperature, plays a major role. Some of these studies have been directed towards monitoring the degradation of paintings over time through aging (39, 40). The study performed by Marengo et. al evaluated the conservation state of paintings by understanding one of the natural cause of degradation in paintings: its exposure to sunlight. To evaluate this phenomena, a cotton canvas strip painted with a natural pigment (Alizarin) was exposed to UV light (λ =254nm) for a total of 276hours. At every 12 hours of exposure, the irradiation was interrupted and the IR spectra were obtained using the Attenuated-Total-Reflectance Fourier Transform IR (ATR-FT-IR) spectroscopy instrument. Results showed that exposure to UV light produced some changes in the loss of gloss on the sample surface and that the aggression of the UV light caused the degradation (oxidation) of the pigment and the cotton canvas.

Similar conclusion was observed in a later research performed by the same authors (41). Ten mixtures of three organic pigments (Alizarin, Permanent Red and Phtalocyanine Green) were prepared, mixed with linseed oil and spread on 10 canvas strips, to represent the typical complexity of a real painting. The canvases were irradiated with UV light (λ = 254nm) for a total of 272hours. Regular exposure was interrupted every 16 hours for analysis using the ATR-FT-IR spectroscopy. With the aim to individuate color difference between treated and untreated samples, no color change, but only a loss of gloss on the surfaces of the paintings was observed after UV treatment.

The authors performed another related study by using the FT-Raman instrument to investigate color change on the surface of canvases exposed to UV light (42). Raman spectroscopy was used because of its ability to monitor changes without the necessity of sample preparation and its lack of destruction towards the samples. Unlike the previous studies, the intensity of the UV exposure was lessened. Red and blue colored pigments mixed with linseed oil (1:1, w/w) were painted onto a cotton canvas and exposed to UV light (λ= 234nm) for a total of 12 hours. The radiation was interrupted every 45minutes and the Raman spectra was recorded. Macroscopic changes could be observed in two of the colored pigments; the blue pigment faded and became opaque and the red pigment became darker and opaque. It was estimated that both the samples became opaque because of the degradation of the linseed oil.

In summary, a review of the current literature shows that color changes can be observed when a sample has been exposed to UV aging for a period of time. Although the notice of color change is not always evident, the degree of fading increases as the fiber is gradually exposed to any environmental conditions.

4. Materials and Methods

4.1 Materials

4.1.1 Textile materials used

The type of fiber chosen for this experiment was100% polyester because of its popularity and widespread use. Seventeen polyester shorts were bought from local Wal-Mart stores (Morgantown, WV). These shorts were all new and were never processed or worn. The two brand names bought were Danskin Now® and Garanimals®. The Danskin Now® products only consisted of polyester shorts are dyed with.., but the Garanimal® products were both polyester and cotton skirt-short style shorts dyed with pigment print. The Garanimal® skirts were 100% polyester and the under-shorts were 100% cotton. The portion of the cotton fabrics was not analyzed.

These two brands were chosen because of its low-cost, variability in colors and accessibility. Each item was bought in quantities of two or three. Table 5 describes in detail the information about the shorts and Table 6 describes how the shorts were labeled for this project.

Figure 9: Photograph of the Polyester shorts used

Note: Garanimals® style shorts left two pictures and Danskin Now® at right.

Table 5: Polyester shorts used in the project

Brand	**Fiber Type**	**Total**	**Sample name**	**Style**	**UPC**	**Size**	**Manufactured in**
G	P	2	Orange solid dazzle short	GAB 2103001	01326486542	18M	Honduras
G	C & P	2	Green mesh short w/ PRT WB skirt	GAG 2102031	01326486956 01326486954	24M 12M	Honduras
G	C & P	2	Red mesh short w/ PRT WB skirt	GAG 210203T	01326487346	4T/NP4	Honduras
G	P	3	Dark pink mesh short w/ PRT WB	GAG 2102031	01326486990	12M	Honduras
G	C & P	2	Purple mesh	GAG	01326486985	18M	Honduras

			short w/ PRT WB	2102031	01326486984	12M	
DN	P	3	Pink magic active short (w/ gray sides)	DG20B006	66046913740	L/G 10-12	China
DN	P	3	Pink magic DN color block athltc short (w/ gray sides)	DG20B006	84391301744	XL/ 14-16	Jordan

Legend: C- cotton; DN- Danskin Now, G- Garanimals, P- polyester

Table 6: Reference labels for the Polyester short.

Reference name (labeled as)	**Item's actual name**
GMP	Polyester shorts
RMP	Polyester shorts
PMP	Polyester shorts
OSDP	Orange Solid Dazzle Polyester short
DPMP	Dark Pink Solid Dazzle Polyester short
PMJX	Pink Magic (Danskin Now polyester shorts)Jordan size XL/ S/ S sides
PMCL	Pink Magic (Danskin Now polyester shorts) China size L

In total, five different colors were analyzed in this experiment: green, orange, pink, purple, and red. The colors were selected to represent the low, medium and high energy ranges of the visible spectrum. Three pink colors of varying shades were chosen to observe if the treatment would affect each sample similarly. Among the three, sample DPMP varied greatly in shade from the two other pink shorts. In fact, samples PMCL and PMJX were not easily differentiated. The difference between them was their manufacturing location: PMCL was made in China and PMJX in Jordan. This closeness in color was also evaluated for the discriminating power of the MSP.

Figure 10: Similarity between reference PMCL (left) and PMJX (right) samples

4.1.2 Detergents tested

The two detergents used for washing were Tide® (24 loads, original scent) and Tide® with bleach (18 loads, original scent). The oxygenated bleaching system was sodium percarbonate. This brand of detergent was chosen based on consumers' reviews of its effectiveness in cleaning (43). Both detergents were in powder form**.**

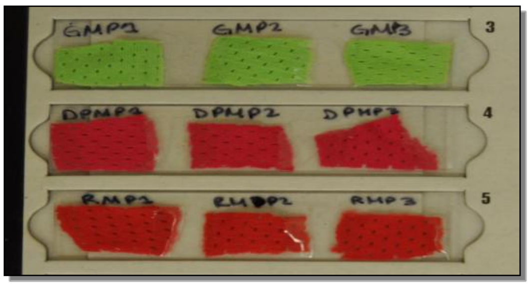
4.2 Methods

4.2.1 Aging Treatment

4.2.1a Aged Standards

For reference controls, 3 swatches of approximately 2cm by 1.5cm were randomly cut from each sets of shorts, and taped onto a Fisherbrand frosted microscope slide (size 25 x 75x 1mm) at the sides using clear tape. The slides were labeled and numbered appropriately based on the item's reference name, and swatch number1, 2 or 3. From each swatch, individual fibers were also extracted, then mounted with Entellan, a permanent mounting media, before being covered with a Fisherbrand cover glass slides (size 22x 22-2mm). These slides were also labeled in the same manner. These standards were then organized by color and stored in a microscope slide box. This box was immediately stored in the dark.

Figure 11: Photograph of the Prepped Aged Standards



<u>*4.2.1b Aged Samples*</u>

One item for each color of shorts was used. From each garment, one large swatch was cut into three rectangular pieces and taped horizontally on the outer surface on the slide. To eliminate UV absorption from the glass slide, the samples were taped on Fisherbrand precleaned microscope slides (size 75 x 50 x 1mm) that were already completely covered with aluminum foil. The slide was then labeled on the bottom left corner ‘O’ for ‘outer-surface’ using permanent marker. Small pieces of blank paper were taped on the opposing side in order to record the item’s reference name and other information. As the samples were aged, the date and hours of aging were subsequently recorded.

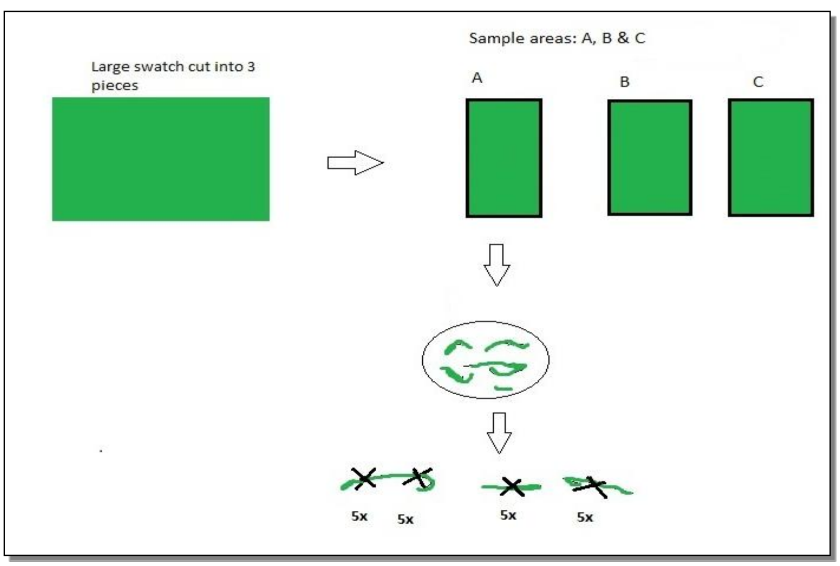
<u>*4.2.1c Aging Process*</u>

Since seven slides were prepared where each slide had a total of three rectangular taped swatches, a total of 21 swatches of samples were aged during part one of this experiment. The source used to provide the aging treatment is discussed in section 4.3.1. These samples were aged for a total of 80 hours. At 16 hour intervals, the samples were removed, and fibers were extracted and preserved for MSP analysis. Three sample areas, A, B and C were chosen from every swatch. A miniscule amount of fibers were extracted from these sample areas and stored in 1.5µl eppendorf tubes. These tubes were appropriately labeled based on the reference name, the sample area, and the total hours aged. They were then organized by colors and hours aged and immediately stored in Ziploc® bags in the dark. Twenty-one eppendorf tubes were stored for each aged period totaling 105 eppendorf tubes with the extracted fibers for analysis.

<u>*4.2.1d MSP Preparation and Analysis for Aged Samples*</u>

For MSP preparation, small amounts of fibers were obtained from each eppendorf tube and mounted with Entellan on a Fisherbrand precleaned microscope slide (size 75 x 50x 1mm). Three mountings were performed on each slide to represent sample areas A, B and C. Three fibers were examined per sample area: one fiber was analyzed at two different locations on that fiber, and two fibers were analyzed at only one location (see Figure 12 below).

Figure 12: Preparation of Aged Samples for MSP analysis

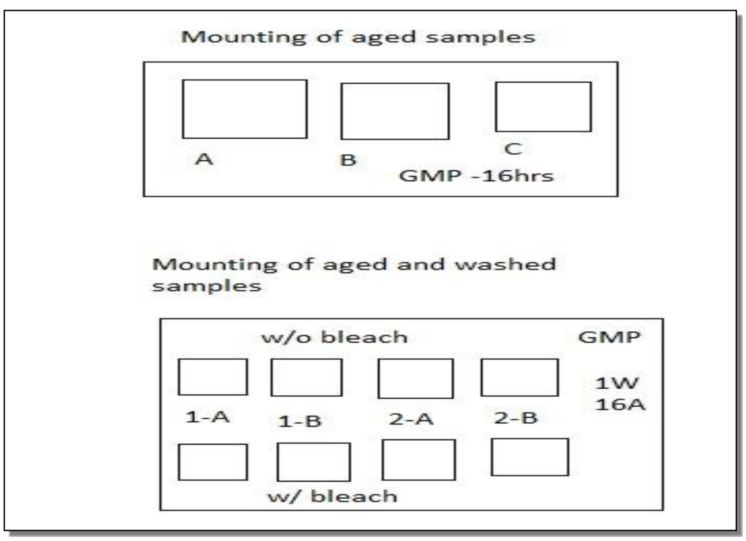


Note: Green swatch represent reference sample GMP

The first fiber was used to evaluate fiber intra-variability and the latter two fibers were used to evaluate inter-variability among neighboring fibers. A minimal amount of fiber intra-variation is expected from manufactured fibers; therefore, only one fiber per sample area was analyzed at two different locations. Analyzing three different sample areas from the same garment enables inter-variability determination across that garment.

All analysis was done in replicates of five; the measurements were performed simultaneously without moving the stage or removing the samples between measurements. This replicate of five simultaneous measurements accounts for any instrumental variability. The sample mounting can be seen in Figure 13a below.

Figure 13a-b: The mounted samples for further analysis with the MSP



Note: The top image (a) represents the aged samples; the bottom image (b) represents the washed and aged samples. 'W' represents 'Washed' and 'A' represents 'Aged'.

4.2.2 Washed-Aged Treatment

4.2.2a Washing Process for Washed Standards

A pretrial washing was done with both detergents to determine if any color bleeding would occur among the light or dark colors being washed together. All washings were performed using a Kenmore 70 Series Heavy Duty Plus washing machine set for a normal wash cycle (cotton sturdy cycle), with the water level set to medium, and the water temperature set to warm-warm (wash-rinse). The samples were washed with approximately 15 to 20lbs of similar color laundry to incorporate the mechanical action from rubbing, spinning and tumbling of clothes during washing. Four large swatches were cut from each item; two were washed with bleach and the other two washed without bleach. Since samples PMCL and PMJX could not be easily differentiated visually, samples PMCL were cut in the middle to prevent any error and confusion. Two ounces (line 1 from the measuring scoop) were used for washing and kept constant throughout the experiment. After washing, the samples were air dried in the dark to lessen any exposure to light.

4.2.2b Preparation and analysis for Washed standards for MSP analysis

Once the samples were dried, fibers were extracted and mounted in the same manner as the aged samples (Figure 13b and 14). Although the aged samples analyzed fibers at three sample areas, only two were observed for the washed-aged treatment. This was done for efficiency and comparison purposes. Figure 14 below diagrams this sampling procedure. Similar to the aged analysis, three fibers from each swatch were analyzed in replicates of five: the first fiber was analyzed at two different locations, and the last two fibers were analyzed at one location each.

4.2.2c Washing Process for Washed-Aged Samples

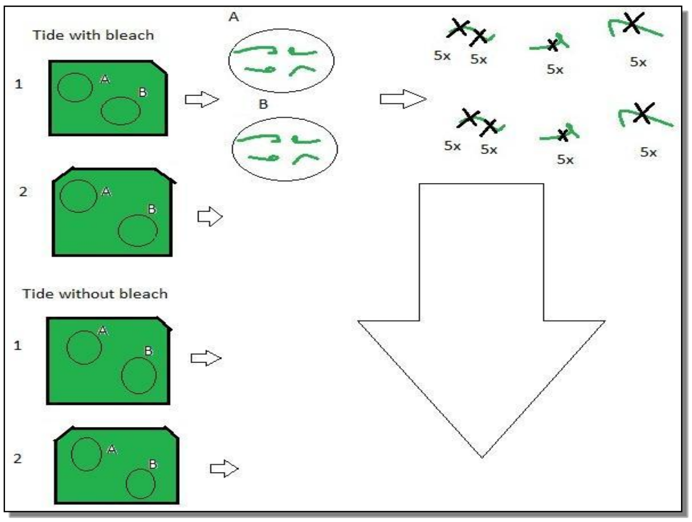
From each reference garment, four medium size swatches were cut from different places and labeled swatch one and two, for each detergent. To differentiate the swatches, swatch one was cut diagonally at one corner, and swatch two was cut diagonally at both corners (see Figure 16). PMCL samples were also cut in the middle to differentiate it from PMJX samples. The swatches were stored in manila envelopes and grouped by detergent, and labeled either ‘With bleach’ or ‘Without bleach’. The samples were then washed using the same parameters set during this project. Immediately after air drying, the swatches were then aged for 16 hours. Aluminum foil was placed at the bottom of the UV box and using a permanent marker, a line was drawn to use as a divider between the bleached and non-bleached detergent samples. This washed-aged cycle repeated until the total number of washing was equal to five and aging equal to 80 hours. The samples were washed and aged once per day around the same time. After analysis, the samples were stored in its manila envelope in the dark until the next day.

The labeling on the microscope slide was abbreviated as follows: 1W 0A- the sample was washed once but was not aged; 1W 16A- the sample was washed once and aged for 16 hours; 2W 32A- the sample was washed twice and aged for 32 hours…; 5W 80A- the sample was washed five times and aged for 80 hours.

4.2.2d MSP Preparation and Analysis for Washed-Aged Samples

Fibers were extracted from each swatch at two sample areas, A and B. These sample areas were on extreme sides of each swatch for separation purposes and remained consistent throughout most of the experiment. Note that between swatches, sample areas may have differed by location. Fibers were randomly collected from the outer surface of the swatch, mounted, and labeled according to its reference name and the number of the washed-aged cycles (see Figure 13b). Similar to the analysis of the aged samples, three fibers were analyzed. The first fiber from each sample area was analyzed at two locations on that particular fiber, whereas the last two fibers were only analyzed at one particular location. These measurements were performed in replicates of five, totaling 20 measurements. Thus from every cycle, a total of 40 measurements were collected per swatch.

Figure 14: Preparation of Washed-Aged Samples for MSP Analysis



4.3 Instrumentation

4.3.1 UV lamp

The UV lamp used for artificial lighting was manufactured through the American Ultraviolet Company (model CE-6-BL, 120V, 60Hz and 194Amps). It emits wavelengths of 405nm, 440nm, 550nm and 580nm with a power of 23W. Mercury bulb was used as the light source. The UV lamp was assembled into a built wooden box with an integrated built-in timer. A $9^{1/2}$ x $4^{1/2}$in opening in the wooden cover of the UV box, sealed with black Styrofoam-like material was created for easy insertion and removal of the UV lamp. When the box was closed, the dimensions were 18in x 14in x 7in in length, width, and height, respectively. The inside dimensions were 16 $^{5/8}$in x 12 $^{5/8}$in x 6 in. The height of the UV lamp from the sample directly below was 6 $^{3/4}$in.

Figure 15: UV lamp and box used for artificial aging

The samples were artificially aged by exposing them to UV light. The simulation of the exposure to sunlight was obtained by exposing the samples surfaces to the UV light to produce aging as it would occur through normal wearing and fading of fibers (41)**.**

4.3.2 Stereomicroscope

The stereomicroscope used to initially observe and extract the fibers during mounting was the Leica EZ4 [Leica Microsystems (Schweiz) AG; with input of 100-240V, 15W and 60HZ]. Because of its ability to magnify an object between 10X to 40X, the magnification was effective for fiber extraction. No further analysis was performed with this instrument other than to initially observe the samples for any contamination (especially when washed) and to extract the fibers from its respective swatches.

4.3.3 Ultraviolet – Visible- Near Infrared Microscpectrophotometer

The instrument used in this research experiment was the QDI 1000 ultra-violet- visible- near infrared Microspectrophotometer (serial number 20040122A1). The light source was provided by Leica DMRX (12Vmax at 100W). The transmission power supply necessary for analysis in the transmittance mode was received from a 75W xenon bulb. The data acquisition software used was the CRAIC MSP created on the 14Sep 07. The image acquisition software used during this experiment was the Image Control (IC) Capture 2.0 (version 2.0.0.290).

4.3.3a Measurement of samples using the MSP

The MSP was operated in transmission mode (95W xenon source) using the 36x objective. Spectra were collected by taking an average of 50 scans over the spectral range of 350 - 850nm, with a bandwidth (resolution factor) of 10. The integration time was adjusted to the optimized value obtained during daily calibration and this value was recorded each day. The purpose of integrating the instrument is to maximize sensitivity of the measured signals approaching the detector. This improves the signal-to-noise ratio and the precision of the photometer. The integration period is analogous to the shutter speed of a camera. The higher the value specified, the longer the detector collects the incoming photons. Aperture size of the MSP was 10x10 microns. The UV-Vis spectra were recorded from three randomly selected fibers from each mounting. Five replicates of spectra were taken for each fiber and by using the IC Capture Image software; one image per sample was photographed and stored. CIELab results were also obtained from each spectrum using the GRAMS/AI system (version 7.02). The settings used to obtain color analysis were as follows: standard observer 10 degree, illuminant CIE A, calculation type CIE L*a*b and spectral range 360-830nm.

4.3.3b Instrument Calibration

The instrument was daily calibrated before use. Craic Technologies issued the National Institute of Standards (NIST) traceable standard sets to be used for calibration and the expected calibration results including the uncertainty values. The calibration set used throughout this experiment was CAL2710 (Craic Technologies with recertification due Sept 25, 2011). The purpose of calibrating the MSP is to increase the productivity of the instrument, by assuring consistency and precision to guarantee that the results are valid and reliable in spectral measurements. Daily calibration ensures proper system functioning and will help to detect systematic errors that might occur. The instrument was calibrated to manufactured instructions.

The QDI Image and Data Acquisition Software instrumentation were turned on for thirty minutes before any analysis was done, to allow the lights from the system to warm up. The reference filter was placed on the stage in sharp focus, and remained in that location during the entire calibration process. The instrument was first optimized to set the instrument parameters. Once the instrument is successfully optimized, a dark and reference scans were then performed. A dark scan is taken when the light is blocked to the spectrometer head, therefore only allowing the noise of the instrument to be recorded. In the reference scan, light is allowed to the spectrometer head. The reference scan accounts the light intensity, and the blank or microscope slide that is also analyzed before any absorbance, transmittance, or reflectance spectra can be obtained. In the MSP, calibrations are required in three areas:

1. Wavelength accuracy and spectral resolution
2. Absorbance and spectral linearity
3. Colorimetry

1. Wavelength accuracy and spectral resolution

Wavelength accuracy over the visible region can be checked using holmium oxide glass and didymium glass filters because these filters both have some narrow absorption bands. The spectrometer is calibrated in the spectral range from 240nm to 650nm. Once completed the blank and reference scan is performed, the wavelength calibration can be executed. To initiate the wavelength calibration, the holmium filter is placed on the field diaphragm of the microscope stand. Once the sample is analyzed, the filters are then switched and analyzed. After the filters have been analyzed, results are stating if the instrument is within established calibrating limits.

2. Absorbance and spectral linearity

Standardization of absorbance is required particularly if colorimetry is to be used for recording and comparing color. Accuracy can be controlled using optical density (OD) filters OD0.1, OD0.5 and OD1.0. OD filters reduce the amount of energy transmitted through; higher OD values indicate very low transmission and lower OD values indicate high transmission. Therefore, OD 0.1 filter will have a higher transmission and OD 1.0 will have a lower transmission. This system which obeys Beer's Law can roughly indicate the spectral linearity of the system. The calibrating procedure performed was similar to the wavelength calibration procedure. The filters were placed on the field diaphragm and analyzed. Once all three filters were measured, the results of the analysis were produced, which affirmed if the instrument is within established calibrating limits.

3. Colorimetry

Three set of filters blue, green, and red must be used to calibrate its respective area of the spectrum for the accuracy of the tristimulus values and the chromaticity coordinates. However, this calibration was not performed because of the unavailability of these filters. For this reason, the instrument was instead validated with red, green and blue fibers.

4.3.3c Validation

To validate the instrument, blue, green, and red color fibers were analyzed once per day for two weeks. Each sample was examined in transmittance mode in replicates of five. In total, 150 measurements were obtained for each colored fiber. CIELab values were obtained using the GRAMS/ AI under the same parameter settings. Fibers were photographed only once per analysis and stored in the same folder with its corresponding spectra. These values were stored in the hard drive of the computer and later copied to a personal computer as backup files.

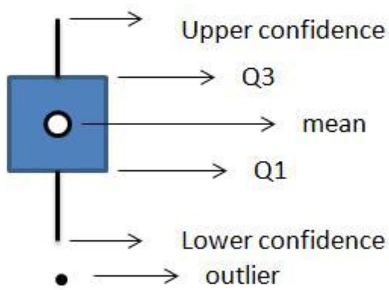
4.4 Statistical Analysis

The first step in any data analysis is to inspect the distribution of the data. To ensure proper analysis, the data was screened to detect missing values, outliers, and departures from assumptions on which the analyses were based.

4.4.1 Descriptive statistics- although there are many descriptive statistics available, only ones of interest were mentioned here: distribution, median, percentiles, quantiles, quartiles and variables. Distribution is the amount (spread) and pattern (shape) of variation, both characterized by the average and typical value (location). Median is the 50th percentile, which conveys information about what a typical value is. It is informative to compare it to the mean, as these two statistics will provide information about the symmetry of the distribution. Percentiles are the division of the total observations into 100 equal parts. Quantiles are the division of the observations into *n* equal parts and is the fraction of the observations that are at or below this division. These cut-points are referred to as quartiles. Q1, Q2 and Q3 correspond to the 25^{th}, 50^{th} and 75^{th} percentiles or .25, .50, and .75 quantiles. Variables are attributes that can be measured and that varies between subject, place or time. When measured, a number is assigned to each of its levels.

4.4.2 Graphical summarization- Two plots were used to help assess and describe the distribution of the data:

4.4.2a Box and whisker plot: is a type of graph showing the distribution of a set of data along a number line. It describes any type of population, regardless of the data's distribution(44). The data is described in five parameters: mean, upper and lower extremes or values and upper and lower quartiles. The mean of the data is plotted as a dot; the box is delimited by quartiles of the upper and lower means and standard deviations, and the whiskers by the extremes of the ninety-five percent confidence interval. Note that the default settings for a typical box plot differ from the settings used in this experiment. With these graphs, outliers are easier to visualize because they are plotted as separate dots. Several box and whisker plots can be plotted simultaneously on the same graph for easier observation of several variables. An example is given below.



4.4.2b Histogram: is a type of bar graph representing the frequency distribution of a data. It was employed because the parameters of a distribution can be estimated from the plotted graph. This graph depends on the width of the bins, or class intervals that are based on how many dividing points there are and where they are made. The height of each bar gives the frequency in its respective interval. The histogram graphically displays the data obtained (x-axis) against the frequency of those values (y-axis).

4.4.3 Assumptions- Three assumptions were made in regards to the data obtained:

4.4.2a Independence: occurs when a random sample, as a subset of the population, is chosen in such a way that any subset of equal size is equally likely to be chosen. Any two observations in a random sample are statistically independent of each other. Since the fibers were randomly chosen from each garment for analysis, the results are then independent from each other.

4.4.2b Homogeneity of variances: variance estimation from two samples is made to infer about the two populations. This assumption states that the groups are similar in essence regardless of the independent variables and that the variances are equal. This is often referred to as homogeneity of variance. Homogeneity of variance exists when H_o: $\sigma_1^2 = \sigma_2^2$. There are several test procedures that can be used to check the equal variance assumption; however, the Levene's test was employed because it is one of the most frequently used.

i. Levene's test: checks whether or not the variances of the groups being analyzed are statistically different. It has the advantage that the samples being drawn from a normal distribution is not assumed. The Levene's test evaluates the deviations around the median in each group, instead of the variances across the group. The larger the deviations in one group in comparison to the others, the greater the spread. Larger spreads increase the difference in variability within the population from which the samples are being drawn. If the results show a value ≤ 0.05, then it can be concluded that the variances are significantly different, and that at least one of the samples in the test has a significantly different variance. When significant differences are observed in group variances, then the Welch test was applied.

I. Welch test: when samples have different standard deviations, there is a greater likelihood that the test will reach incorrect conclusions. The Welch correction is an approximate degree of freedom solution that not only depends on the sample size, but also on the sample variance to assess the significance of the t-statistics computed (45). For the Welch test, two hypotheses were tested:

- H_0: $\mu_1 = \mu_2 \ldots = \mu_k$
- H_A: $\mu_i \neq \mu_j$, for some i, j.

Consider two populations A and B which in this project could be red and green fibers. Assume that we have two independent samples: *Swatch 1* with *50* observations from red, and *swatch 1* with *45* observations from green. The appropriate test statistic is

$$W^*=(\overline{red} - \overline{green} = \sqrt{(\frac{S_{red}{}^2}{50} + \frac{S_{green}{}^2}{45})}$$

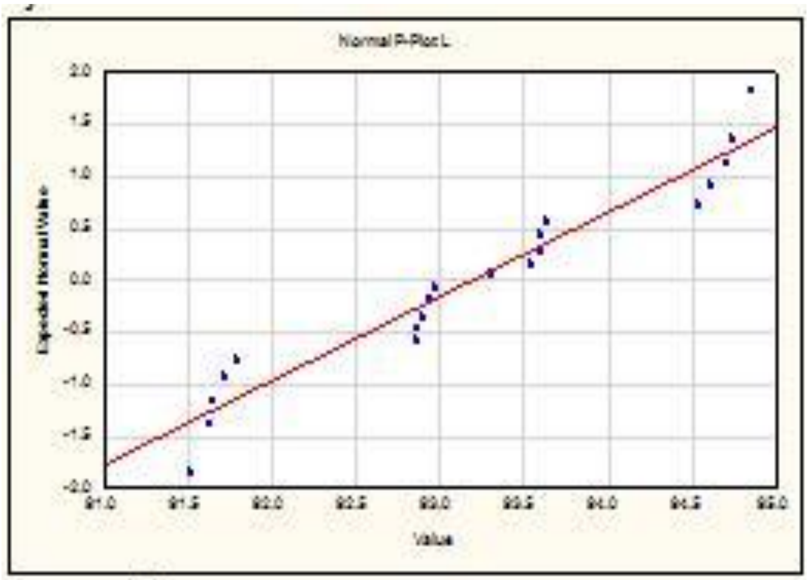
Where W* is approximately t-distributed with F_w degrees of freedom and S^2 is the sample variance of either groups:

$$F_W = \left(\frac{S_{red}}{50}^2 + \frac{S_{green}}{45}^2\right)^2 \Big/ \left(\frac{S_{red}}{50^3 - 50^2}^4 + \frac{S_{green}}{45^3 - 45^2}^4\right) \quad (46)$$

The Welch test for testing equality of the population means compares the statistic W* to the F distribution. The Welch test rejects the null hypothesis if $W^* \geq F_{50-1, 45-1, 1-\alpha}$. If the population means of red fibers in swatch 1 equals that from swatch 1 of the green fibers, (although the standard deviations

<u>4.4.2c Normal Distribution</u>(47)- the pattern for the distribution of a dataset in which the curve is bell-shaped. When the distribution is normal, reliable and valid inference and prediction can be drawn about the population from the subset samples. The normal distribution has two parameters: the mean tells where the central point of the distribution lies, and the standard deviation tells how wide the distribution is spread. To access whether a sample comes from a normal distribution, the graphical approach of the normal quantile plot, plus two statistical tests for normality were employed.

i. Normal Quantile plot: a graphical technique for assessing normality. Each ordered observation is plotted against the value it would be expected to assume if the data came from a standard normal distribution or normal quantile ($\mu = 0$, $\sigma = 1$). The resulting graph is two-dimensional with the property that if the random sample comes from a normal distribution, the plotted points appear to lie in a straight line (48). It is a mapping between the distribution of the data and the ideal distribution. This graph is easy to understand by just examining the plot to check linearity(49). Any non-linear plot would suggest that the data did not come from a normal distribution. An example of this plot is inserted below.



Say for my red fibers, I analyzed four different areas on swatch 1, and for each area five measurements were taken. As these values are plotted, it first can be observed that the values between each groups varies. Also, within each group, the plotted points observed little intra-variability. As the measurements approaches linearity, or that the points fall on the line, suggests that the measurements taken from the swatch comes from a normal distribution.

ii. Kolmogorov- Smirnov (K-S): a test that is often used to test the normality of a distribution. The testing statistic 'd' is the maximum difference between the empirical distribution (an estimation from the data) and the theoretical distribution (a standard normal distribution), to assess if the proportion difference is due to chance alone(50). Previous studies have reported that the K-S test is liable in producing type II errors of not rejecting the null hypothesis when it is indeed false, when the parameters of the distribution are estimated from the same dataset (51-53). The K-S test is appropriate to use when the parameters of the hypothesized distribution is known. In other words, the hypothesized distribution is taken from a normal distribution with known mean and standard deviation. However, if this distribution is unknown, a Lillefors modification of the K-S test must be employed(54). The Lillefors test employs the same statistical method as the K-S test but the critical values are adjusted based on the estimated sample used and not affected by the estimated population parameters(55)**.** The null hypothesis of a normal distribution is rejected at a given significance level when the testing statistic exceeds the critical value.

iii. The Shapiro-Wilk (S-W): a test that is another powerful alternative method used to determine normality because it can be applied against an extensive range of alternative distributions and sample sizes (54-56). It is statistically similar to the Lillefors test. The S-W test is based on the fact that the correlation coefficient of the normal probability is a measure of the strength of the linear relationship between the empirical and normal quantiles (48). The tested statistic 'W' ranges from zero to one, where one is the maximum value that occurs when all the data points on the normal Q plot fall on a straight line. Its correlation coefficient depends upon the sample size, which must fall below the critical value in order to reject the hypothesis of normal distribution. If 'W' is small, the null hypothesis is then rejected.

4.4.2d Interpretation of normality testing -to test normality, two hypotheses were created:

- H_o: $\mu_1 = \mu_2$ (the dataset came from a normal distribution)
- H_1: $\mu_1 \neq \mu_2$ (the dataset did not come from a normal distribution)

To interpret the K-S and S-W test, both methods produce a p-value, which is based on the probability or assumption that the distribution is normal. In forensic science, $\alpha = 0.05$ (95% confidence interval) is frequently cited and was used here (57). This is considered the significant or alpha level. With this confidence, you can be 95% sure that 95% of the time, the calculated data range is included in the true population value, or that the probability of rejecting the hypothesis when the means are really equal, is 0.05.

When the null hypothesis is rejected, this means that the results provided strong evidence against the null hypothesis, and when it is accepted, it means that the results did not provide strong evidence against it. For this purpose, the p-value is reported with the results. A test is said to be statistically significant at that alpha level if the p-value is smaller than alpha. A small p-value provides evidence against the null hypothesis. Furthermore, the null hypothesis is rejected when the p-value is less than or equal to the alpha value.

4.5 Statistical Methods

The statistical method of choice was based on the research questions asked. In this project, comparing color before and after treatment in fibers is the primary concern. For this reason, ANOVA was chosen for such analysis.

Analysis of variance (ANOVA) tests the significant difference between means within a population by actually comparing or analyzing the variances. This significant testing is done by comparing the variance due to the between-group variability (called the mean square effect) with the within-group variability (called the mean square error) by partitioning the total variance into components due to random effects (difference of means within group) and systematic effects (difference of means between groups). The latter component is then tested for statistical significance to conclude the acceptance or rejection of the null hypothesis (58).

The types of factors influencing the different variances are due to the systematic or random effects. Systematic effects are the controlled factors being tested. In this experiment, the controlled factors being investigated are aging and washing. The random effects may arise potentially from different sources within the sample, such as the lack of homogeneity within the fibers themselves or from the inconsistency with dye uptake. However, it is best to consider experiments of three kinds:

1. Those in which the factors affected are systematic (Model I);
2. Those where all the factors are random (Model II);
3. Those where there is a mixture of random and systematic effects (Mixed Model Effect).

By analyzing each experiment under the three models stresses that the appropriate tests in a particular case depends on the experimental conditions (59). If one controlled factor is being examined, such as the factor aging in part 1 of this project, then one-way ANOVA was used. In one-way ANOVA, the variance due to the systematic effect is compared with the variance due to the random effect. In my aging treatment, the variance due to aging is compared to the variance due to any random effect that was not due to aging. The heterogeneity of the fibers or the heterogeneity of the dye uptake along the fiber may produce within-group variability that is significant. Consequently, one-way ANOVA is used to determine if variances occur, and if so, additional statistical test can locate where these variances occur. The statistical test used to compare two such values is called the F-test. If multiple controlled factors are being examined, such as the different detergents used and washings performed in part 2 of this project, then multifactorial ANOVA was used. Once significant results are found in both analysis, post hoc tests were employed (discussed in section 4.5.3).

4.5.1 One-way ANOVA and the F-test

In part A of this analysis, one-way ANOVA was used because only a single factor, aging, was varied. To test the significance of the mean between populations, two hypotheses were created:

- H_o: $\mu_1 = \mu_2 = \mu_3 = \ldots \mu_k$ (no significant mean difference observed between population)

- H_1: at least one μ is different (at least two of the population means are different)

The purpose of ANOVA is to determine whether differences exist between two or more populations. If the population means are equal, it can be concluded that no treatment effect was observed and no variances exist among the groups. If the population means are not equal, and at least one population mean is different, then some treatment effect was observed. However, it does not assume that the entire population mean differs. For example, my fiber was aged at five intervals of 16 hours each, creating five populations. If the mean values do not differ significantly among intervals, it can then be concluded that the aging treatment had no effect on the sample. However, if two of those intervals observe significant mean differences between them, it can then be concluded that the aging treatment affected at least two of the populations, not necessarily all of them.

The F-test, named after the statistician R.A. Fisher, is used to compare the variances due to the effect under investigation with the variance due to chance.

$$F = \frac{\text{Systematic effect variance (between groups)}}{\text{Random effect variance (within groups)}}$$

In ANOVA, the F value has to reach a certain value to attain statistical significance and this value is dictated by the degrees of freedom (df). There are always two df values with a F-distribution: df_1 is associated with the numerator and df_2 is associated with the denominator, of the F ratio. Thus, to attain significance, the F value must be greater than 1.

Consider a single factor which has *p* different levels and suppose that *n* observations have been made at each level, totaling $N=np$. Let the results be represented by x_{ij} $(i=1\ldots p, j=1\ldots n)$. Note that the first subscript in x_{ij} specifies the category group or level and the second subscript specifies the observations. Assuming for any given level, *n* observations have a mean, which combines the overall mean plus any variation found in the levels chosen. Then the mathematical formula for ANOVA would resemble:

$$x_{ij} = \mu + F_j + \varepsilon_{ij}$$

Where:

- x_{ij} is the single response from factor *j*,
- μ is the overall mean,
- F_j is the effect due to the contribution of *j*, and
- ε_{ij} is the variation of the results within a particular factor level (random effects).

ANOVA assumes that observations at a fixed factor level are normally distributed about the mean value $(\mu + F_j)$ with a common variance $\sigma^{2.}$ The variance estimate is calculated using the sum of squares. The variability of *n* sample measurements about their mean can be measured using the sum of squared deviations from the grand mean: $S = \sum_{ij} (x_{ij} - x_{..})^2$

- The sum of square deviations variability between levels: $S_1 = n \sum_{ij} (x_{i.} - x_{..})^2$
    - The sum of square deviations variability within each level: $S_2 = \sum_{ij} (x_{ij} - x_{i.})^2$

Table 7: ANOVA Summary Table

Source of estimate	Sums of squares (SS)	Degrees of freedom (df)	Mean squares (MS)	F-statistics

Between levels Within levels	$S_1 = n \sum_{ij} (x_{i\cdot} - x_{\cdot\cdot})^2$ $S_2 = \sum_{ij} (x_{ij} - x_{i\cdot})^2$	$p - 1$ $N - p$	$M_1 = \frac{S_1}{(p - 1)}$ $M_2 = \frac{S_2}{(N - p)}$	$F_{calc} = \frac{S_1^2}{S_2^2}$
Total	$S = \sum_{ij} (x_{ij} - x_{\cdot\cdot})^2$	$N - 1$		

Note: The notation of a dot in place of a suffix means that that particular suffix has been averaged out over its appropriate observations.

The table is broken down into five items: the SS, df, and MS for the between and within group levels, the f-value and the p-value. The p-value, although not included in the table above, indicates the likelihood that a given result could have occurred by chance alone. It basically tests the level of significance.

For example, the red swatch was aged for five intervals equating to six populations (with the untreated source). For each interval, three samples areas were analyzed and three fibers within each sample area were analyzed. The ANOVA summary table would look similar to this:

Source of estimate	Sums of squares (SS)	Degrees of freedom (df)	Mean squares (MS)	F-statistics
Between levels Within levels	$S_1 = 3 \sum_{6,54} (x_{6\cdot} - x_{\cdot\cdot})^2$ $S_2 = \sum_{6,54} (x_{6,54} - x_{6\cdot})^2$	$6 - 1$ $15 - 6$	$M_1 = \frac{S_1}{(6 - 1)}$ $M_2 = \frac{S_2}{(15 - 6)}$	$F_{calc} = \frac{S_1^2}{S_2^2}$
Total	$S = \sum_{6,54} (x_{6,54} - x_{\cdot\cdot})^2$	$15 - 1$		

Note: The notation of a dot in place of a suffix means that that particular suffix has been averaged out over its appropriate observations.

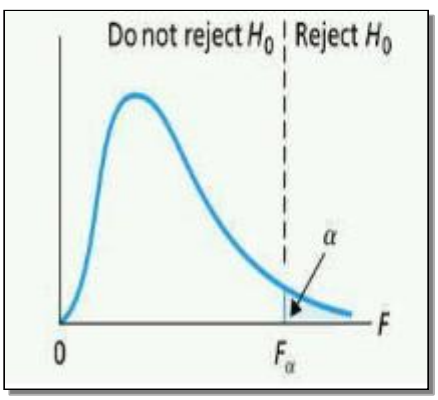
<u>4.5.1a Interpretation of the ANOVA F- test and p-values</u>

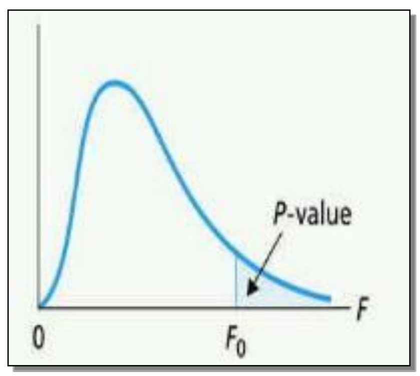
In any given test, the question of "How do we determine if something is significantly different" usually arises. In order to compute if the means are equal in the population from which the samples are taken, the hypothesis test called the ANOVA F-test was performed. The significance test carried out with one-way ANOVA is compared with the F-distribution such that if the hypothesis is incorrect, the statistic will tend to be greater than one. This upper tail of the f-distribution is the criteria for rejecting the null hypothesis.

There are two approaches that can be used to interpret the results for the F test. Using the same example above:

Critical Value Approach **or** **P-Value Approach**

Critical Value Approach	P-Value Approach
The critical value is F_α with df= (6-1, 15-6)	The critical value is F_α with df= (6-1, 15-6)





If F-statistics ≥ F-critical at α= 0.05, reject H_o; otherwise, do not reject H_o.

If $P \leq \alpha$, reject H_o, otherwise do not reject H_o.

Since most software packages compute the F and p-value with the ANOVA tests, the decision was made to compare the level of significance with the p-value. The p-value provides information about how unusual the calculated F statistic is if the population means are the same.

When the p-value is less than the critical or alpha value, the null hypothesis of equal means is rejected. When this is true, the effect is said to be significant.

The results obtained from the one-way ANOVA are presented in four headings: Descriptives, Test of Homogeneity of Variances, the ANOVA table, Post Hoc Comparisons. Each will be discussed separately below.

The first table provides descriptive statistics for each factor. For aging, the number of scores, mean, standard deviation, standard error, upper and lower bounds of the 95% confidence interval and the minimum and maximum values for each aged interval.

The second table supplies the results of the Levene's test. The results are nonsignificant when the p-value is < 0.05, showing that there is no evidence to support that the variances of the six factors of aging are different from one another.

The third table is the standard ANOVA table observed in Table 7. An additional column with the appropriate p-values is included.

Two tables are produced for the post hoc test because two different post hoc tests were applied. These tables show the results of the multiple pair-wise comparisons among the six intervals, representing the five aging intervals and the standard.

4.5.2 Multifactorial Analysis of Variance

In part B of the analysis, multifactorial ANOVA was used because the number of independent factors was greater than one. It is basically an extension of the one-way ANOVA, used to simultaneously analyze the effects of two or more factors on a dependent variable. This extension accounts for the possible interactions and the effects associated with them. In this method, the difference among several group means is analyzed by partitioning the total variance from the dependent variable into effects due to: each of the factors (called main effects), interactions between the factors, and the error variance (60).

From the data obtained in part B, 2^2 experimental designs, a two way ANOVA was done to establish the presence or absence of significant differences in the treatment of the fibers considering the detergent and the washings performed. Thus, in this two-way ANOVA, the main effects of the detergents used and the washed-aged cycles are analyzed separately to determine of either factor affected the outcome of the results, or if any interaction between both groups are significant.

4.5.2a Interpretation of multifactorial ANOVA

The results obtained from the multifactorial ANOVA are presented in five general headings: Univariate Analysis of Variance, Estimated Marginal Means, Post Hoc Tests, Homogeneous Subsets, and Profile Plots. Each section will be discussed separately.

The univariate analysis of variance is broken down into two separate analyses tables: the 'between-subjects factors' and the 'test of between-subjects effects'. The first table of the output, labeled Between-Subjects Factors, summarizes the factors and shows how the factors were labeled and how many scores are in each group. The second table, labeled Test of Between-Subjects Effects, is a standard ANOVA table with a few additions. This addition lists the sources of variation that are analyzed including the main and interaction effects of the factors. The main body of the table corresponds to Table 7. However, a final column is added to the table along with the F value, listing the significance of F (Sig).

Under the heading Estimated Marginal Means, the number of tables are produced based on the total amount of factors. In each responding table, the means, standard error and 95% confidence interval is recorded.

Under the Post Hoc Test general heading, a table is generated with the results of the multiple pair-wise comparisons among the independent variables or groups. This result was based on the post hoc test chosen for analysis, which is discussed in section 4.5.3. Column 1 lists the representing group (listed as I) and its pair-wise counterpart (listed as J). This pair is compared to determine any significant difference at the 0.05 level. Columns 2-6 list various descriptive statistics: the mean difference between ‘I’ and ‘J’, the standard error, the significance, and the lower and upper 95% confidence interval.

A final table is generated under the Homogeneous Subsets heading. Similarly to the previous table, it shows the result of the post hoc test chosen but in slightly different ways. Based on the multiple pair-wise comparisons, the independent groups are divided into homogeneous subsets. Homogeneous subsets are the factors grouped together based on significance; factors that are not significantly different from another are grouped into one homogeneous subset, and factors that are significant are grouped in separate subsets.

Lastly, under the Profile Plot heading, an interaction graph is generated. A profile plot is a type of line plot in which each point indicates the estimated mean of the dependent variable at one level of a factor. It shows whether the estimated means are increasing or decreasing across levels. The interaction effects between groups are significant to note, and through the observation of the graph, the interpretation is sometimes obvious. For two or more factors, if the lines are parallel, this indicates that there is no interaction between the factors. If the lines are nonparallel and intercross, this indicates that an interaction occurs between the factors, even if this interaction is not significant.

4.5.3 Post Hoc Comparisons

The post hoc (meaning ‘after the fact’ or ‘after the data collection’) comparisons were employed when the ANOVA F was found significant. ANOVA does not provide specific insights into what caused the null hypothesis to be rejected, thus by using a post hoc procedure, the researcher attempts to investigate the data to find out which of the possible non-null scenarios are most likely to be true. It is basically conducted once the outcome of the F-test in ANOVA yields a significant F to help in understanding why the ANOVA H_o was rejected. The F-value in ANOVA can be significant for different reasons; for instance, there could be different possible mean patterns. For this reason the post hoc analysis helps the researcher in their effort to understand the true pattern of the population means.

The post hoc procedures will function correctly if three underlying conditions holds true for the population and samples involved in the study. These conditions being met are the same as those for the one-way ANOVA F-test: independence, normality and homogeneity of variance. Although this test is generally robust to the normality assumption, they might be affected if the equal variance assumption does not hold true, especially when the sample sizes are very dissimilar.

In the post hoc procedure, two hypotheses were analyzed:

- H_0 = the observed difference in group means is entirely accounted for by inherent variability

- H_A = the observed difference in group means is not due to inherent variability alone, it is the result of experimental intervention or treatment (61)

Again, the accepted criterion for significance was set to 0.05, such that the probability of a Type 1 error must be less than 0.05. With this probability, there is a 5% chance or less that the difference in the data is caused by inherent variability. Two post hoc tests were applied with ANOVA based on the results of the Levene's test of equal or unequal sample variances.

4.5.3a The Tukey Honest Significant Difference (HSD) test

Although a wide array of statistical procedures are employed for post hoc comparison, the most frequently used for color analysis is the Tukey HSD test, and thus employed in this project (62-66). As long as the assumption for homogeneity of variance is met, this test can be used. This test has also been adapted to unequal sample sizes, and uses the harmonic mean as its *n* value (67).

The Tukey test permits complete pair-wise or pair-by-pair comparisons for all possible combinations and their contrasts. The term 'pair-wise' simply means that groups are being compared two at a time. Fifteen pair-wise comparisons were made for the analysis of the aged samples:

$H_{o:\ \mu 0} = \mu_{16}$;	$H_{o:\ \mu 16} = \mu_{32}$;	$H_{o:\ \mu 32} = \mu_{48}$;	$H_{o:\ \mu 48} = \mu_{64}$;	$H_{o:\ \mu 64} = \mu_{80}$;
$H_{o:\ \mu 0} = \mu_{32}$;	$H_{o:\ \mu 16} = \mu_{48}$;	$H_{o:\ \mu 32} = \mu_{64}$;	$H_{o:\ \mu 48} = \mu_{80}$;	
$H_{o:\ \mu 0} = \mu_{48}$;	$H_{o:\ \mu 16} = \mu_{64}$;	$H_{o:\ \mu 32} = \mu_{80}$;		
$H_{o:\ \mu 0} = \mu_{64}$;	$H_{o:\ \mu 16} = \mu_{80}$;			
$H_{o:\ \mu 0} = \mu_{80}$;				

The null hypothesis of each pair states that the means of each group are the same. If this hypothesis is true, then there is no reason to believe that the variances of the two groups are different from each other. The Tukey test is more conservative than liberal in the fact that conservative procedures provide more control over Type I errors at the expense of higher Type II error risks.

i. Presentation and Interpretation of Tukey HSD test

Two tables are produced for the Tukey test. The first table is presented in a triangular table of mean differences. In the table, each numerical entry is simply the difference between the means of the group that label the row and column where the number is located. Each of these mean differences is evaluated to observe if the value is greater than what would be expected by chance alone. At a significant level of 0.05, the p-value is compared to ‘α’ to make the determination of whether this pair is significantly different. Marked differences are significant when $p \leq \alpha$, where the null hypothesis of the two groups being different is rejected. These significant differences, illustrated in bold, reveal where they are found among the comparing groups.

The second table, labeled as Homogeneous Subsets, presents the results of the Tukey pair-wise comparison differently. In this table, the groups are divided into homogeneous subsets. All the insignificant groups are placed together in one subset. When the values are significant, i.e. when the means are significantly different, those groups are then placed in its individual subset. For instance, if the mean values for the untreated fibers (only) present a significant value from the remaining pair-wise groups, then this group will be placed separately in subset 1 while the other groups are placed together in subset 2. This differentiation in subsets accounts for the difference observed between the untreated standard and the treated fibers.

4.5.3b Games-Howell (G-H) test

The Games-Howell test is another pair-wise comparison method that is employed when the data being analyzed does not meet the homogeneity of variance assumption (68). It can also be used when the total number of observation varies between groups. This test defines critical value of each pair-wise comparison by determining the variances and the number of observation in each comparing group.

I. Presentation and Interpretation of the G-H test

The results of the G-H test is presented in table format: Column 1 lists the dependent variable; Column 2 list the pair-wise groups; Column 3 lists the mean difference between the pair-wise groups; Column 4 list the standard error associated with these groups; Column 5 list the significant p-values, and, Columns 6 and 7 lists the lower and upper bounds of the confidence interval.

The interpretation of the G-H test is consistent with the TUKEY test. Marked differences are significant when $p \leq \alpha$, where the null hypothesis of the two groups being different is rejected. These significant differences, illustrated in bold, reveal where they are found among the comparing groups.

4.6 Statistical Software Used

4.6.1 Matrix Laboratory (Matlab)

Matrix Laboratory or Matlab is a numerical computation and simulation tool where its strength is observed in matrix manipulation (69). It has been used as a program that implements many multivariate statistics and is preferred to use during this research because of its simplicity (70, 71). The data analysis was conducted using Excel spreadsheets and graphed using Matlab (version 7.12.0.635). Matlab was used to create 3-D bubble plots for the validation results.

The validation results were transferred into an Excel file which were then organized and imported into Matlab. Three-dimensional bubble plots were graphed based on the 3-D bubble script downloads available on Matlab's website. In total, 12 plots were created of the validation results. The first plot contained all 150 measurements obtained from the blue, green and red fibers over the 10 day period. The second and third plots contained the average measurements of each day for all three colors, as well as the 95% confidence interval, respectively. Plots four to six are the breakdown of all 150 measurements plotted separately for each color. Plots seven to nine are the averaged measurements per day plotted separately for each color. And finally, plots ten to twelve are the 95% confidence interval of the averaged measurements of plots seven to nine.

4.6.2 STATISTICA

STATISTICA (version 10) software was used to compute one-way ANOVA of the aged samples, and the results were produced in tabulated form with the F and p-values provided. This software was chosen for its accessibility. Mean plots were graphed of the overall dependent variables Lab. Three additional plots were also graphed for each dependent variable grouped by the independent variable 'hours'. These interaction plots were used for observation of the mean varying between the hours aged. If the results produced were significant, i.e. if the alpha value exceeded the p-value, then the post hoc test, Tukey HSD, was applied. Statistica software is limited in calculating the H-W test. The Games-Howell test was calculated using another statistical software discussed below.

The data obtained from aging was transferred into Excel, organized and imported into Statistica. To compute one-way ANOVA, from the dialog box, the following factors were chosen: dependent variables ‘Lab’; categorical factors ‘Hours, Swatch, Sample Area and Fibers’ and the between effects were all levels for each factor; the summary table of descriptive statistics; the Welch and Levene’s test; the Tukey post hoc test; and, the interaction plots of each categorical factor against the Lab variables.

4.6.3 Statistical Procedure and Service Solutions (SPSS)

SPSS is one of the oldest and most popular statistics computer programs that provide statistical analysis of data. It was employed in this project to evaluate the washed-aged samples using multifactorial ANOVA. This software is able to calculate both post hoc comparison tests. This software was also used to calculate the Games-Howell post hoc test for the aged samples that was not available on STATISTICA software. IBM® SPSS® Statistics software version 20 was used.

The results obtained were transferred into Excel, appropriately organized before imported into SPSS. For the multifactorial analysis, the Univariate General Liner Model was chosen because one dependent factor was being analyzed at a time. In this case, variables Lab were analyzed separately. In the Univariate dialog box, the following factors were chosen: the dependent variable was ‘L, a or b’; the fixed factors were ‘bleached, non-bleached and washing’; five plots were created for the interaction effects: ‘Sample Area * Swatch’, ‘Sample Area * Bleached’, ‘Washing * Bleached’, ‘Washing * Swatch’, ‘Washing * Sample Area’; and as an options, Display Means for the main effects of: ‘Sample Area’, ‘Swatch’, ‘Bleached’. ‘Washing’, as well as the interaction effects listed above.

For the one-way ANOVA, the post hoc tests were also included in the results.

5. Project Approach

This project was separated into two parts: Part 1 focused on understanding the degradation of color in fibers by direct exposure to UV light and Part 2 focused on understanding the degradation of color change in fibers after being laundered and aged. This project attempted to replicate the washing and aging affect in a fiber multiple times to determine if precise color comparisons between the treated and unaltered fiber is possible.

5.1 Original Project Plan

In the original plan, cotton textiles were to be used and compared. Five of the eight colors of interest to be analyzed, blue, gray and yellow were not used in this project. In addition, two other detergent brands were to be used: All, and Gain. However, with limited accessibility to the MSP instrument, and for efficiency purposes, only one type of textiles, five colors, and one type of detergent brand was chosen.

5.2 Budget

The resources necessary for this project was limited to the materials needed: the detergents, and garments. The costs of the Tide detergents were six dollars each and the price of the polyester garments price range from three to seven dollars. In total, the budget for this project was approximately ninety dollars.

5.3 Limitations and implications

The purpose of this project was to determine if a fiber can be accurately compared to its source after being laundered and aged for a two week duration period. To age the fiber without including unknown variables, UV-lamp was used to maintain control of the experiment.

Part one for the research tends to focus on the visual and objective expectation of aged fibers under UV exposure. The aim of the experiment will only focus on the color change as the fibers are aged and not on the components that generate the color in the dye. The UV-Vis MSP generated spectral data and computed the chromaticity coordinates to provide a means of comparing the overall color of the sample. It has been published that MSP gives no information about the individual dye component with some exceptions (72). Therefore, no attempt was made to reference the mechanism of dye degradation in the fibers.

Part two of the project created a true representation of actual washing of samples using washers found in a Laundromat. It is expected that the samples might be contaminated when washed simultaneously with other clothing. Therefore the samples were first evaluated under the stereoscope to decipher the relevant fibers from any external source. This process was performed after drying and before analysis with the MSP.

6. Results and Discussion

6.1 Calibration

6.1.1a Wavelength Calibration

Holymium and Didyium Oxide filters were used to measure the wavelength accuracy and spectral resolution. Table 7 below shows an example of the calibration results: Column 1 refers to the target absorbance band of the filters, column 2 refers to the measured absorbance band of the instrument, column 3 refers to the deviation of the measured value from the true value; and Column 4 refers to the acceptance or rejection of this difference. As long as the measured results are within the uncertainty values, the wavelength calibration will be accurate within the established limits.

Table 8: Example of the Wavelength Calibration Printout

Wavelength Accuracy

Holmium Oxide

Filename: Holmium-2011y02m07d15h11m54s.spc
Memo: ScanTime=522.26ms:NS=50:Obj=36X (2/7/2011 3:11:54 PM)

NIST Peak	MSP Value	Difference	Passed?
360.2	359.4	0.8	Yes
418.5	416.8	1.7	Yes
445.8	445.5	0.3	Yes
536.0	535.4	0.6	Yes
637.2	636.5	0.7	Yes

Didymium

Filename: Didy-2011y02m07d15h12m39s.spc
Memo: ScanTime=522.26ms:NS=50:Obj=36X (2/7/2011 3:12:39 PM)

NIST Peak	MSP Value	Difference	Passed?
441.2	440.9	0.3	Yes
513.5	512.9	0.6	Yes
684.4	683.5	0.9	Yes
806.8	806.2	0.6	Yes

Note the unit of measurement is in absorbance.

6.1.1b Photometric Calibration

The OD filters were used to calculate and control the absolute absorbance accuracy of the instrument by checking the spectral linearity of the system. Table 8 below shows an example of the calibration results. In addition to the results obtained in the calibration table, another column is added which specifies the wavelength range.

Spectral linearity is observed in the absorption values. As the OD filter values increase, the absorption values increase. For example, the absorbance value at 400nm increases from 0.108 (OD 0.1), to 0.529 (OD 0.05), to 0.987 (OD 1.0). At low absorption values, more light is being transmitted because the absorbance matter is quite small. In contrast, at high absorption values, lesser light is being transmitted because the absorbance matter is greater. Thus the spectral linearity of the system is observed through the use of these filters.

Table 9: Example of the Photometric Calibration Printout

Photometric Accuracy

ND 0.1

Filename: ND01-2011y02m07d15h13m40s.spc
Memo: ScanTime=522.26ms:NS=50:Obj=36X (2/7/2011 3:13:40 PM)

Wavelength	NIST	MSP	Difference	Passed?
400	0.106	0.108	-0.002	Yes
500	0.095	0.091	0.004	Yes
635	0.085	0.083	0.002	Yes

ND 0.5

Filename: ND05-2011y02m07d15h14m22s.spc
Memo: ScanTime=522.26ms:NS=50:Obj=36X (2/7/2011 3:14:22 PM)

Wavelength	NIST	MSP	Difference	Passed?
400	0.524	0.529	-0.005	Yes
500	0.510	0.499	0.011	Yes
635	0.474	0.466	0.008	Yes

ND 1.0

Filename: ND10-2011y02m07d15h15m04s.spc
Memo: ScanTime=522.26ms:NS=50:Obj=36X (2/7/2011 3:15:04 PM)

Wavelength	NIST	MSP	Difference	Passed?
400	0.977	0.987	-0.010	Yes
500	1.008	1.008	-0.000	Yes
635	1.009	1.016	-0.007	Yes

Note that the unit of measurement is absorbance.

6.2 Method validation

The MSP was validated to verify the proper functioning of the instrument by checking the accuracy and precision of wavelength and photometric measurements. Suggested by Craic Technologies, 50 measurements of each red, green and blue sample were analyzed over a two week period. These colors were analyzed once per day for two weeks and their CIELab coordinates were recorded. Five replicates per analysis were performed to examine variability.

Twelve charts were plotted for the validation results. These charts included the overall measurements of all the samples analyzed over the 10-day period. It also included the average measurements taken per day and the 95% confidence interval for each of these average measurements. Different magnification was used to enlarge the data points for visualization purposes. There were some instances where the uncertainty points were larger than others and blocked the visibility of the smaller uncertainties; when this occurred, the magnification was decreased to a value of 1, so that visibility was observed for all the points.

6.2.1 Discrimination between colors

Figure 16: Validation Results of Blue, Green and Red Fibers

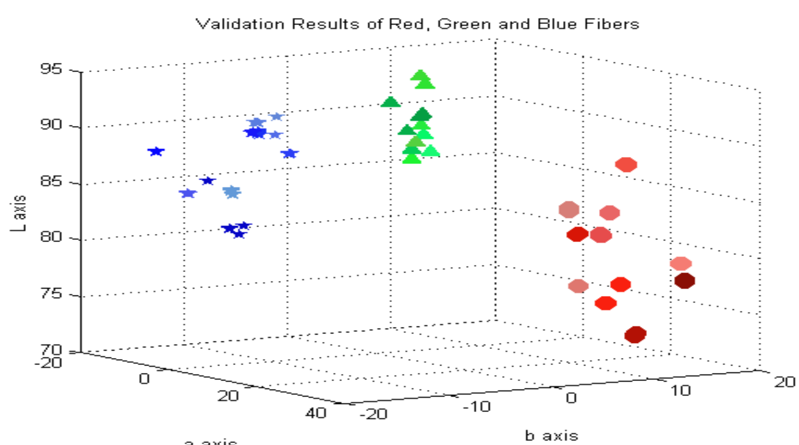


Figure 16 encompasses the total measurements collected in the 10-day validation experiment. Fifty measurements were plotted for each color fiber, with a total of 150 data points on this graph. However, some overlap each other. This was better observed as the data was plotted separately for each color.

Figure 17 below is the averaged 50 measurements for each color over the 10-days studies. Inter-variability can be readily observed here. As the fibers are analyzed daily, the Lab values vary. This may be due to the variability within the fiber itself, but more so, to the fact that the same fiber was not analyzed daily as the selection day-to-day was randomly done. Another possible explanation is the variability within the instrument from day-to-day.

Figure 17: Average Validation Results of Blue, Green and Red Fibers

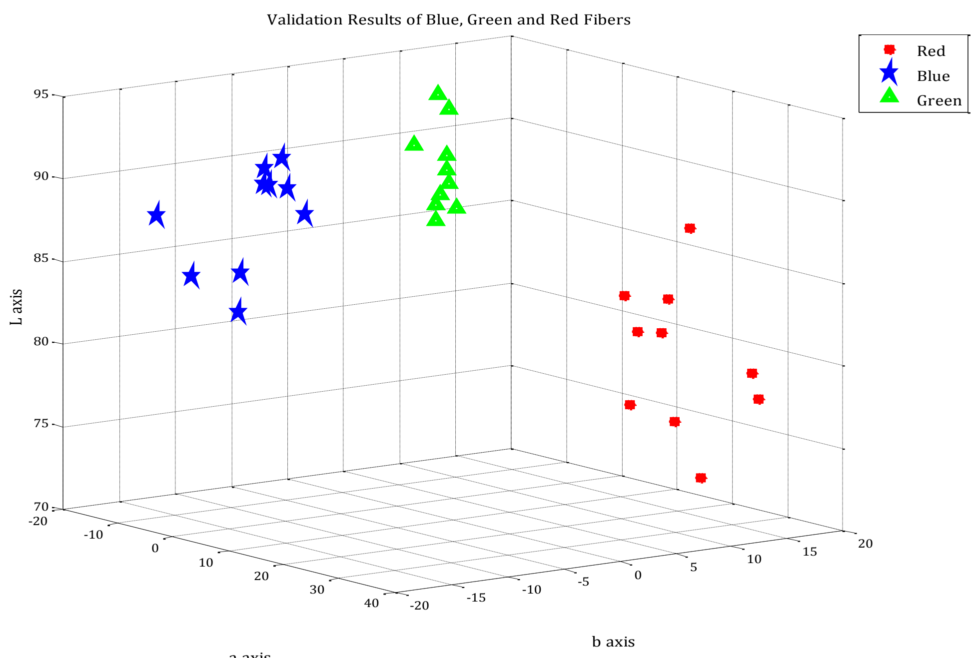
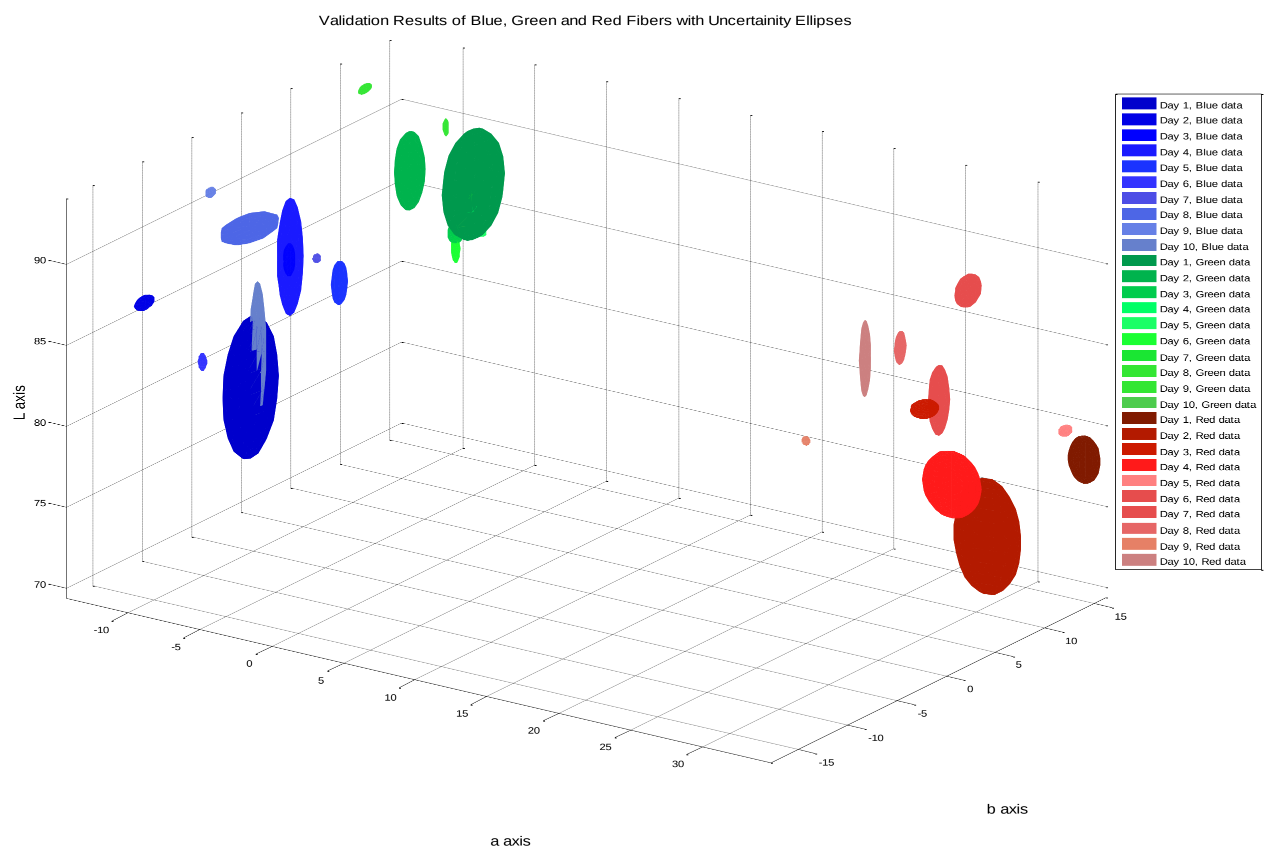


Figure 18 is the individual 95% uncertainty values plotted for the average measurements taken over the 10-day studies. The 95% CI defines the elliptical shape for each sample on the L-, a- and b-axes with n=5. It can observed that the blue, green and red fibers are clearly separated.

Although red is clearly differentiated from blue and green, it also observes larger volumes of deviation as seen in the larger ellipses. Inter-variation is also observed greatest in the red fibers. Blue and green fibers are very closely observed although a separation can be seen. Blue fibers also observes a great amount of deviation among the 10-day study. Inter-variation is also observed here. With green fibers, which also observes some deviations, the inter-variation of the sample among the 10-day studies is minimal. Infact, the values in some days overlap others.

Figure 18: Average Validation Results of Blue, Green and Red Fibers with Uncertainty Ellipses



The variation that occurs for each sample is observed at specific coordinates. For the blue fibers, the greatest amount of variation seems to occur at the b-axis. This result is plausible because the results would most likely affect the yellow to blue region since the color of the fiber is blue.

Notice this contrast with the red and green fibers. In both instances, both fibers observed the greatest amount of variation at the a-axis. For the green fibers, the ‘a’ values moves towards the green region as all of the values were negative, whereas for the red fibers, the ‘a’ values move towards the red region as all the values were positive. It can be further concluded that variation would exist greater in the coordinate at which the color is represented by, and must be taken into account for the remainder of this study.

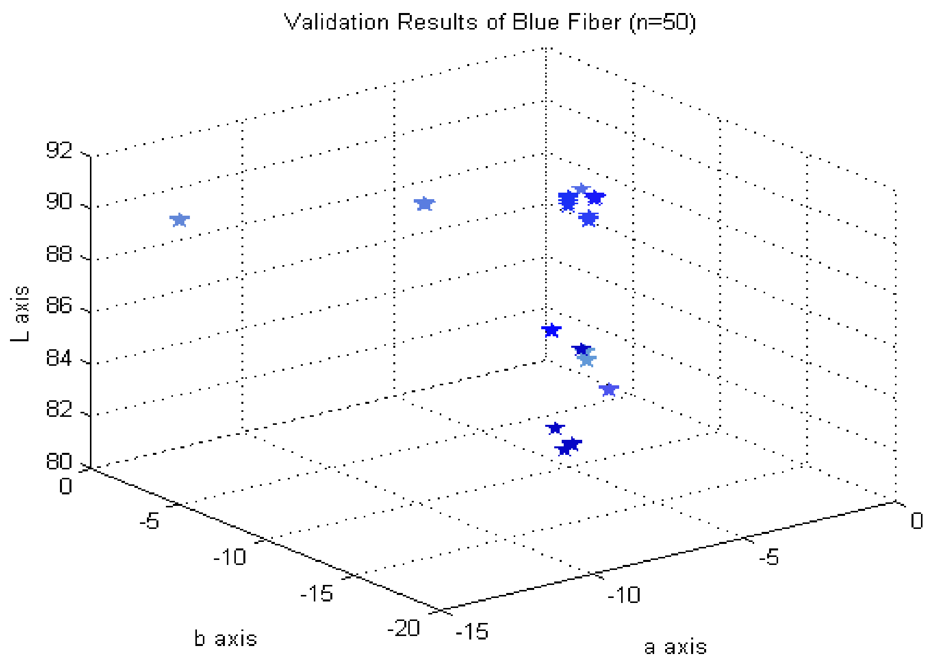
6.2.2 Precision

The precision of the validation results was investigated through its repeatability. Precision is the closeness of agreement (degree of scatter) between a series of measurements obtained from multiple sampling of the same sample under a set condition. The precision of the instrument was investigated through repeatability. Repeatability is the precision estimate obtained from replicate measurements in a single batch of analysis made during a single setting by one analyst. For two weeks, the samples were analyzed by the same analyst. The 95% confidence interval was computed to describe the uncertainty associated with the samples. These results were discussed separately by color.

6.2.2a Blue Fibers

Of the 50 total observations, the degree of scatter in the Lab values minimal. Two clusters of values are observed in the graph below. Within one cluster, the deviation seems to be very minimal, however with the second cluster; this degree of variation is greater. Also, two potential outliers were present. It is unclear as to what may have caused these values to differ from the normal values, however, observing the averaged and uncertainty values may shed light onto this matter.

Figure 19: Validation Results of Blue Fibers



Figures 20 and 21 show the average measurements of the 10-day studies. The difference between these two figures is the markers used to illustrate the actual days. This was done for accurate interpretation. Everything else remains consistent between the graphs. As the data is averaged, fluctuations can be observed between days. However, with the averaging, the groupings of the two clusters are better observed. Cluster 1 is comprised of days 1, 2, 6 and 10, and cluster 2 is comprised of days 3-5, and 7. The clusters themselves are random with the days they are comprised of. The samples were randomly measured daily, so the same fiber was not analyzed. This might account for the random variability observed between the days. Again, two outliers can be seen here which represents days 8 and 9, respectively. Unless this pattern is observed for the other samples, then the variability could have been caused by the instrument's configuration.

Figure 20: Averaged Validation Results of Blue Fibers

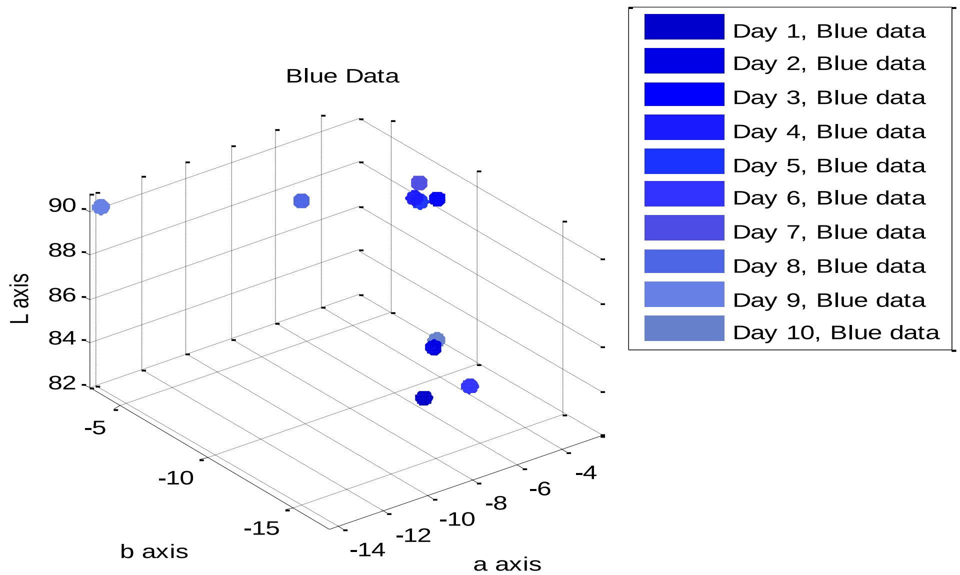


Figure 21: Averaged Validation Results of Blue Fibers, specified in difference markers

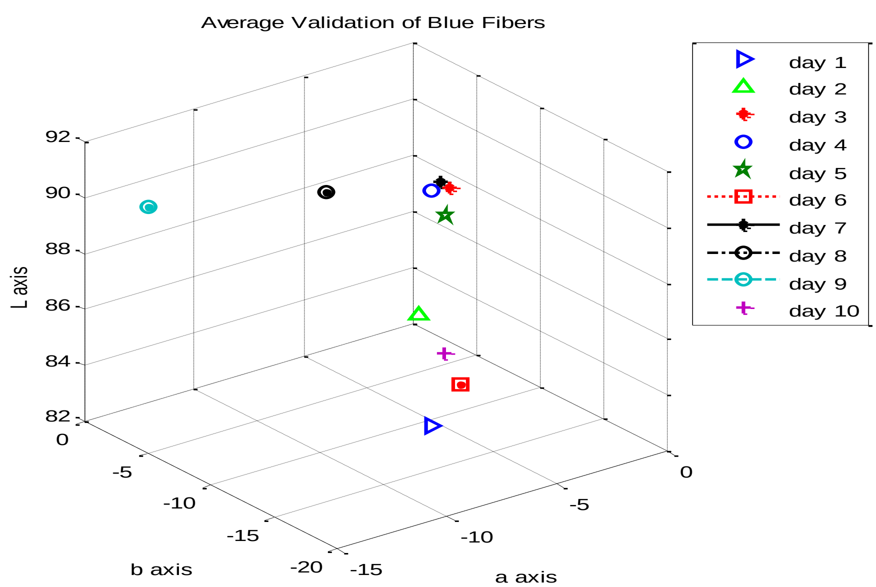
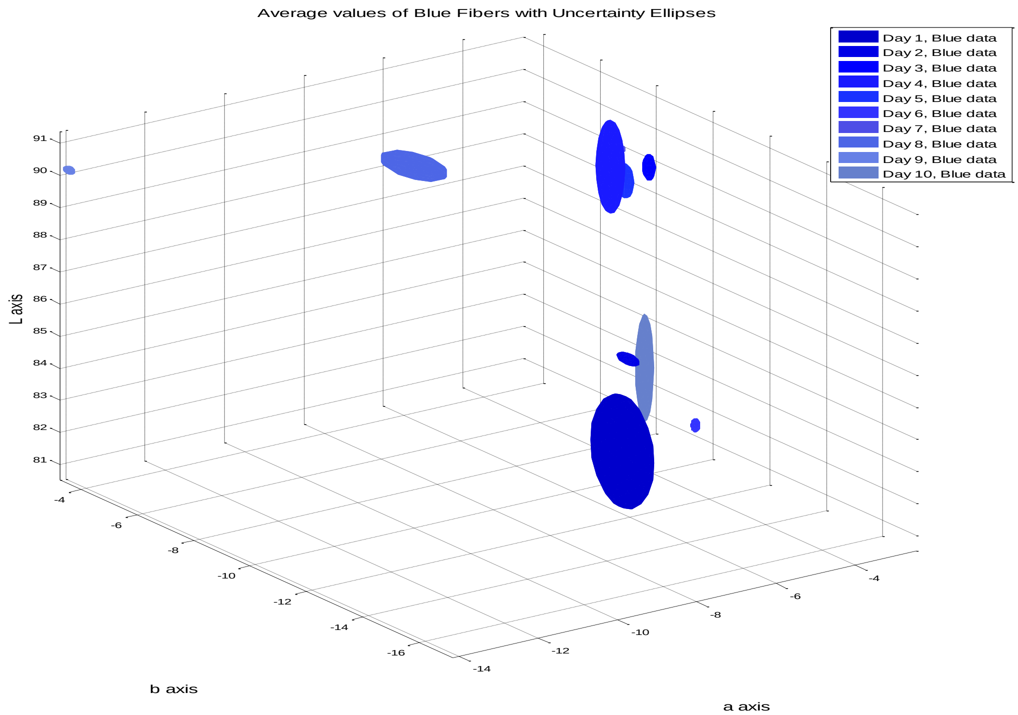


Figure 22: Average Validation Results of Blue Fibers with Uncertainty Ellipses

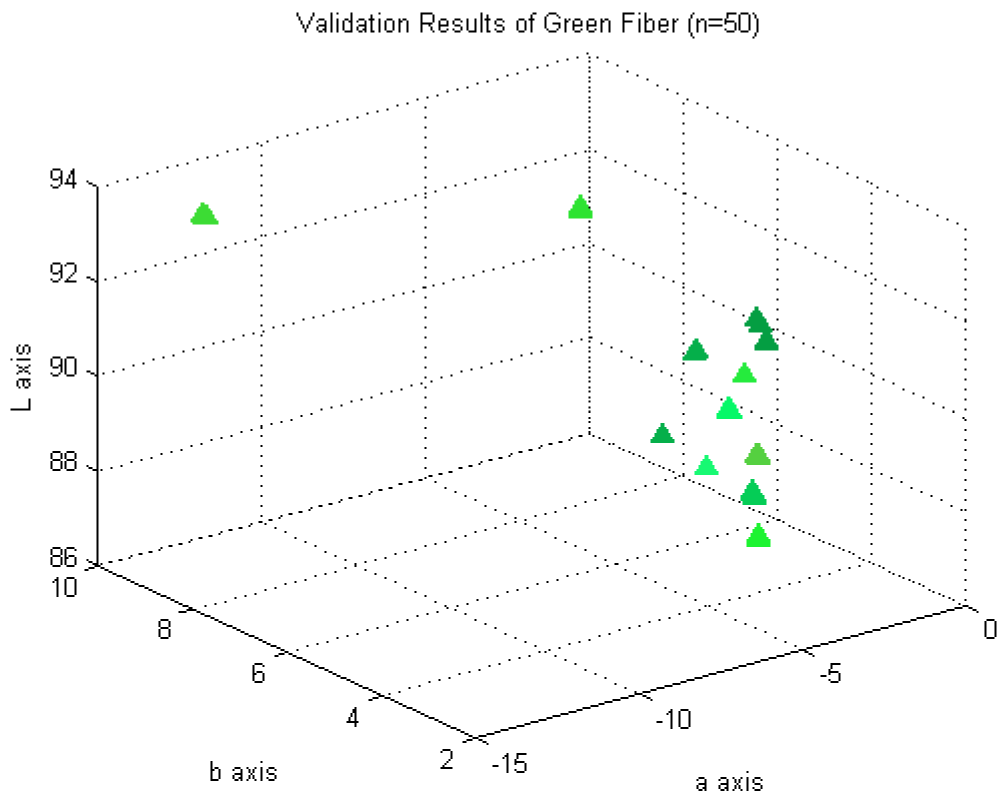


Between the 10-day repeatability studies, most of the days can be separated from each other. And even within days, the variations in the Lab values are observed by the elliptical shapes where the larger the shapes respond to greater amounts of variations. The greatest amounts of deviations are observed at days 1 and 2. So between the measurements on both days, the greatest amount of deviations occurs here.

6.2.2b Green Fibers

Similarly the precision of the repeatability study was investigated for the green fibers. Figure 23 below is the overall 50 measurements obtained during the 10-day repeatability study.

Figure 23: Validation Results of Green Fibers over the 10-days period



Over the 10-day period, the degree of scatter in the Lab values was more conjugated than the blue fibers. One large cluster of values is observed in the graph above. Within the cluster, the deviation from day to day measurements can be observed indicating inter-sample variation. The intra-sample variation cannot be clearly observed as most of the individual points for each data measurements are summed as one large data point. The day-to-day intra-sample variation is very minimal here. Also, two outliers are present. It is unclear at this point if the instrument or the fiber themselves contribute to the variation observed.

Figure 24: Average Validation Results of 50 Measurements Green Fibers

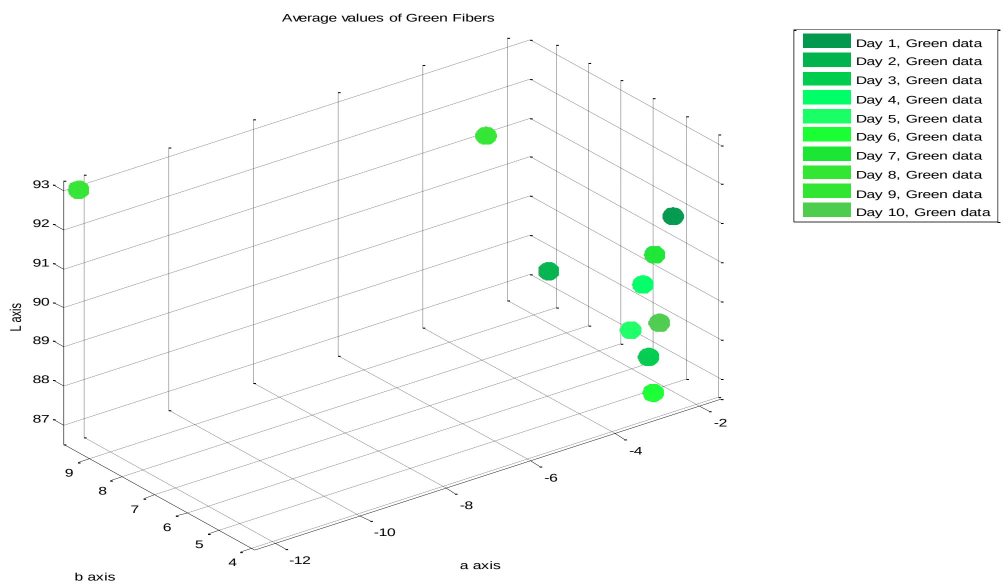
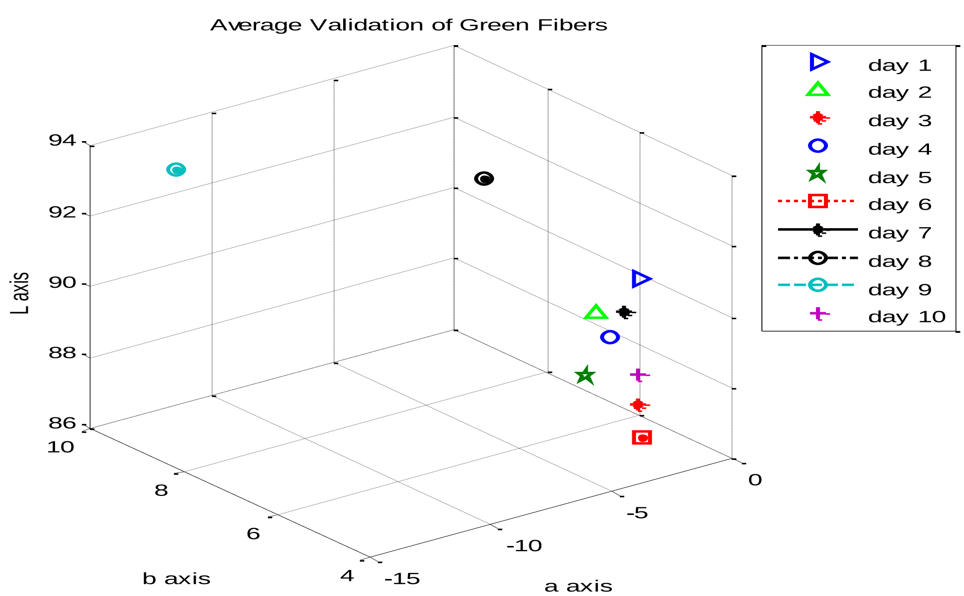


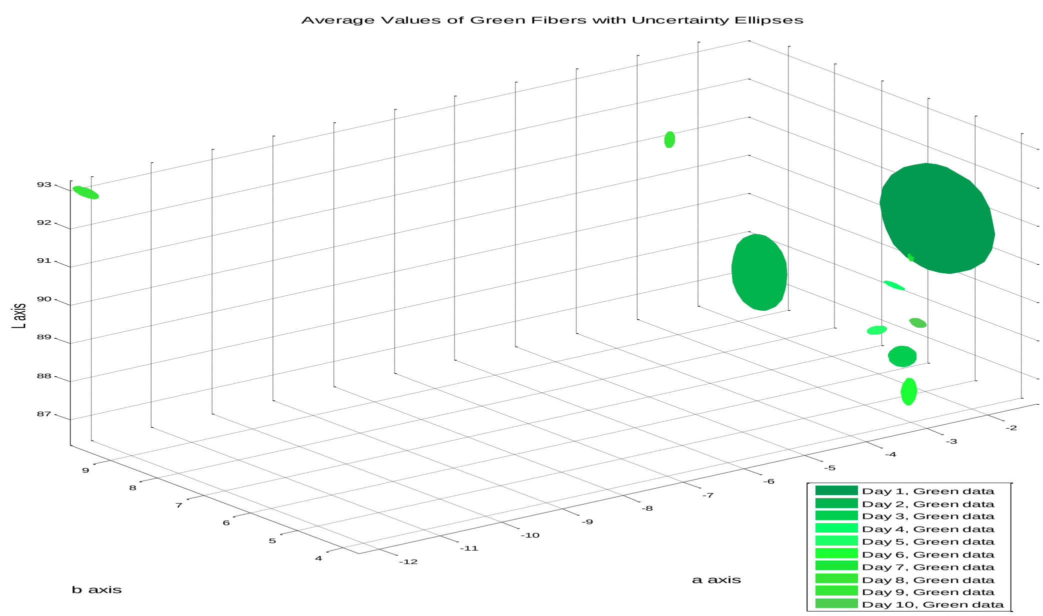
Figure 25: Average Validation Results of Green Fibers specified in difference markers



Figures 24 and 25 are the average measurements of the 10-day studies for the green fibers. As the data are averaged, fluctuations can be observed between days. However, with the averaging, one large cluster and two outliers are observed. This cluster is comprised of days 1-7 9, and 10.

The samples were randomly measured daily, so the same fiber was not analyzed twice. This might account for the random variability observed between the days. Again, two outliers can be seen here which represents days 8 and 9, respectively. This pattern was also observed for the blue fibers, may have been caused by any fluctuations within the instrument's configuration.

Figure 26: Average Validation Results of 50 Measurements Green Fibers with Uncertainty



In Figure 26, two large CI can be observed which corresponds to days 1 and 2. So between the measurements on both days, the greatest amount of deviations occurs here. Over the 10-day period, the degree of scatter in the Lab values was more conjugated than for the blue or green fibers. One large cluster of values was observed in the graph above. Within the cluster, the deviation from day to day measurements can be observed indicating inter-sample variation. The day-to-day intra-sample variation is very minimal here. Also, two outliers are present. This figure shows the variation of the instrument when five simultaneous measurements are taken for each sample. The instrument's variability and the fiber's inter-variability are observed within and among the day-to-day measurements, respectively. The instrument's variability, although observed, is not substantial in some analyses but is in others. This would suggest that the variation also occurs within the fibers themselves.

6.2.2c Red Fibers

Figure 27: Validation Results of Red Fibers

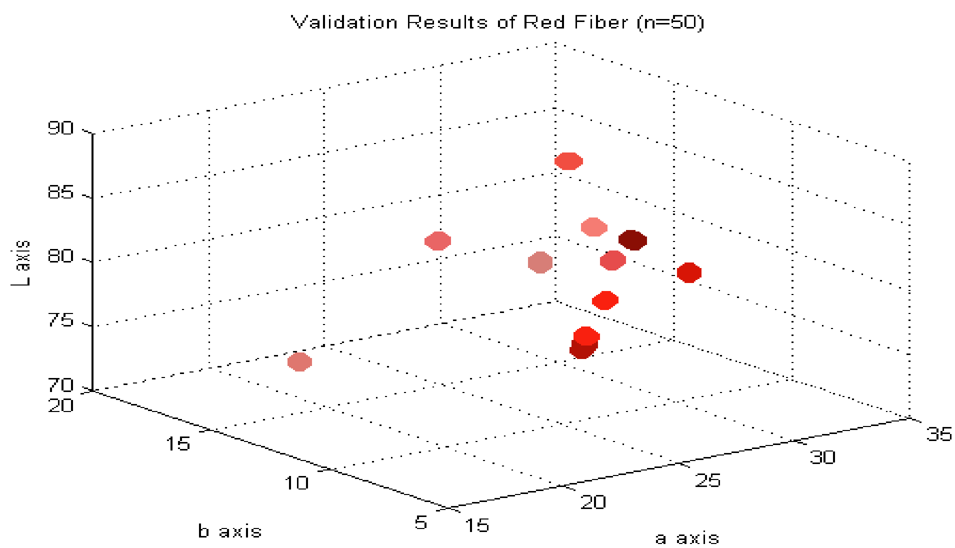


Figure 28: Average Validation Results of Red Fibers

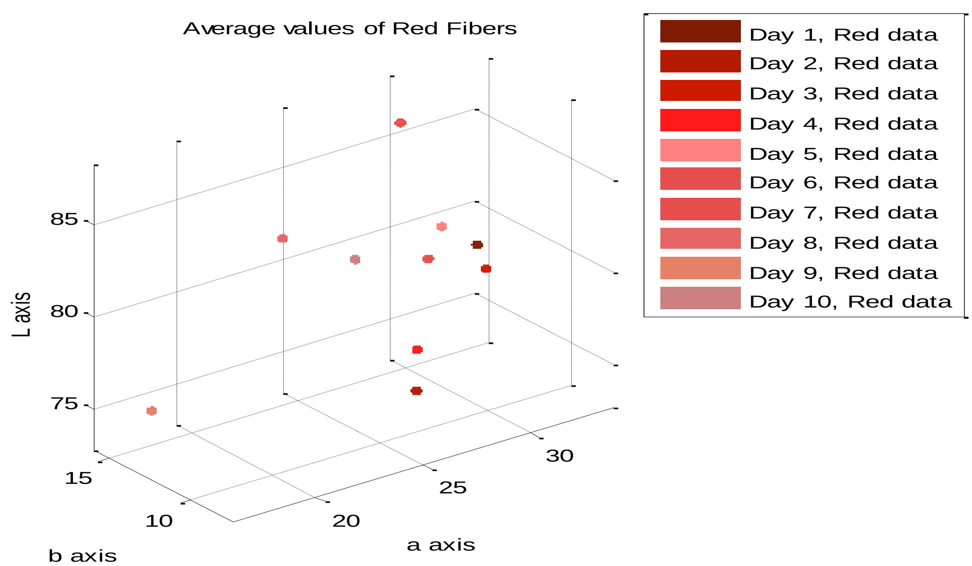
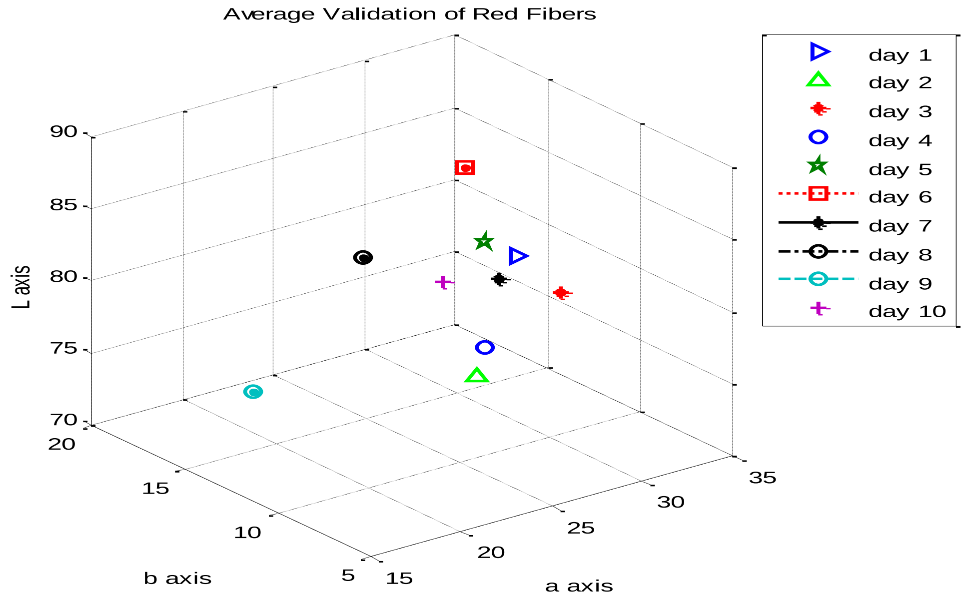


Figure 29: Average Validation Results of Red Fibers specified in different markers

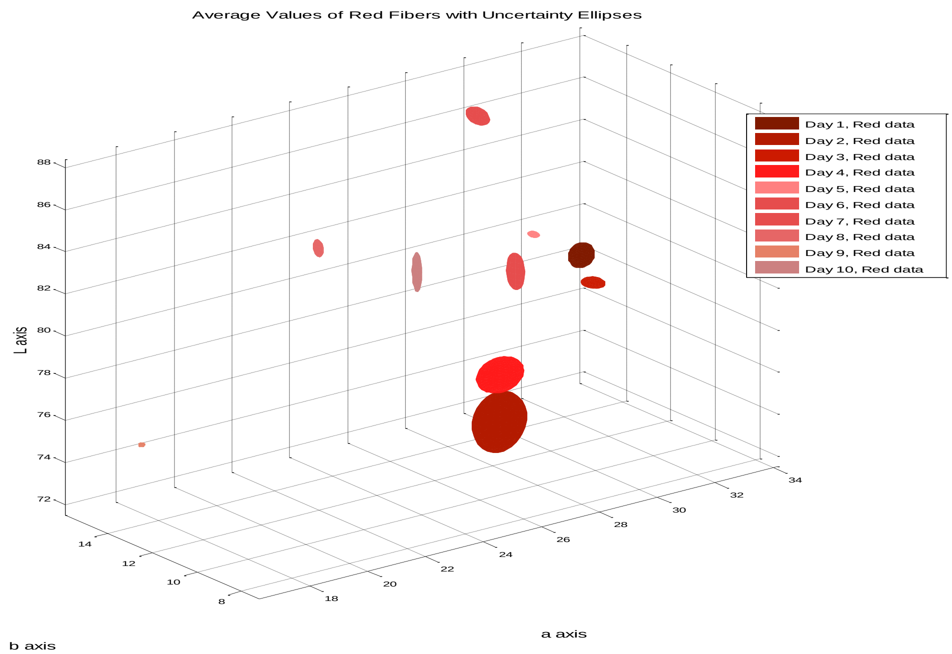


Upon further analysis, the deviations between the 10-day studies observe to be minimal as the data points are observed to be more clustered together. It is also clearly perceived that two outliers are present at days 8 and 9. Day 6 can be considered as a potential outlier, but it also seems to be associated with the clustered data. Since both days were considered as outliers for all three colors, it can be concluded that the variations presents in these days were contributed from the instrument's configuration.

For figure 30, unlike the other colors, the elliptical shapes did not observe as much variation. These ellipses are smaller than those observed in the blue and green fibers. Although, the inter-variation was greatest in this sample, the intra-variation was smallest.

It can be concluded that inter-variation and intra-variation of fibers are prominent in fibers, independent of the color being analyzed. The variation within the instrument can readily be observed, which negatively affected the results at days 8 and 9. Otherwise, this variation is present, but not significant in altering the outcome of the results.

Figure 30: Average Validation Results of Red Fibers specified in different markers



6.3 Analysis of Results

The objective was to determine how color is affected through aging and washing. The questions addressed were:

- Is there intra-variability within the fiber that would significantly affect the analytical result from the treatments? In other words, does it matter where on the fiber the sample is being analyzed?
- Is there inter-variability among the fibers that would significantly affect the analytical results from the treatment?

- Is each colored garment affected differently?
- Do the treated fibers change such that Lab values can be used to analyze these results?

To answer these questions, two hypotheses were created:

- H_o: $\mu_1 = \mu_2$ (no significant color changes were observed between fibers of the same garment)
- H_1: $\mu_1 \neq \mu_2$ (significant color changes were observed between fibers of the same garment)

6.3.1 Analysis of Aged Results- Part one of this study focused on understanding the degradation of fibers through artificial UV aging.

6.3.1a Normality Testing of Aged Samples

For normal distribution determination, a chart producing a histogram, a normal plot, and a box and whisker plot was graphed. Two statistical tests, K-S Lillefors and S-W test were employed for each variable to check the normality of each distribution. The data analysis was broken down into three separate steps because of the type of analysis that was performed on the samples. These steps were:

1) Normal distribution was determined for the overall Lab variables;
2) Normal distribution was determined based on the sample area and hours for each L, a, and b value;

3) Normal distribution was determined based on the sample area, hours and fiber of each L, a, and b variable. (Since it is impossible to analyze the same fiber aged at different time intervals, the analyzed fibers varied between hours aged).

Two hypotheses were created to test the distribution of the sample:

- H_o: $\mu_1 = \mu_2$ (sample comes from a population that is normally distributed)
- H_1: $\mu_1 \neq \mu_2$ (sample does not originate from a population that is normally distributed)

Using a significance level of 0.05, a p-value less than or equal to the significance level would result in the rejection of the null hypothesis.

1) Normal distribution of all groups against variables Lab.

The distributions for all samples were not normal. Therefore, the null hypothesis of normal distribution was rejected. Table 10 below provides the summary results taken from the S-W test.

Table 10: Summary p-values from the S-W test

P-value from the Shapiro-Wilk 'W' test				
Grouping	**Ref name**	**L**	**a**	**b**
all groups	DPMP	0.00332	0.00057	0.000
	GMP	0.00927	0.00000	0.000
	OSDP	0.00646	0.00000	0.000
	PMCL	0.000	0.002	0.000
	PMJX	0.006	0.000	0.000
	PMP	0.004	0.011	0.000
	RMP	0.000	0.000	0.000

At this level of interaction, it is understandable that normal distribution might not be observed on the overall sample as the inter-variability across a garment may vary greatly. With large samples, minor deviations from the normal may be flagged as very significant. A subset of the population was also tested for normality.

2) Normal distribution of 'Hours' and 'Sample Area' against variables Lab.

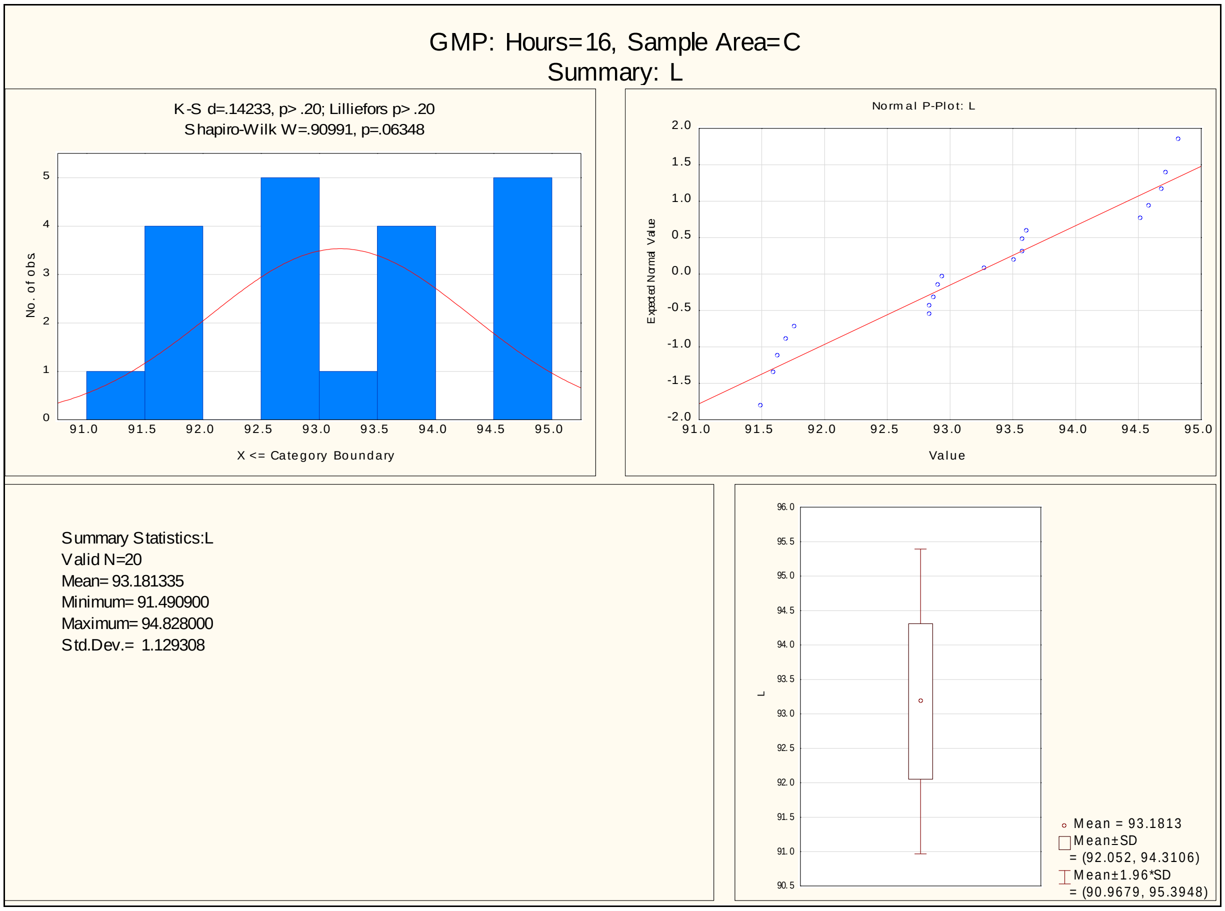
Three charts producing histogram, normal plot and box and whisker plot were graphed for each CIE Lab variable grouped by the sample areas A, B and C, at each hour interval. In total, 54 charts were plotted for each reference sample.

The p-values calculated from reference samples DPMP, PMCL, PMP, PMJX and RMP were all below the significant value and thus, the hypothesis of normal distribution was rejected. The summary results of the p-values taken from the S-W test can be found in Section 2 of the appendix. Only samples GMP and OSDP were found to have some data normally distributed. These samples are discussed separately below.

i. GMP

Only one measured dataset was observed to be normally distributed and is presented below. The histogram has numerous peaks and lacks the pleasant normal bell-shape curve. However, upon observing the S-W p-value, the value at $p = 0.06348$ is only slightly larger than 0.05. There is evidence that supports the null hypothesis of normal distribution. Note that as the p-value approaches 1, linearity and normality is better achieved.

Figure 31: Normal Distribution of Sample GMP

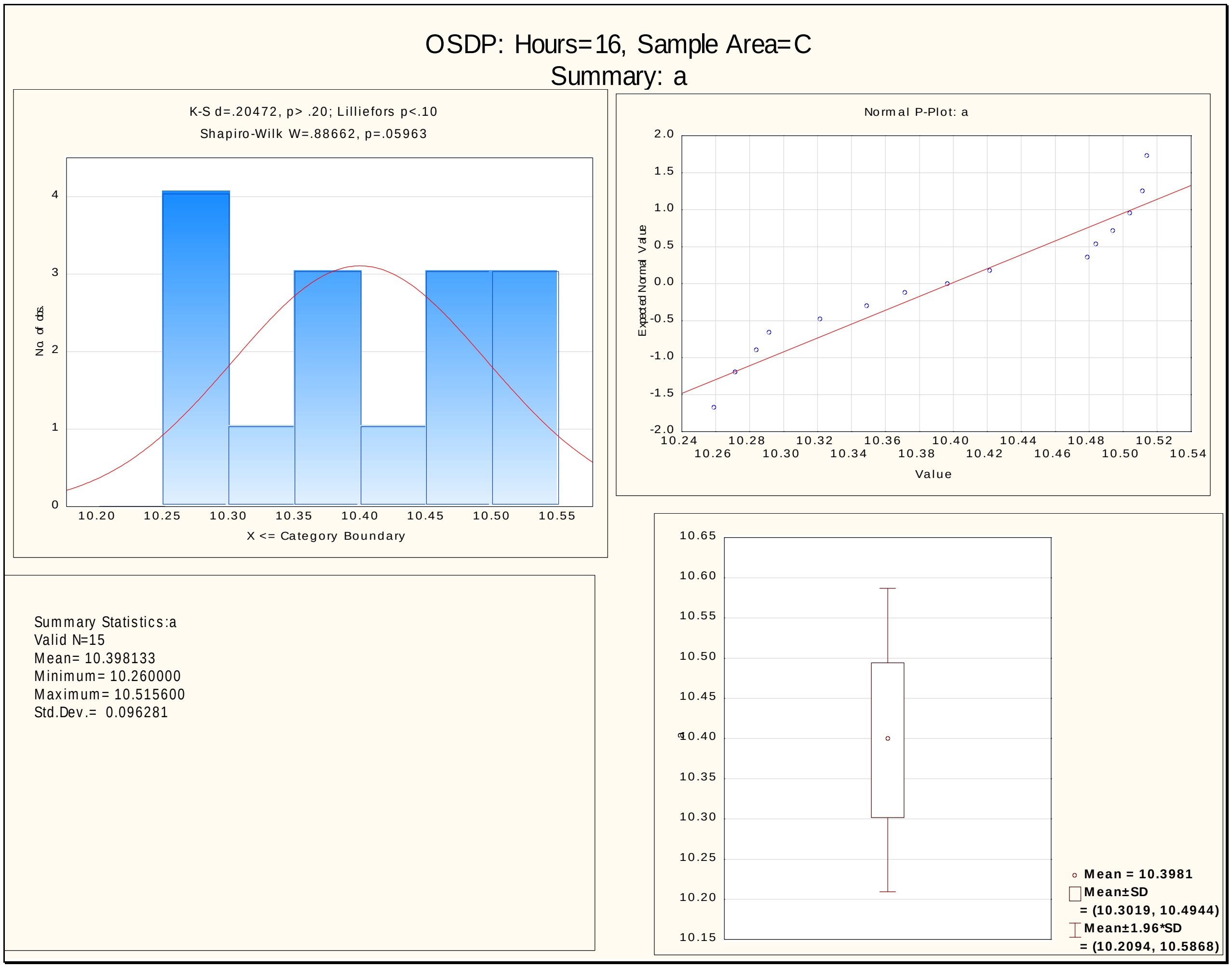


At 16 hours of aging, at sample area C, variable 'L' was observed to be normally distributed. Yet, normal distribution was not observed for the remainder of the data. No explanation or assumption can be inferred with regards to this random observation.

ii. OSDP

Three normally distributed datasets were observed in this sample: at 0 hours (untreated), at sample area A variable 'b'; and again at both 16 and 32 hours, at sample area C, variable 'a'. Only these three datasets observed a normal distribution at the p-values calculated at the given significant level. With such a small report of normality, again no inference can be suggested based on the outcome of these results.

Figure 32: Normal Distribution of Sample OSDP



Sample Area is a subset of the population taken from the swatch. As the levels of sampling become more concentrated, inter-variability decreases and intra-variability increases. For instance, if fibers are analyzed randomly about the swatch, the inter-variability can be observed better. As the subset of the population becomes more concentrated, i.e., as the analysis is only performed on a smaller area, the inter-variability will decrease. Finally, if a single fiber is analyzed continually at different locations, inter-variability is not observed, but the intra-variability will increase. Observing the sample area of the garment might not truly represent a subset of the population because of the intra-variability of the fiber. The analysis was further broken down to observe individual fibers from each garment.

3) Normal distribution of 'Hours', 'Sample Area' and 'Fiber' against variables Lab.

Three charts producing a histogram, normal plot and box and whisker plot were plotted for each Lab variable, grouped by hours, sample area and fiber. Nine different fibers were analyzed per sample area for every hour aged, totaling 54 different fibers. The result of the normal distribution test was tabulated in Section 2 of the appendix.

Normal distributions were observed for all samples but not for all data measurements. At this discrete level of sampling, normal distribution should be expected because the sample set taken from a larger population (in this case, the sample area) should have a smaller variance and standard deviation than from the larger population. However, small discrepancies were still present. For certain measurements, normal distribution was rejected when the analysis of the fiber was performed at two locations on that fiber. However, this was not always the case. Also, some variables observed normal distribution while others did not. For example, in reference sample DPMP at 48 hours, sample area A at fiber 29, variable 'a' was not observed to be normally distributed while the 'L' and 'b' variables were normally distributed. Such irregularities were observed throughout the reference samples.

It can be estimated that most of the fibers come from a normally distributed sample although variation within the fibers exist and sometimes affect this result.

6.3.1b One-way ANOVA of Aged Results

One-way ANOVA analysis was performed on the samples that were aged during the experiment. The questions addressed in this part of the analysis were:

1. Are there significant changes observed in the aging process?

    a. If so, what are these changes and where do they occur?

To answer these questions, two hypotheses were created:

- H_o: $\mu_1 = \mu_2 = \mu_3 = \ldots \mu_k$ (no mean differences were observed between populations);
- H_1: at least one μ is different (at least two of the population means were different).

I. Descriptive Statistics

The first table from the ANOVA output provides descriptive statistics for the dependent variables 'Lab' for each sample. They are presented in table format in 10 columns: Column 1 lists the name of the dependent variable; Column 2 lists the independent variable; Column 3 lists the number of observations; Column 4 to 6 list the mean, the standard deviation, and the standard error; Column 7 and 8 list the upper and lower confidence intervals; and Columns 9 and 10 list the minimum and maximum observation values. Table 11 below shows a descriptive statistics for sample DPMP. See Section 3 in appendix for the remaining values.

Table 11: Descriptive Statistics for Sample DPMP

DPMP	Hours	N	Means	Std. Dev	Std. Err.	95% Confidence Interval for Means Lower Bound	Upper bound	Minimum	Maximum
L	0	45	84.484	3.922	0.585	83.306	85.663	77.915	89.022
	16	60	86.446	3.638	0.470	85.506	87.386	82.267	94.640
	32	60	83.659	2.694	0.348	82.963	84.355	77.552	86.551
	48	60	83.798	3.064	0.396	83.006	84.589	78.376	88.713
	64	60	86.303	3.465	0.447	85.408	87.198	81.939	94.845
	80	60	83.305	3.815	0.493	82.319	84.290	76.581	90.204
	All Grps	**345**	**84.674**	**3.647**	**0.196**	**84.288**	**85.060**	**76.581**	**94.845**
a	0	45	26.830	2.344	0.349	26.126	27.534	23.068	30.920
	16	60	26.928	2.826	0.365	26.198	27.658	21.818	31.669
	32	60	25.791	4.281	0.553	24.685	26.897	19.549	35.793
	48	60	25.035	3.333	0.430	24.174	25.896	21.321	33.077
	64	60	26.935	3.556	0.459	26.016	27.853	21.023	32.374
	80	60	25.384	2.577	0.333	24.719	26.050	20.792	30.484
	All Grps	**345**	**26.121**	**3.323**	**0.179**	**25.769**	**26.473**	**19.549**	**35.793**
b	0	45	7.307	2.610	0.389	6.523	8.091	0.762	9.900
	16	60	8.467	1.692	0.218	8.030	8.904	5.518	11.350
	32	60	7.599	1.656	0.214	7.172	8.027	4.866	10.948
	48	60	7.161	1.827	0.236	6.689	7.633	4.716	10.067
	64	60	8.070	2.132	0.275	7.519	8.620	4.561	11.151
	80	60	7.652	1.471	0.190	7.271	8.032	5.234	9.894
	All Grps	**345**	**7.727**	**1.938**	**0.104**	**7.522**	**7.932**	**0.762**	**11.350**

II. The Levene's test for Homogeneity of Variance

To check the assumption that variances of each reference sample is equal, i.e., not significantly different, Levene's test was employed. This test is not sensitive to departures from normality (73). In order to check this assumption, two hypotheses were created:

- H_o: $\sigma_1^2 = \sigma_2^2 = \sigma_3^2 = \ldots \sigma_k^2$ (no differences in variance were observed between groups);
- H_1: at least one σ_k^2 is different (at least two of the group variances were different).

Based on the results from the Levene's test, the null hypothesis was rejected for all the samples except samples PMP and RMP. The remaining reference samples produced significant results at all three variables (Section 4 in the appendix). Sample PMP and RMP did not produce significant results at variables 'b', and 'L', respectively.

Table 12: PMP Results from Levene's Test

	Levene Test of Homogeneity of Variances (PMP spreadsheet) Marked effects are significant at p < .05000							
Variable	SS Effect	df Effect	MS Effect	SS Error	df Error	MS Error	F	p
L	402.9	5	80.58	1518.4	339	4.479	17.991	0.000
a	27.29	5	5.46	178.2	339	0.526	10.381	0.000
b	26.51	5	5.30	1098.0	339	3.239	1.637	0.150

Note: Significance are written in red and marked in bold.

The result is not significant at variable 'b', as the significance is far greater than 0.05. Therefore, there is no reason to assume that the variance of this variable in this sample is not different.

Table 13: RMP Results from Levene's Test

	Levene Test of Homogeneity of Variances (RMP spreadsheet) Marked effects are significant at p < .05000							
Variable	SS Effect	df Effect	MS Effect	SS Error	df Error	MS Error	F	p
L	70.43	5	14.09	2384.8	339	7.035	2.002	0.078
a	580.82	5	116.16	2349.8	339	6.931	16.759	0.000
b	404.48	5	80.90	1310.7	339	3.866	20.923	0.000

Note: Significance are written in red and marked in bold.

The result is not significant at variable 'L', as the significance is greater than 0.05. It can then be assumed, that the variance at this variable is not different across the data.

III. One-way ANOVA for Aged Samples

To test the significant difference of means between populations using one-way ANOVA, the data analysis was broken down into three separate steps to account for the independent or grouping variables. These steps were:

1) ANOVA was performed on variables Lab grouped by variable ‘Hours’;
2) ANOVA was performed on variables Lab grouped by ‘Sample Area’;
3) ANOVA was performed on variables Lab grouped by ‘Fibers’.

One table and four graphs were plotted for each color sample. The table comprised of the computed results from the ANOVA calculation. Based on these results, a plot of mean and confidence interval was graphed was as summary plot that included all three dependent variables. Three additional mean plots were graphed separately for each dependent variable, and the calculated F- and p-values were recorded on its respective graph.

1) ANOVA was performed on variables Lab grouped by ‘Hours’

Based on the ANOVA calculations, there was strong evidence (at p=0.05, or the 5% level) that the means differ significantly from one another. Of the samples analyzed, all but PMJX calculated significant p-values to reject the null hypothesis. The mean values between groups were substantial in proving that there were differences greater than those that would occur by random chances alone. The ‘L’ value in sample PMJX was not be significantly different among the hours aged. The F-value below, yet close 1, signifies that the within-group error was much greater than the between-group effect. However, variables ‘a’ and ‘b’ produced different outcome. Based on the calculated value in variable ‘a’, the probability of obtaining an F-value greater than the calculated value 10.70831 when the population means are really equal, is 0.00, interpreted as 0.01. It can be concluded that the aging treatment affected the outcome of the results.

Table 14: ANOVA results of Lab variables grouped by 'Hours'

Grouped by Hours								
DPMP	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	569.71	5	113.94	4006.62	339	11.819	9.641	0.000
a	211.27	5	42.25	3587.82	339	10.584	3.992	0.002
b	68.42	5	13.68	1223.05	339	3.608	3.793	0.002
GMP	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	467.35	5	93.47	6871.38	339	20.270	4.611	0.000
a	12.13	5	2.43	271.79	339	0.802	3.025	0.011
b	59.06	5	11.81	1636.50	339	4.827	2.447	0.034
OSDP	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	319.39	5	63.88	6404.05	339	18.891	3.381	0.005
a	60.05	5	12.01	904.65	339	2.669	4.500	0.001
b	1084.60	5	216.92	7931.01	339	23.395	9.272	0.000
PMCL	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	584.50	5	116.90	7208.86	339	21.265	5.497	0.000
a	11.06	5	2.21	177.70	339	0.524	4.220	0.001
b	34.09	5	6.82	508.53	339	1.500	4.545	0.001
PMJX	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	88.77	5	17.75	6060.02	339	17.876	0.993	0.422
a	22.01	5	4.40	139.34	339	0.411	10.708	0.000
b	144.62	5	28.92	505.76	339	1.492	19.387	0.000
PMP	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	6011.57	53	113.43	1166.09	291	4.007	28.306	0.000
a	659.30	53	12.44	104.98	291	0.361	34.481	0.000
b	3149.89	53	59.43	370.70	291	1.274	46.654	0.000
RMP	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	355.70	5	71.14	5259.36	339	15.514	4.585	0.000
a	317.16	5	63.43	6965.90	339	20.548	3.087	0.010
b	304.24	5	60.85	4095.89	339	12.082	5.036	0.000

Note: Significances are marked in bold italics.

The ANOVA table listed below was computed using the SPSS software. This is a key table because it shows whether the overall F-ratio for ANOVA is significant.

Table 15: ANOVA Output for Sample DPMP

ANOVA: DPMP						
		Sum of Squares	df	Mean Square	F	Sig.
L	Between Groups	569.71	5	113.94	9.641	.000
	Within Groups	4006.6	339	11.819		
	Total	4576.3	344			
a	Between Groups	211.27	5	42.253	3.992	.002
	Within Groups	3587.8	339	10.584		
	Total	3799.1	344			
b	Between Groups	68.42	5	13.684	3.793	.002
	Within Groups	1223.1	339	3.608		
	Total	1291.5	344			

The results show that the three means for the variables are significant. Within each variable, the means are observed to be significantly different from the other: the significance level of the F ratio is given as <.001, .002 and 0.02 for variables ‘L’, ‘a’ and ‘b’, respectively.

For variable ‘L’, $F (5,339) = 9.641$, $p <0.05$. The 5 and 339 are the two df values for the between- groups effect and the within-groups error, respectively. The 9.641 is the obtained F-value and the $p <0.05$, is the probability of obtaining that F value by chance alone. The results produced in this table show that significant values are observed and thus, the null hypothesis is rejected. This hypothesis of all five groups being equal is rejected. It can be concluded that at least one of the group means is significantly different from the others.

The adjusted F-test called the Welch test, was also employed because of the violation of the equal variance assumption. The F-test commonly used with ANOVA is based on the assumption of equal population variance. To address the problem of unequal variance, the Welch test was developed as an alternative to the F-test. The Welch test was used along with the ANOVA F-test for more accurate results. The p-values were also computed using the Welch test as a robust test for the equality of means.

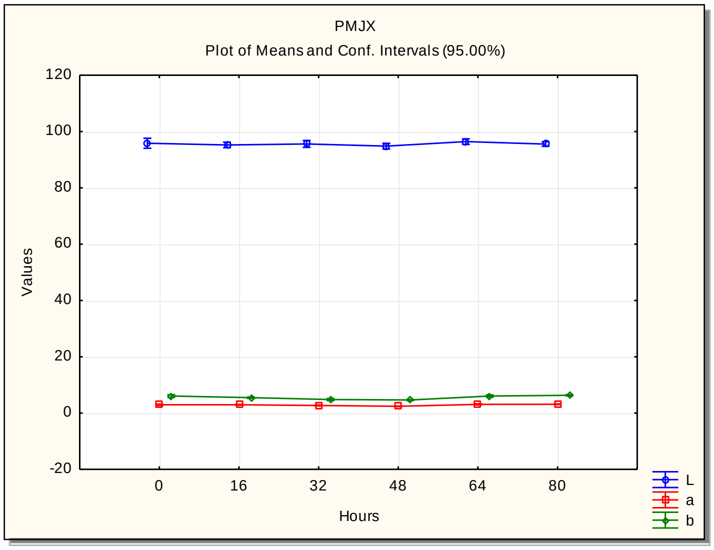
Table 16: Welch results of Lab variables grouped by 'Hours'

Grouped by Hours									
DPMP	Welch df	Welch df	Welch F	Welch p	PMJX	Welch df	Welch df	Welch F	Welch p
L	5	154.17	9.486	0.000	L	5	153.17	1.145	0.339
a	5	156.65	4.653	0.001	a	5	151.36	21.280	0.000
b	5	153.29	4.017	0.002	b	5	151.78	30.584	0.000
GMP	Welch df	Welch df	Welch F	Welch p	PMP	Welch df	Welch df	Welch F	Welch p
L	5	151.93	4.508	0.001	L	53	88.21	48231.2	0.000
a	5	151.15	6.311	0.000	a	53	88.24	30178.9	0.000
b	5	156.65	3.077	0.011	b	53	87.08	84713.2	0.000
OSDP	Welch df	Welch df	Welch F	Welch p	RMP	Welch df	Welch df	Welch F	Welch p
L	5	156.54	4.428	0.001	L	5	154.37	3.909	0.002
a	5	157.12	9.757	0.000	a	5	148.30	6.801	0.000
b	5	156.33	31.895	0.000	b	5	150.57	4.934	0.000
PMCL	Welch df	Welch df	Welch F	Welch p					
L	5	153.71	4.292	0.001					
a	5	153.82	3.879	0.002					
b	5	153.01	6.183	0.000					

Note: Significances are marked in bold italics.

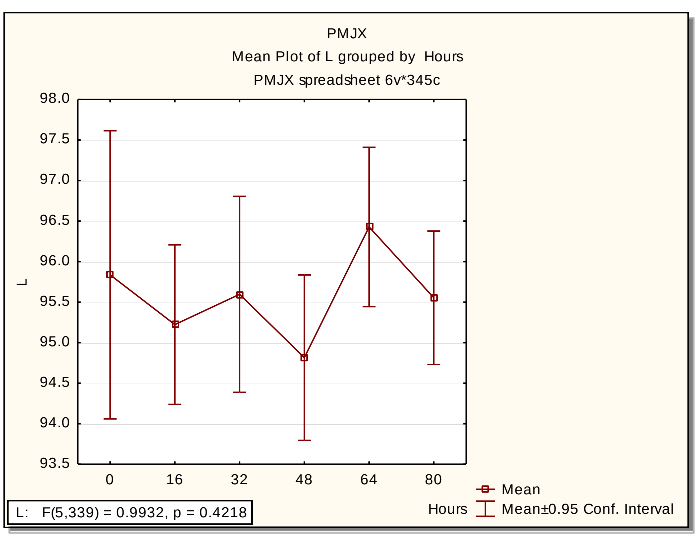
The results from the Welch test complement those from the ANOVA results. Both test produced insignificant mean values of sample PMJX at variable 'L', was not observed to be significantly different. Since the results of the two tests are similar, the results of the standard ANOVA are discussed. Charts were created better interpretation purposes. A summary mean plot of the overall Lab variables was plotted, and three additional charts were created for each variable. The results of sample PMJX are provided below. These plots were also used for greater visualization of the means of each dependent variable at each hour interval and thus accessibly note where the error bars overlap. The F-test was then employed for each dependent variable disjointedly.

Figure 33: Mean plot of Lab variables grouped by 'Hours'



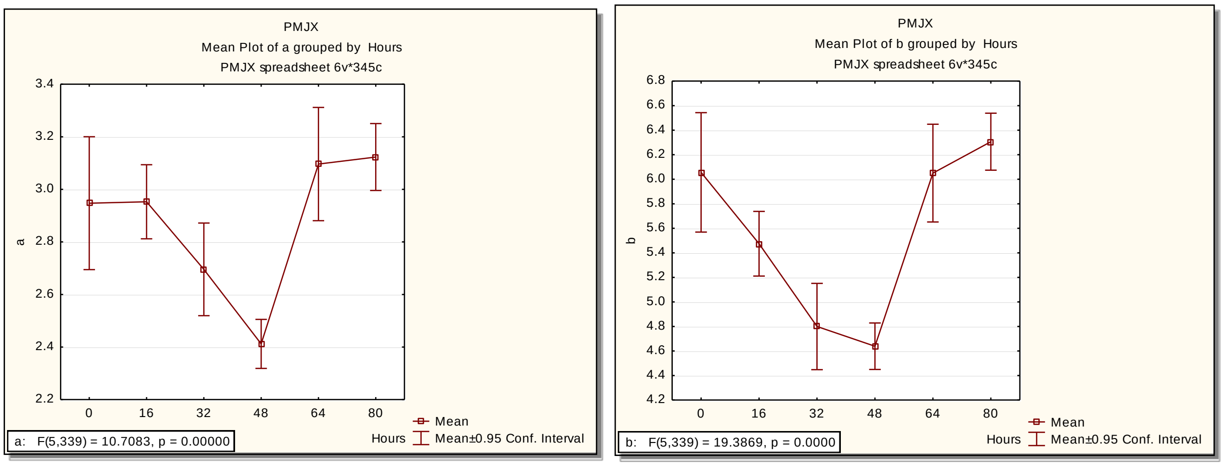
Notice that in the mean plot of variable 'L', overlapping occurs within the intervals. A sign of overlapping within the confidence interval implies that the population means are similar. Since the confidence overlaps, it means that at a 95% level of confidence, there is not sufficient evidence (at p = .4218) in rejecting the null hypothesis.

Figure 34: Mean plot of variable 'L' grouped by 'Hours'



Notice the contrast among the patterns of the confidence level from variable ‘L’ to variables ‘a’ and ‘b’.

Figure 35a-b: Mean plot of variables ‘a’ and ‘b’ grouped by ‘Hours’



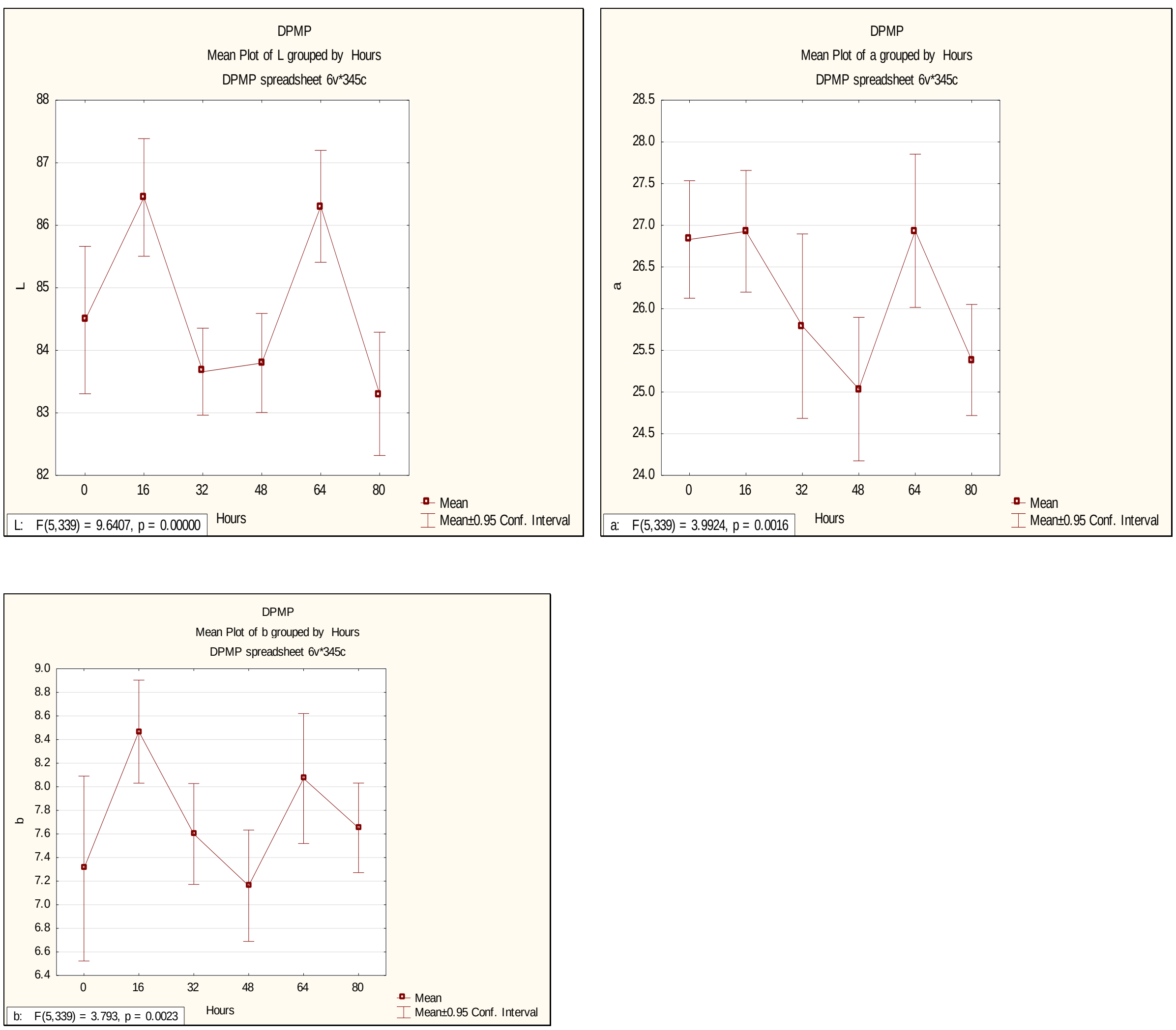
Although some overlap is seen, there are instances in the aging intervals, where the mean varies between different groups. For instance, variable ‘a’ at 0, 16, 64, and 80 hours overlaps each other in some areas. This suggests that they were some similarities between the groups. However, at 48 hours of aging, the confidence interval does not overlap with the means of the other groups. This therefore implies that the mean is different in this group. This result is also very similar to variable ‘b’. The ANOVA test establishes that there is some significance among the means, but it is limited in explaining where the differences lie. Analyzing the mean plots only provides insight as to where this might occur. Again, the p-value was used in corroboration with the charts to reach the decision of rejecting the null hypothesis.

Samples DPMP, GMP, OSDP, PMCL, PMP, and RMP

Significant changes were observed throughout the aging treatment based on the calculated ANOVA F-statistics and p-values, as well as for the patterns of the means and confidence interval plots. As the samples were aged, the changes observed in color were greater than what would occur by random chance alone and the variances that occurred were substantially greater between-groups than within-groups. When the error bars overlap each other, they suggest that the average value is not significantly different from the other, whereas when the error bars do not overlap, they suggest significant difference. Based on the results in table 10, each sample will be summarized below. See Section 6 in the appendix for the remaining graphs.

DPMP

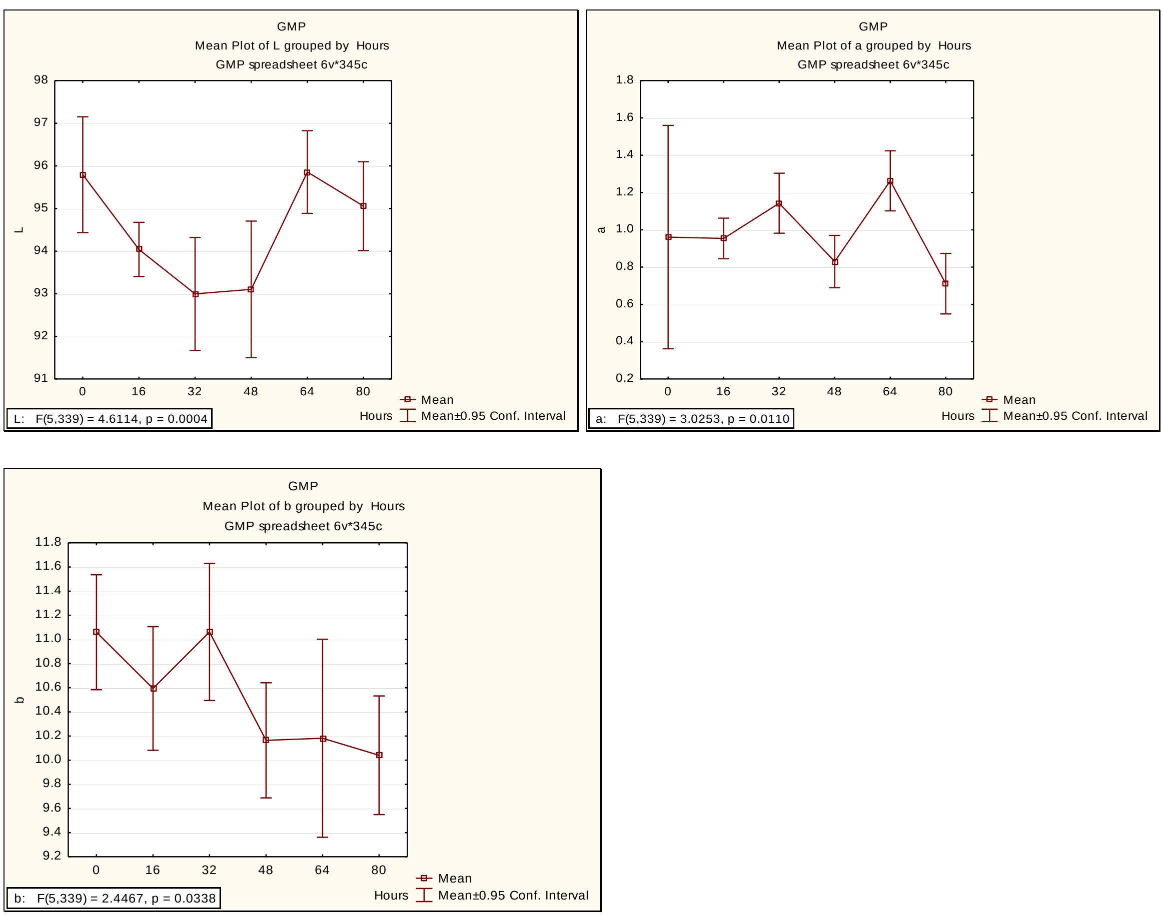
Figure 36a-c: Mean plot for sample DPMP grouped by 'Hours'



The results showed that the three means from each variable are significantly different in each group. At variable ‘L’, it can be observed that the means at 16 and 64 hours of aging vary significantly from the others. At variable ‘a’, differences can be observed at more than one group. For instance, the means of hours 0, 16 and 64 are significantly difference from 48 hours. The means of hours 32 and 48 are observed to not be significantly different from each other as their bars overlaps. And lastly at variable ‘b’, the mean value at 0 hours is not significantly different from the others. Some of the remaining bars do not overlap each other which would then suggest significant. Again, the p-values assist in these interpretations.

GMP

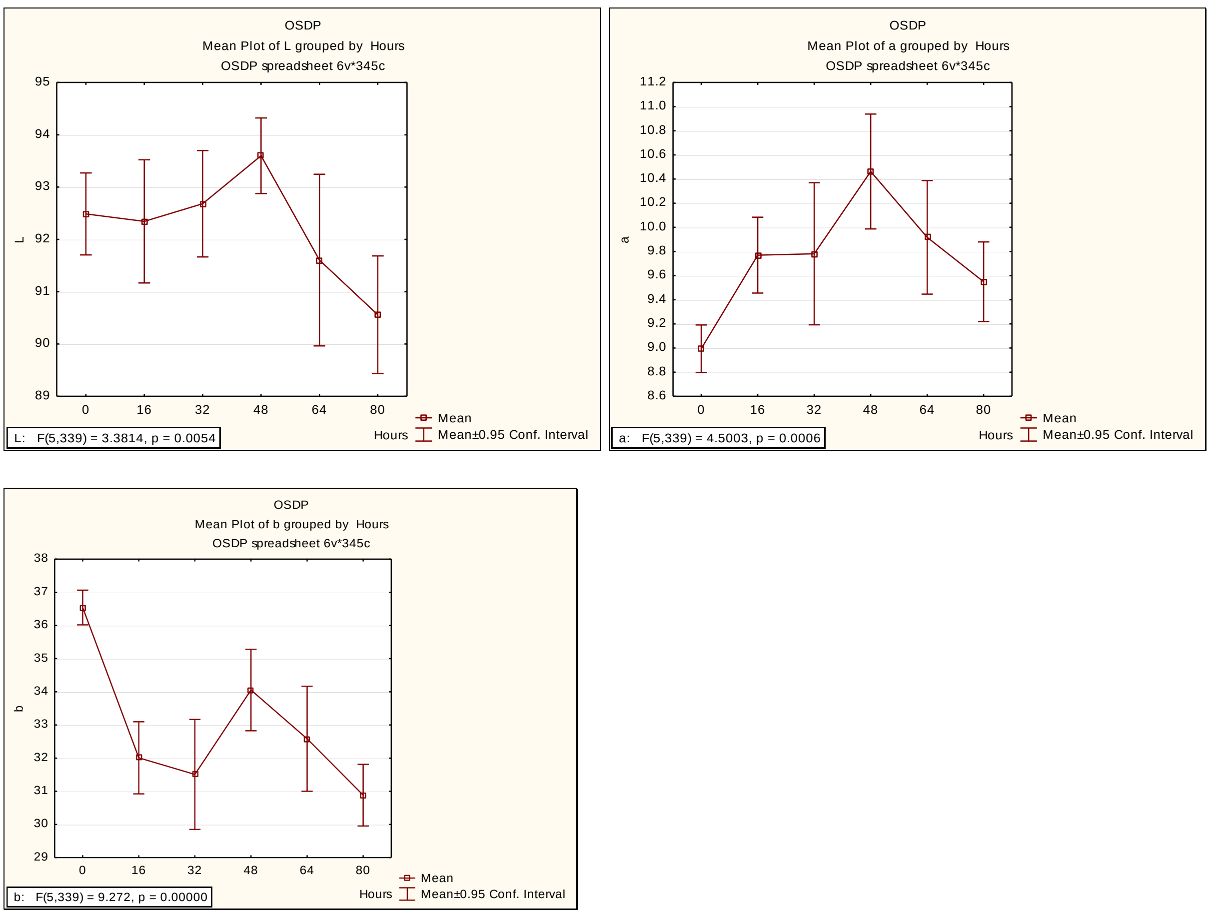
Figure 37a-c: Mean plot for Sample GMP of variables Lab grouped by ‘Hours’



Significant differences are observed in the means of all three variables. The interesting point in these graphs is the fact that the patterns are dissimilar. The aging treatment affects each variable differently; from 0 to 48 hours, the mean values decrease for ‘L’ and fluctuates for ‘a’ and ‘b’. Then, from 48 to 80 hours, the mean values increase for ‘L’, continues to fluctuate for ‘a’, and decrease for ‘b’.

OSDP

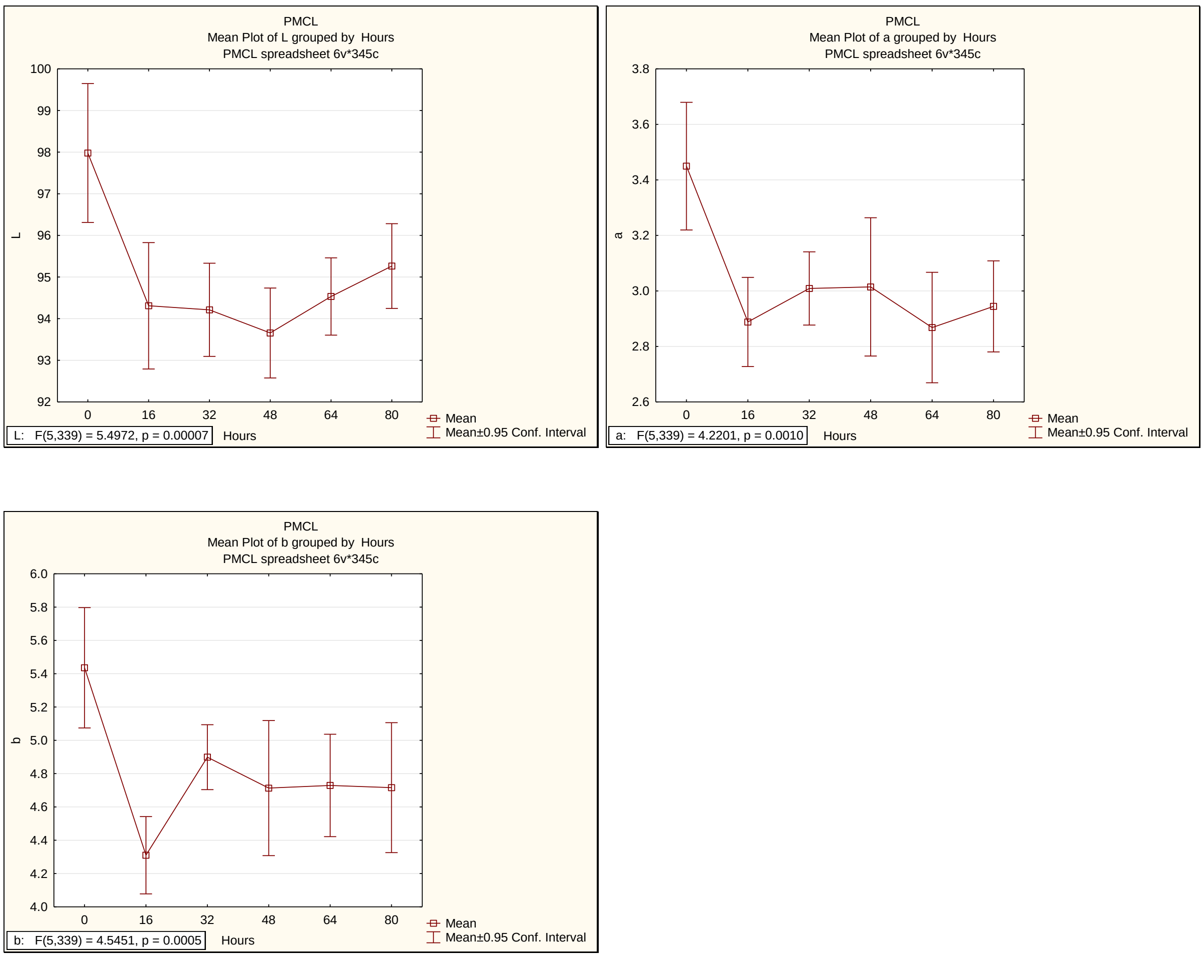
Figure 38a-c: Mean plot for sample OSDP grouped by ‘Hours’



Significant differences in means were observed for all three variables. A similar pattern was observed in variables ‘a’ and ‘b’ where at 0 hours; the means of this group was significantly different from the remaining groups. Also notice in variable ‘L’, a pattern was starting to develop until at 64 hours of aging. This pattern was not observed in the other samples, so no inference can be made at this stage.

PMCL

Figure 39a-c: Mean plot for Sample PMCL grouped by ‘Hours’

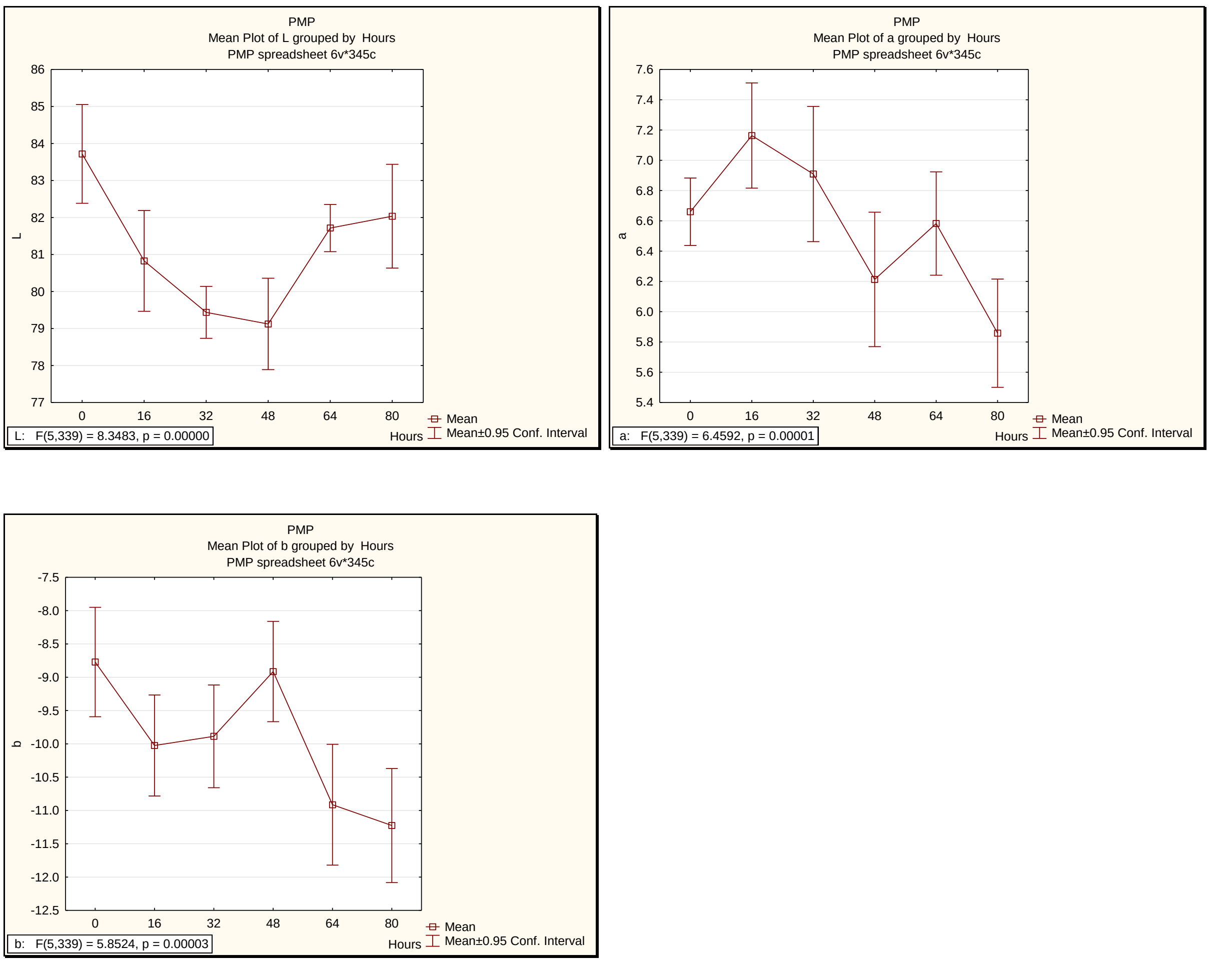


Significant differences were observed for all three variable means. A pattern can be observed for all three variables at 0 hours, where the mean value differs from most of the other groups. There is a decrease in mean value for the other groups whether significant differences occurred or not.

Also in variable ‘b’, the changes in mean difference at 48, 64 and 80 hours were not significant. In fact, among these hours, the changes seemed to be so minor.

PMP

Figure 40a-c: Mean plot for Sample PMP grouped by ‘Hours’

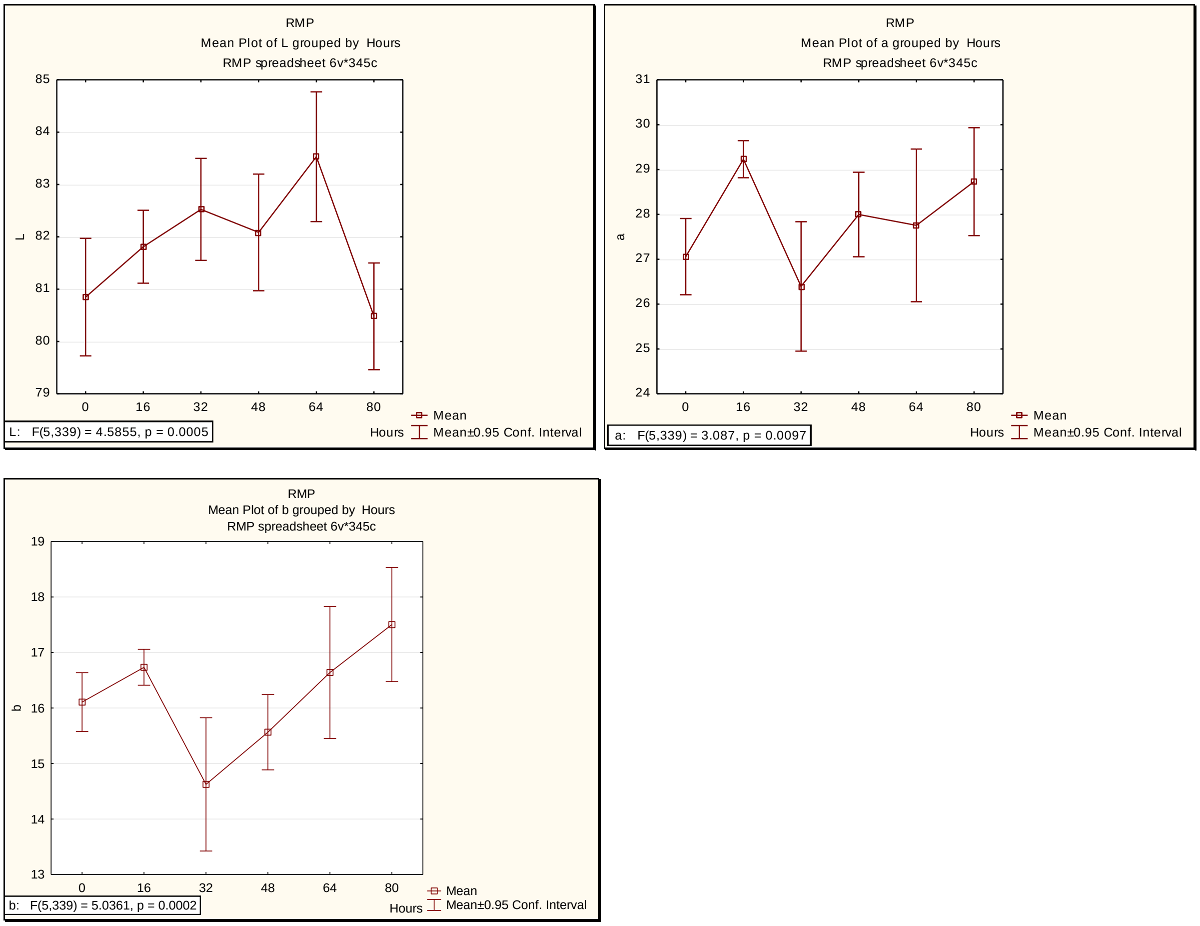


Significant differences in means are observed for all three variables. There is also a notable pattern observed in these variables; as the samples continue to age, there is a slight decrease that is observed in the mean values of each aging interval. However, at 64 hours, this decrease in values is interrupted for variables ‘L’ and ‘a’ but is interrupted at for variable ‘b’ at 48 hours.

Again, there are no consistencies in the way the Lab variables are affected by the aging treatment.

Lastly, sample RMP

Figure 41a-c: Mean plot for Sample RMP grouped by 'Hours'



Significant differences in means are observed for all three variables. Unlike sample PMP, as the aging interval increases, the mean values also increases between groups. For example, at variable 'L', the mean values continued to increase until 80 hours where it substantially decreases. Further analysis of these results will be investigated using the post hoc tests.

2) ANOVA performed on variables L, a, b grouped 'Sample Area'

Unlike hours, sample area was used to analyze inter-variability of the fibers for the Lab values. At p=0.05, or the 5% level, there is strong evidence that the means differ significantly from one another. Among the sample areas, significant differences were not observed for any one reference sample at all three dependent variables.

Table 17: ANOVA results of Lab variables grouped by 'Sample Area'

Grouped by Sample Area								
DPMP	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	60.19	2	30.10	4516.14	342	13.205	2.279	0.104
a	192.99	2	96.49	3606.10	342	10.544	9.151	0.000
b	45.95	2	22.97	1245.52	342	3.642	6.308	0.002
GMP	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	540.49	2	270.25	6798.24	342	19.878	13.595	0.000
a	9.39	2	4.69	274.53	342	0.803	5.848	0.003
b	12.33	2	6.16	1683.22	342	4.922	1.253	0.287
OSDP	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	468.82	2	234.41	6254.62	342	18.288	12.817	0.000
a	3.26	2	1.63	961.43	342	2.811	0.580	0.560
b	12.83	2	6.42	9002.78	342	26.324	0.244	0.784
PMCL	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	91.62	2	45.81	7701.74	342	22.520	2.034	0.132
a	5.66	2	2.83	183.10	342	0.535	5.284	0.005
b	37.68	2	18.84	504.94	342	1.476	12.760	0.000
PMJX	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	82.78	2	41.39	6066.01	342	17.737	2.334	0.098
a	3.63	2	1.81	157.72	342	0.461	3.931	0.021
b	12.47	2	6.23	637.90	342	1.865	3.342	0.037
PMP	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	786.90	5	157.38	6390.75	339	18.852	8.348	0.000
a	66.48	5	13.30	697.80	339	2.058	6.459	0.000
b	279.74	5	55.95	3240.85	339	9.560	5.852	0.000
RMP	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	28.51	2	14.25	5586.55	342	16.335	0.873	0.419
a	458.17	2	229.08	6824.89	342	19.956	11.479	0.000
b	350.72	2	175.36	4049.41	342	11.840	14.811	0.000

Note: Significances are marked in bold italics.

Table 18: Welch results of Lab variables grouped by 'Sample Area'

Grouped by Sample Area									
DPMP	**Welch df**	**Welch df**	**Welch F**	**Welch p**	**PMJX**	**Welch df**	**Welch df**	**Welch F**	**Welch p**
L	2	226.96	2.214	0.112	L	2	227.93	2.299	0.103
a	2	226.16	8.258	0.000	a	2	226.96	3.699	0.026
b	2	222.50	5.649	0.004	b	2	227.92	3.407	0.035
GMP	**Welch df**	**Welch df**	**Welch F**	**Welch p**	**PMP**	**Welch df**	**Welch df**	**Welch F**	**Welch p**
L	2	227.65	14.090	0.000	L	5	151.71	10.412	0.000
a	2	187.75	4.074	0.019	a	5	158.03	6.498	0.000
b	2	221.09	1.154	0.317	b	5	156.13	5.745	0.000
OSDP	**Welch df**	**Welch df**	**Welch F**	**Welch p**	**RMP**	**Welch df**	**Welch df**	**Welch F**	**Welch p**
L	2	227.57	12.732	0.000	L	2	226.39	0.886	0.414
a	2	223.08	0.504	0.605	a	2	226.12	11.598	0.000
b	2	222.73	0.296	0.744	b	2	216.91	18.298	0.000
PMCL	**Welch df**	**Welch df**	**Welch F**	**Welch p**					
L	2	227.17	1.887	0.154					
a	2	221.42	6.391	0.002					
b	2	221.61	16.628	0.000					

Note: Significances are marked in bold italics.

Again, the Welch test was used in corroboration with the F-test when the variances are not homogenous. The ANOVA results are discussed in two different groups below based on similar patterns of results observed in the dependent variables.

Samples DPMP, PMCL, PMJX, and RMP

A similar pattern was noticed for all four samples: variables 'a' and 'b' observed significant differences in their mean values. These four samples were the only ones that observed this pattern. Note that three of the colors were pink and one was red, which might play an important role into deciphering this pattern. This will be further investigated in the post hoc comparison test. See Section 7-11 in the appendix for the ANOVA results and the mean plots.

Samples GMP, OSDP and PMP

Samples GMP, OSDP and PMP were separated because there was no similar pattern observed with these samples in comparison to the others listed above. Although all three samples had marked significances, only two will be discussed in greater detail below. The mean plots of sample GMP can be found in Section 11 of the appendix.

Figure 42 below shows the overall mean plot of variables Lab for samples PMP and OSDP. The changes that occur among sample areas are not readily observed in these graphs; these graphs were included to observe the overall change.

Figure 42a-b: Mean plot of Lab grouped by 'Sample Area' for PMP (a) and OSDP (b)

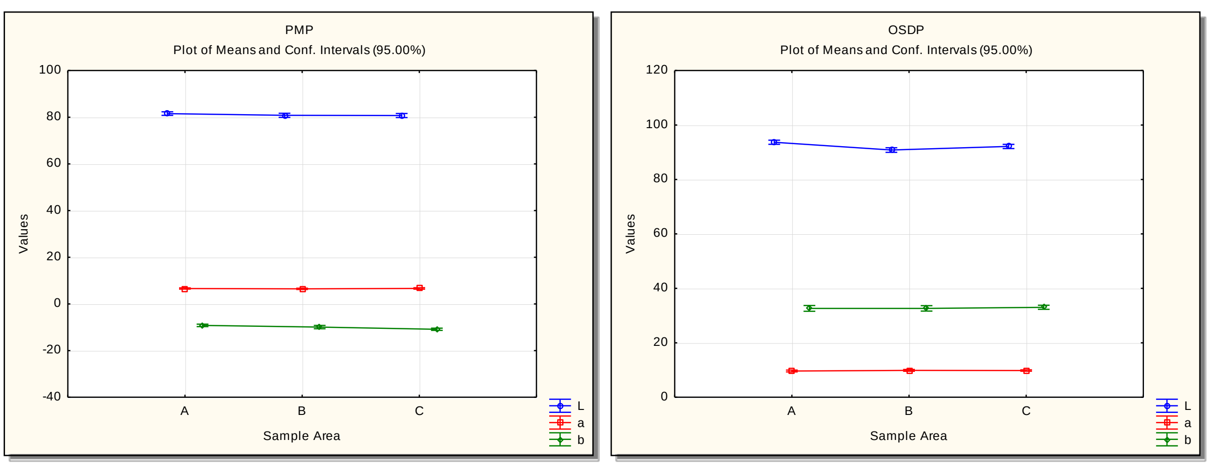
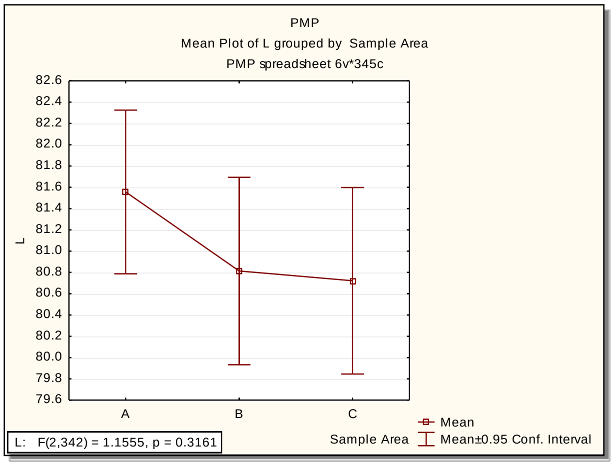


Figure 43 below shows the mean plot at variable 'L' for samples PMP and OSDP. The changes that occur among sample areas can be easily observed here. The difference in bar overlapping can be seen in samples PMP and OSDP. While all three intervals overlaps in sample PMP, sample area B overlaps with C for sample OSDP. Based on the associated p-values for each graph, the null hypothesis of no means differences was rejected for sample OSDP but was accepted for sample PMP at variable 'L'.

Figure 43a-b: Mean plot of 'L' grouped by 'Sample Area' for PMP (a) and OSDP (b)



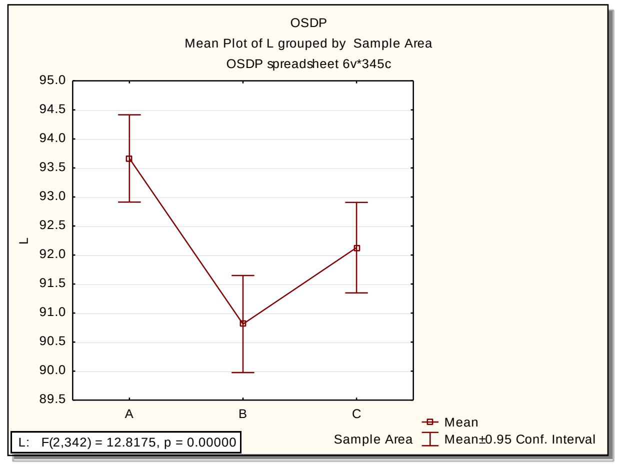
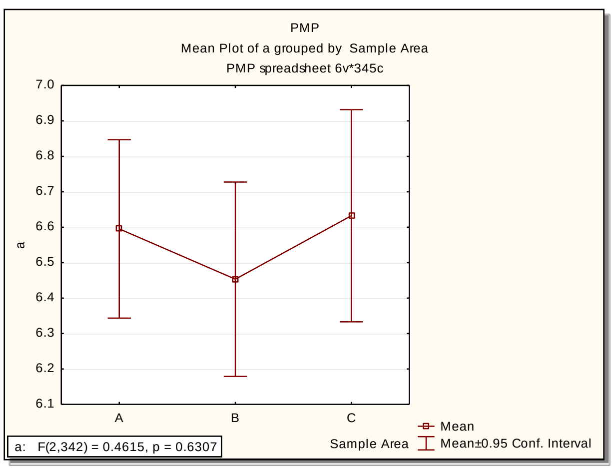
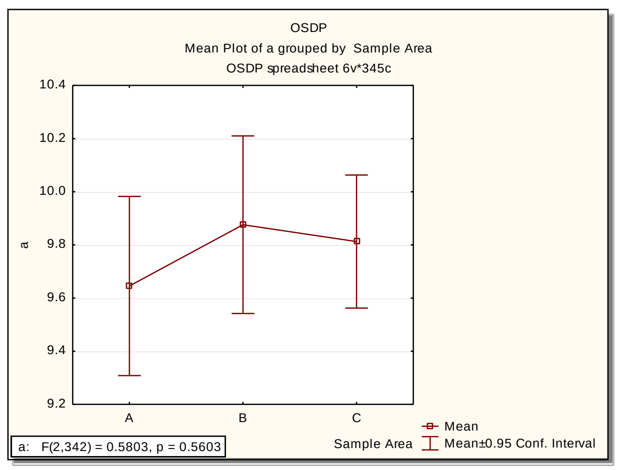


Figure 44below shows the mean plot at variable 'a' for samples PMP and OSDP.

Figure 44a-b: Interaction plot of 'a' grouped by 'Sample Area' for PMP (a) and OSDP (b)

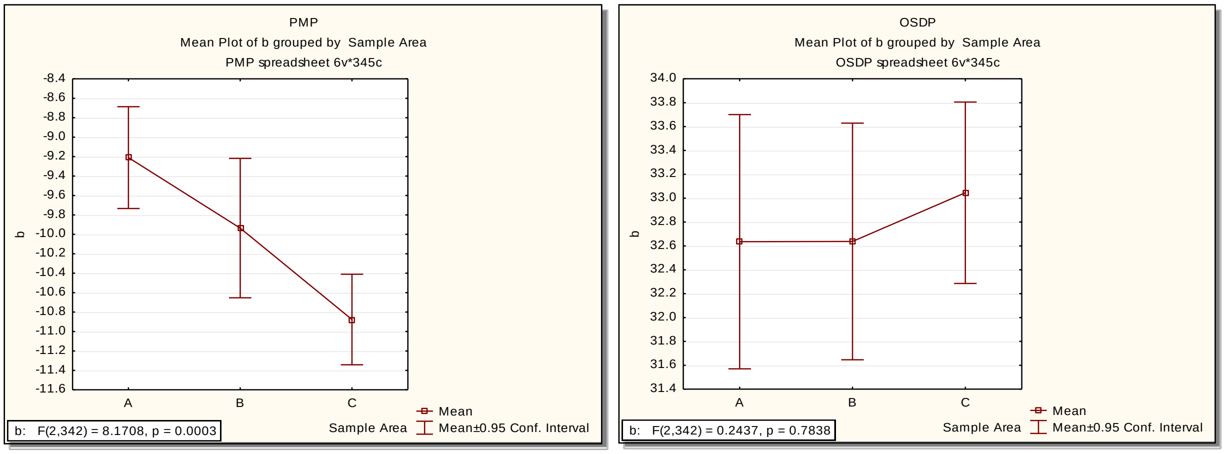




For variable 'a', both charts shows similarities as the error bars overlap among the sample areas. Therefore, for both samples, the null hypothesis was not rejected.

Lastly, Figure 45 below shows the mean plot at variable 'b' for samples PMP and OSDP.

Figure 45a-b: Mean plot of 'b' grouped by 'Sample Area' for PMP (a) and OSDP (b)



For variable 'b', again there was a difference in overlapping as was observed in variable 'L'. A notable difference in group means was observed among the groups in sample PMP, whereas, this difference was not observed in OSDP. In fact, sample OSDP observes such similarity that it has a substantial p-value. As the p-value approached 1, it indicated that the samples are the same or that they were from the same population. For this reason, the null hypothesis was accepted for sample OSDP, but was rejected for sample PMP at variable 'b'.

3) ANOVA was performed on variables Lab grouped by variable 'Fiber'

Variable 'Fibers' was used to analyze intra-variability of the fibers for the Lab values. Among the fibers, significant differences were observed for all measurements. Based on the results, there was strong evidence (at p=0.05, or the 5% level) that the means differ significantly from one another.

Significant differences were observed among the fibers. One explanation for this is the fact that inter-variability and intra-variability observed among the fibers are substantial. If the fibers themselves are not homogeneous, it can be stipulated that with or without treatment, differences are probable.

Table 19: ANOVA results of Lab grouped by 'Fiber'

Grouped by fibers								
DPMP	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	3729.97	53	70.38	846.36	291	2.908	24.197	0.000
a	2590.73	53	48.88	1208.36	291	4.152	11.772	0.000
b	964.17	53	18.19	327.30	291	1.125	16.174	0.000
GMP	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	5582.56	53	105.33	1756.17	291	6.035	17.454	0.000
a	246.23	53	4.65	37.69	291	0.130	35.870	0.000
b	1270.59	53	23.97	424.96	291	1.460	16.416	0.000
OSDP	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	5694.21	53	107.44	1029.22	291	3.537	30.377	0.000
a	753.18	53	14.21	211.51	291	0.727	19.552	0.000
b	7484.85	53	141.22	1530.76	291	5.260	26.847	0.000
PMCL	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	5972.71	53	112.69	1820.65	291	6.257	18.012	0.000
a	158.45	53	2.99	30.31	291	0.104	28.705	0.000
b	464.20	53	8.76	78.42	291	0.269	32.502	0.000
PMJX	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	5621.41	53	106.06	527.39	291	1.812	58.524	0.000
a	130.42	53	2.46	30.92	291	0.106	23.160	0.000
b	546.36	53	10.31	104.02	291	0.357	28.840	0.000
PMP	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	48.17	2	24.09	7129.48	342	20.846	1.155	0.316
a	2.06	2	1.03	762.22	342	2.229	0.461	0.631
b	160.55	2	80.28	3360.04	342	9.825	8.171	0.000
RMP	**SS**	**df**	**MS**	**SS**	**df**	**MS**	**F**	**p**
L	4770.90	53	90.02	844.16	291	2.901	31.031	0.000
a	6120.40	53	115.48	1162.66	291	3.995	28.903	0.000
b	3987.32	53	75.23	412.81	291	1.419	53.033	0.000

Note: Significances are marked in bold italics.

Again, the Welch test was used to corroborate the ANOVA F-test.

Table 20: Welch results of Lab grouped by 'Fiber'

Grouped by Fibers									
DPMP	**Welch df**	**Welch df**	**Welch F**	**Welch p**	**PMJX**	**Welch df**	**Welch df**	**Welch F**	**Welch p**
L	53	88.78	18349	0.000	L	53	88.80	33611	0.000
a	53	88.63	40029	0.000	a	53	88.86	32073	0.000
b	53	88.87	39886	0.000	b	53	88.37	44990	0.000
GMP	**Welch df**	**Welch df**	**Welch F**	**Welch p**	**PMP**	**Welch df**	**Welch df**	**Welch F**	**Welch p**
L	53	88.94	76705	0.000	L	2	227.04	1.257	0.287
a	53	89.09	17043	0.000	a	2	226.88	0.449	0.639
b	53	88.40	47740	0.000	b	2	222.18	11.177	0.000
PMCL	**Welch df**	**Welch df**	**Welch F**	**Welch p**	**RMP**	**Welch df**	**Welch df**	**Welch F**	**Welch p**
L	53	88.65	100584	0.000	L	53	88.24	273758	0.000
a	53	88.85	32532	0.000	a	53	88.51	88586	0.000
b	53	88.68	26469	0.000	b	53	88.45	89798	0.000

Note: no values were produced for sample OSDP

The Welch test cannot be performed for sample OSDP because at least one group has a variance of 0. Two groups of measurements had missing data where either the data was not collected, or it was corrupted using the GRAIMS software. When missing data was observed in this sample, the average value for the entire measurement replaced the sets of missing data. For this reason, the variance would be zero for these two groups.

Post hoc comparisons were not applied to the ANOVA results taken from the variable 'Fiber' as this result was only used as initial observations to determine if intra-variability is found in fibers. However, for the variable 'Sample Area', only certain measurements were further analyzed. Among the pink and red samples, similarities were observed in the dependent variables over the aging treatment. To observe where these similarities might have occurred, the post hoc comparisons were applied. For the remaining samples, only intra-variability was checked and determined based on the ANOVA results. This result is sufficient to prove that intra-variability occurs within a garment. However, since the objective of part 1 of this project is to determine how the aging treatment affects the color in the fibers, further statistical approaches from the variable 'Hours' were investigated using the post hoc tests. By this, it can be determined where the significant differences between groups occurred.

6.3.1c Post Hoc Comparisons of Aged Results

In the post hoc test, means between groups are compared two at a time. In order to interpret the results, two hypotheses were created:

- Ho: $\mu_1 = \mu_2$ (the means of this group are the same)
- H_A: $\mu_1 \neq \mu_2$ (the means of this group are not the same)

Two post hoc tests, Tukey HSD and Games-Howell methods were employed. The tests are broken down into two analyses:

1) Post Hoc Comparisons of Lab grouped by 'Hours'
2) Post Hoc Comparisons of Lab grouped by 'Sample Area'

The results of these tests were broken down into three tables for each dependent variable.

i. Tukey Multiple Comparisons Results of variables Lab;
ii. Games-Howell Multiple Comparisons of variables Lab;
iii. Homogeneous Subsets Results based on Tukey of variables Lab.

Based on the previous ANOVA results in which the null hypotheses were rejected, two post hoc comparisons, Tukey HSD and Games-Howell tests, were employed. This was done to evaluate the null hypothesis associated with each contrast or group that is investigated. The mean differences highlights where significant differences are found among the comparing group. The results of the Tukey test are tabulated in a triangular table of mean differences, whereas the results of Games-Howell were only tabulated. Note that the Tukey results were computed using Statistica, and the Games-Howell and Homogeneous Subsets results were computed using the SPSS software.

1) Post Hoc Comparisons of Lab grouped by 'Hours'

Based on the previous ANOVA results, all the reference samples, except sample PMJX, observed significant p-values. Sample PMJX only observed significant p-values at variable 'a' and 'b'. The null hypothesis of mean differences between groups at variable 'L' was accepted. These results are discussed separately below by reference samples.

I. DPMP - Variable 'L'

In sample DPMP, significant changes were observed greatest in the 'L' value then variables 'a' and 'b'. Since L refers to light or luminance, the greatest change observed during UV exposure affected the gloss of the sample.

Table 21: Tukey HSD test of sample DPMP at variable 'L'

		Tukey HSD test; Variable: L (DPMP spreadsheet) Marked differences are significant at p < .05000					
Hours		{1} M=84.484	{2} M=86.446	{3} M=83.659	{4} M=83.798	{5} M=86.303	{6} M=83.305
0	{1}		***0.0441***	0.8286	0.9138	0.0787	0.5049
16	{2}	***0.0441***		***0.0002***	***0.0004***	0.9999	***0.0000***
32	{3}	0.8286	***0.0002***		0.9999	***0.0004***	0.9932
48	{4}	0.9138	***0.0004***	0.9999		***0.0009***	0.9701
64	{5}	0.0787	0.9999	***0.0004***	***0.0009***		***0.0000***
80	{6}	0.5049	***0.0000***	0.9932	0.9701	***0.0000***	

Note: Significances are marked in bold italics.

This table shows the results of multiple pair-wise comparisons among the six groups, representing the hours aged: from 0 hours for the untreated sample to 80 hours of aging. *M* in each column is the average mean of each group. In the first column, second row shows the first pair-wise comparison; this cell shows that the mean at 0 hours is significantly different from the mean at 16 hours (where the values in bold indicates a difference at the 0.05 level). No other significant difference was observed at 0 hours (group 1).

Table 22: Homogeneous Subsets: DPMP 'L'

Homogeneous Subsets: Variable 'L'

Hours		N	Subset for alpha = 0.05		
			1	2	3
Tukey HSD[a,b]	80	60	83.3046		
	32	60	83.6591		
	48	60	83.7976		
	0	45	84.4845	84.4845	
	64	60		86.3032	86.3032
	16	60			86.4462
	Sig.		.448	.057	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 56.842.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Three subset groups were created: in group 1, the means of the 80, 32, 48 and 0 hours of aging are not significantly different from each other, and forms a homogeneous subset according the Tukey HSD test. It can be observed that the means are quite close together in this group. Yet this subset differs significantly from subset 2 and 4. It may then be concluded that the aging treatment had a significant effect at 16 hours of aging.

Table 23: Games-Howell test of sample DPMP at variable 'L'

Multiple Comparisons: DPMP

Dependent Variable		Group (I)	Group (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
L	Games-Howell	0	16	-1.9617	0.7499	.104	-4.1451	0.2217
			32	0.8253	0.6802	.829	-1.1650	2.8156
			48	0.6869	0.7059	.925	-1.3736	2.7474
			64	-1.8187	0.7361	.144	-3.9633	0.3258
			80	1.1799	0.7644	.637	-1.0444	3.4041
		16	0	1.9617	0.7499	.104	-0.2217	4.1451
			32	2.7870*	0.5844	.000	1.0915	4.4826
			48	2.6486*	0.6141	.000	0.8687	4.4285
			64	0.1430	0.6486	1.000	-1.7361	2.0221
			80	3.1416*	0.6806	.000	1.1698	5.1134
		32	0	-0.8253	0.6802	.829	-2.8156	1.1650
			16	-2.7870	0.5844	.000	-4.4826	-1.0915
			48	-0.1385	0.5267	1.000	-1.6647	1.3878
			64	-2.6440	0.5665	.000	-4.2871	-1.0011
			80	0.3545	0.6029	.992	-1.3954	2.1044
		48	0	-0.6869	0.7059	.925	-2.7474	1.3736
			16	-2.6486	0.6141	.000	-4.4285	-0.8687
			32	0.1385	0.5267	1.000	-1.3878	1.6647
			64	-2.5056	0.5971	.001	-4.2358	-0.7754
			80	0.4930	0.6317	.970	-1.3385	2.3245
		64	0	1.8187	0.7361	.144	-0.3258	3.9633
			16	-0.1430	0.6486	1.000	-2.0221	1.7361
			32	2.6440*	0.5665	.000	1.0011	4.2871
			48	2.5056033*	0.5971	.001	0.7754	4.2358
			80	2.9986*	0.6653	.000	1.0709	4.9263
		80	0	-1.1799	0.7644	.637	-3.4041	1.0444
			16	-3.1416	0.6806	.000	-5.1134	-1.1698
			32	-0.3545	0.6029	.992	-2.1044	1.3954
			48	-0.4930	0.6317	.970	-2.3245	1.3385
			64	-2.9986	0.6653	.000	-4.9263	-1.0709

*. The mean difference is significant at the 0.05 level.

Since the assumption of homogeneity of variance was not met for sample DPMP, only the results Games-Howell test was reviewed and accepted as accurate results. For the remaining dependent variables, only the Games-Howell test will be discussed. The information for the Tukey test can be ignored at this point. Both post hoc comparisons are in agreement with the significant values found for the samples. In this table, there are only certain pieces of data that is needed to make a conclusion. This table is broken down into 8 columns: Column 1 list the dependent variables; Column 2 list the post hoc test being used; Column 3 and 4 lists the factors being compared to each other; Column 5 list the mean difference between the two compared groups; Column 6 through 9 lists the standard error, significant p-value, and the 95% upper and lower confidence interval. The columns of interests are columns 3, 4 and 7. Group 0 (M = 84.484) is not observed to be significantly different from Group 16 (M = 86.446) with a mean difference of -1.962 and a p-value of 0.104. However, Group 16 (M = 86.446) was observed to be significantly different from Group 32 (M = 83.659) with a mean difference of 2.787 and a p-value of 0.001. In total, six marked significant difference in means was observed between the comparing groups. It can therefore be concluded that the aging treatment have reasonably affected the gloss of the sample.

DPMP- *Variable 'a'*

Only five significant differences in means are observed in the variable. From the untreated sample, Group 0, only two marked differences were observed: at Group 48 (M = 25.035) with a mean difference of 1.765 and a p-value of 0.020; and again at Group 80 (M = 25.384) with a difference of 3.142 and a p-value of 0.001. It can therefore be concluded that the color saturation was greatly affected in the red/green region. Two possible explanations can be drawn: the aging treatment reasonably affected the color saturation in the red/green region, or, based on the validation results, variation is typically observed in this region which could have influenced the post hoc results and the aging treatment.

Table 24: Games-Howell test of sample DPMP at variable 'a'

Multiple Comparisons: DPMP

Dependent Variable		Group (I)	Group (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
a	Games-Howell	0	16	-0.0977	0.5052	1.000	-1.5651	1.3697
			32	1.0395	0.6539	.607	-0.8625	2.9415
			48	1.7949*	0.5543	.020	0.1851	3.4048
			64	-0.1047	0.5770	1.000	-1.7808	1.5714
			80	1.4457*	0.4825	.039	0.0435	2.8480
		16	0	0.0977	0.5052	1.000	-1.3697	1.5651
			32	1.1371	0.6623	.524	-0.7864	3.0607
			48	1.8926*	0.5641	.013	0.2576	3.5276
			64	-0.0070	0.5864	1.000	-1.7074	1.6933
			80	1.5433*	0.4937	.027	0.1128	2.9740
		32	0	-1.0395	0.6539	.607	-2.9415	0.8625
			16	-1.1371	0.6623	.524	-3.0607	0.7864
			48	0.7555	0.7005	.889	-1.2758	2.7868
			64	-1.1442	0.7185	.605	-3.2270	0.9386
			80	0.4062	0.6451	.989	-1.4695	2.2820
		48	0	-1.7949	0.5543	.020	-3.4048	-0.1851
			16	-1.8926	0.5641	.013	-3.5276	-0.2576
			32	-0.7555	0.7005	.889	-2.7868	1.2758
			64	-1.8996	0.6292	.036	-3.7227	-0.0766
			80	-0.3492	0.5439	.988	-1.9266	1.2281
		64	0	0.1047	0.5770	1.000	-1.5714	1.7808
			16	0.0070	0.5864	1.000	-1.6933	1.7074
			32	1.1442	0.7185	.605	-0.9386	3.2270
			48	1.8996*	0.6292	.036	0.0766	3.7227
			80	1.5504	0.5670	.077	-0.0948	3.1957
		80	0	-1.4457	0.4825	.039	-2.8480	-0.0435
			16	-1.5433	0.4937	.027	-2.9740	-0.1128
			32	-0.4062	0.6451	.989	-2.2820	1.4695
			48	0.3492	0.5439	.988	-1.2281	1.9266
			64	-1.5504	0.5670	.077	-3.1957	0.0948

*. The mean difference is significant at the 0.05 level.

DPMP- *Variable 'b'*

Only one significant difference was observed at this variable. Group 16 (M = 8.467) was observed to be significantly different from Group 48 (M = 7.161) with a mean difference of

1.306 and a p-value of 0.001. It can be concluded that the aging treatment did not substantially affect the color saturation of this sample at this particular variable.

Table 25: Games-Howell test of sample DPMP at variable 'b'

Multiple Comparisons: DPMP

Dependent Variable		Group (I)	Group (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
b	Games-Howell	0	16	-1.1608	0.4461	.110	-2.4676	0.1460
			32	-0.2928	0.4439	.986	-1.5935	1.0080
			48	0.1455	0.4549	1.000	-1.1852	1.4762
			64	-0.7631	0.4765	.600	-2.1531	0.6270
			80	-0.3449	0.4329	.967	-1.6163	0.9265
		16	0	1.1608	0.4461	.110	-0.1460	2.4676
			32	0.8680	0.3056	.058	-0.0174	1.7533
			48	1.3062*	0.3214	.001	0.3749	2.2376
			64	0.3977	0.3513	.867	-0.6211	1.4164
			80	0.8159	0.2894	.062	-0.0229	1.6547
		32	0	0.2928	0.4439	.986	-1.0080	1.5935
			16	-0.8680	0.3056	.058	-1.7533	0.0174
			48	0.4383	0.3183	.741	-0.4840	1.3606
			64	-0.4703	0.3485	.757	-1.4809	0.5403
			80	-0.0521	0.2860	1.000	-0.8808	0.7765
		48	0	-0.1455	0.4549	1.000	-1.4762	1.1852
			16	-1.3062	0.3214	.001	-2.2376	-0.3749
			32	-0.4383	0.3183	.741	-1.3606	0.4840
			64	-0.9086	0.3625	.131	-1.9591	0.1419
			80	-0.4904	0.3028	.588	-1.3684	0.3876
		64	0	0.7631	0.4765	.600	-0.6270	2.1531
			16	-0.3977	0.3513	.867	-1.4164	0.6211
			32	0.4703	0.3485	.757	-0.5403	1.4809
			48	0.9086	0.3625	.131	-0.1419	1.9591
			80	0.4182	0.3344	.811	-0.5526	1.3890
		80	0	0.3449	0.4329	.967	-0.9265	1.6163
			16	-0.8159	0.2894	.062	-1.6547	0.0229
			32	0.0521	0.2860	1.000	-0.7765	0.8808
			48	0.4904	0.3028	.588	-0.3876	1.3684
			64	-0.4182	0.3344	.811	-1.3890	0.5526

*. The mean difference is significant at the 0.05 level.

II. GMP

This sample observed the greatest amount of change at variable ‘a’. The results from the validation section must also be considered as variations were observed in the red/green region. Each variable will be discussed separately below.

GMP- Variable ‘L’

Table 26: Games-Howell test of sample GMP at variable ‘L’

Multiple Comparisons: GMP

Dependent Variable				Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
L	Games-Howell	0	16	1.7535	0.7449	.189	-0.4357	3.9426
			32	2.7973*	0.9450	.043	0.0515	5.5432
			48	2.6910	1.0465	.114	-0.3481	5.7301
			64	-0.0627	0.8302	1.000	-2.4838	2.3584
			80	0.7378	0.8518	.954	-1.7435	3.2190
		16	0	-1.7535	0.7449	.189	-3.9426	0.4357
			32	1.0439	0.7346	.714	-1.0982	3.1860
			48	0.9376	0.8612	.884	-1.5794	3.4545
			64	-1.8161	0.5795	.027	-3.4995	-0.1328
			80	-1.0157	0.6100	.558	-2.7891	0.7578
		32	0	-2.7973	0.9450	.043	-5.5432	-0.0515
			16	-1.0439	0.7346	.714	-3.1860	1.0982
			48	-0.1064	1.0391	1.000	-3.1186	2.9059
			64	-2.8600	0.8210	.009	-5.2421	-0.4781
			80	-2.0596	0.8428	.150	-4.5034	0.3842
		48	0	-2.6910	1.0465	.114	-5.7301	0.3481
			16	-0.9376	0.8612	.884	-3.4545	1.5794
			32	0.1064	1.0391	1.000	-2.9059	3.1186
			64	-2.7537	0.9360	.046	-5.4749	-0.0325
			80	-1.9532	0.9551	.325	-4.7279	0.8214
		64	0	0.0627	0.8302	1.000	-2.3584	2.4838
			16	1.8161*	0.5795	.027	0.1328	3.4995
			32	2.8600*	0.8210	.009	0.4781	5.2421
			48	2.7537*	0.9360	.046	0.0325	5.4749
			80	0.8005	0.7117	.870	-1.2614	2.8624
		80	0	-0.7378	0.8518	.954	-3.2190	1.7435
			16	1.0157	0.6100	.558	-0.7578	2.7891
			32	2.0596	0.8428	.150	-0.3842	4.5034
			48	1.9532	0.9551	.325	-0.8214	4.7279
			64	-0.8005	0.7117	.870	-2.8624	1.2614

*. The mean difference is significant at the 0.05 level.

Since sample GMP did not meet the homogeneity of variance assumption, only the results taken from Games-Howell test was used. Based on the results, five marked differences were observed. At this variable, an unsubstantial amount of differences in means were observed. Out of the fifteen comparing pairs, only four groups observed to have significant mean differences suggesting that the lightness of the sample was affected but not at an extensively.

GMP- Variable 'a'

Table 27: Games-Howell test of sample GMP at variable 'a'

Multiple Comparisons: GMP

Dependent Variable				Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
a	Games-Howell	0	16	0.0071	0.3021	1.000	-0.8904	0.9045
			32	-0.1817	0.3079	.991	-1.0936	0.7302
			48	0.1310	0.3053	.998	-0.7744	1.0365
			64	-0.3020	0.3079	.922	-1.2139	0.6100
			80	0.2496	0.3080	.964	-0.6627	1.1619
		16	0	-0.0071	0.3021	1.000	-0.9045	0.8904
			32	-0.1888	0.0970	.381	-0.4706	0.0930
			48	0.1240	0.0887	.728	-0.1332	0.3811
			64	-0.3090	0.0972	.023	-0.5912	-0.0269
			80	0.2425	0.0976	.138	-0.0410	0.5260
		32	0	0.1817	0.3079	.991	-0.7302	1.0936
			16	0.1888	0.0970	.381	-0.0930	0.4706
			48	.3127*	0.1066	.045	0.0038	0.6217
			64	-0.1203	0.1138	.897	-0.4499	0.2094
			80	.4313*	0.1142	.003	0.1005	0.7621
		48	0	-0.1310	0.3053	.998	-1.0365	0.7744
			16	-0.1240	0.0887	.728	-0.3811	0.1332
			32	-0.3127	0.1066	.045	-0.6217	-0.0038
			64	-0.4330	0.1067	.001	-0.7423	-0.1238
			80	0.1186	0.1071	.878	-0.1919	0.4291
		64	0	0.3020	0.3079	.922	-0.6100	1.2139
			16	.3090*	0.0972	.023	0.0269	0.5912
			32	0.1203	0.1138	.897	-0.2094	0.4499
			48	.4330*	0.1067	.001	0.1238	0.7423
			80	.5515*	0.1143	.000	0.2205	0.8826
		80	0	-0.2496	0.3080	.964	-1.1619	0.6627
			16	-0.2425	0.0976	.138	-0.5260	0.0410
			32	-0.4313	0.1142	.003	-0.7621	-0.1005
			48	-0.1186	0.1071	.878	-0.4291	0.1919
			64	-0.5515	0.1143	.000	-0.8826	-0.2205

*. The mean difference is significant at the 0.05 level.

The greatest amount of differences in means was observed at this variable. Five mean significant differences were observed here. Although, this number is unsubstantial in comparison to the fifteen pair-wise groups being analyzed, it is still able to determine that negligible degree of color saturation occurred in the red/green region. Again two possible explanations can be drawn: the aging treatment reasonably affected the color saturation in the red/green region, or, based on the validation results, variation is typically observed in this region which could have influenced the post hoc results and the aging treatment.

GMP- Variable 'b'

Table 28: Games-Howell test of sample GMP at variable 'b'

Multiple Comparisons: GMP

Dependent Variable				Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
b	Games-Howell	0	16	0.4658	0.3482	.763	-0.5455	1.4771
			32	-0.0025	0.3692	1.000	-1.0748	1.0697
			48	0.8951	0.3355	.091	-0.0797	1.8699
			64	0.8779	0.4731	.436	-0.4993	2.2551
			80	1.0188*	0.3407	.040	0.0292	2.0085
		16	0	-0.4658	0.3482	.763	-1.4771	0.5455
			32	-0.4684	0.3821	.823	-1.5755	0.6388
			48	0.4293	0.3497	.822	-0.5838	1.4424
			64	0.4121	0.4832	.957	-0.9922	1.8164
			80	0.5530	0.3546	.627	-0.4744	1.5804
		32	0	0.0025	0.3692	1.000	-1.0697	1.0748
			16	0.4684	0.3821	.823	-0.6388	1.5755
			48	0.8977	0.3706	.157	-0.1764	1.9718
			64	0.8805	0.4985	.492	-0.5668	2.3277
			80	1.0214	0.3753	.079	-0.0661	2.1089
		48	0	-0.8951	0.3355	.091	-1.8699	0.0797
			16	-0.4293	0.3497	.822	-1.4424	0.5838
			32	-0.8977	0.3706	.157	-1.9718	0.1764
			64	-0.0172	0.4741	1.000	-1.3964	1.3620
			80	0.1237	0.3422	.999	-0.8676	1.1151
		64	0	-0.8779	0.4731	.436	-2.2551	0.4993
			16	-0.4121	0.4832	.957	-1.8164	0.9922
			32	-0.8805	0.4985	.492	-2.3277	0.5668
			48	0.0172	0.4741	1.000	-1.3620	1.3964
			80	0.1409	0.4778	1.000	-1.2484	1.5303
		80	0	-1.0188	0.3407	.040	-2.0085	-0.0292
			16	-0.5530	0.3546	.627	-1.5804	0.4744
			32	-1.0214	0.3753	.079	-2.1089	0.0661
			48	-0.1237	0.3422	.999	-1.1151	0.8676
			64	-0.1409	0.4778	1.000	-1.5303	1.2484

*. The mean difference is significant at the 0.05 level.

At this variable, only one significant difference was observed. Group 0 (M = 11.05) was observed to be significantly different from Group 48 (M = 10.04) with a mean difference of -1.019 and a p-value of 0.04. Notice that this p-value is close to the alpha level, and thus this difference in means are not very dissimilar. It can be concluded that the aging treatment had trace amount of effect in color change in the yellow/blue region. However, this amount was minimal.

III. Sample OSDP

Sample OSDP observed the greatest amount of mean differences in the pair-wise comparing groups at variable ‘b’. Each variable will be discussed separately below.

OSDP- Variable ‘L’

Based on the results, only one marked significant difference was observed at this variable. At Group 48 (M = 93.56) was significantly different from Group 80 (M = 90.56), with a mean difference of -3.041 and a p-value of .001. No other unique pair comparisons were observed. It can then be concluded that with the aging treatment, the loss of gloss in the sample was detected but minimal.

Table 29: Games-Howell test of sample OSDP at variable 'L'

Multiple Comparisons: OSDP

Dependent Variable				Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
L	Games-Howell	0	16	0.1423	0.7053	1.000	-1.9085	2.1931
			32	-0.1950	0.6400	1.000	-2.0541	1.6640
			48	-1.1129	0.5305	.297	-2.6550	0.4292
			64	0.8827	0.9075	.925	-1.7650	3.5304
			80	1.9282	0.6840	.063	-0.0598	3.9161
		16	0	-0.1423	0.7053	1.000	-2.1931	1.9085
			32	-0.3373	0.7778	.998	-2.5914	1.9168
			48	-1.2552	0.6905	.459	-3.2624	0.7521
			64	0.7404	1.0094	.977	-2.1890	3.6699
			80	1.7859	0.8143	.249	-0.5734	4.1452
		32	0	0.1950	0.6400	1.000	-1.6640	2.0541
			16	0.3373	0.7778	.998	-1.9168	2.5914
			48	-0.9179	0.6236	.683	-2.7277	0.8920
			64	1.0778	0.9649	.873	-1.7268	3.8823
			80	2.1232	0.7584	.065	-0.0744	4.3208
		48	0	1.1129	0.5305	.297	-0.4292	2.6550
			16	1.2552	0.6905	.459	-0.7521	3.2624
			32	0.9179	0.6236	.683	-0.8920	2.7277
			64	1.9956	0.8960	.237	-0.6199	4.6112
			80	3.041*	0.6686	.000	1.0984	4.9837
		64	0	-0.8827	0.9075	.925	-3.5304	1.7650
			16	-0.7404	1.0094	.977	-3.6699	2.1890
			32	-1.0778	0.9649	.873	-3.8823	1.7268
			48	-1.9956	0.8960	.237	-4.6112	0.6199
			80	1.0455	0.9946	.899	-1.8422	3.9331
		80	0	-1.9282	0.6840	.063	-3.9161	0.0598
			16	-1.7859	0.8143	.249	-4.1452	0.5734
			32	-2.1232	0.7584	.065	-4.3208	0.0744
			48	-3.041082*	0.6686	.000	-4.9837	-1.0984
			64	-1.0455	0.9946	.899	-3.9331	1.8422

*. The mean difference is significant at the 0.05 level.

OSDP- Variable 'a'

Based on the results, four marked significant differences were observed at this variable, in which three of these differences were observed at Group 0. Group 0 (M = 8.994) was significantly lower than: Group 16 (M = 9.769), with a mean difference of -0.7751 and a p-value of .001; Group 48 (M = 10.462), with a mean difference of -1.468 and a p-value of .001; and Group 64 (M = 9.917), with a mean difference of -0.9223 and a p-value of .007. It can then be concluded that with the aging treatment, color difference in the treated fibers were affected in comparison to its untreated source in the red/green region.

Table 30: Games-Howell test of sample OSDP at variable 'a'

Multiple Comparisons: OSDP

Dependent Variable				Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
a	Games-Howell	0	16	-.775050*	0.1850	.001	-1.3133	-0.2368
			32	-0.7861	0.3100	.127	-1.6938	0.1216
			48	-1.468044*	0.2570	.000	-2.2189	-0.7172
			64	-.922339*	0.2546	.007	-1.6664	-0.1783
			80	-0.5546	0.1916	.052	-1.1120	0.0029
		16	0	.775050*	0.1850	.001	0.2368	1.3133
			32	-0.0111	0.3335	1.000	-0.9823	0.9602
			48	-0.6930	0.2850	.155	-1.5206	0.1346
			64	-0.1473	0.2829	.995	-0.9688	0.6742
			80	0.2205	0.2277	.927	-0.4393	0.8803
		32	0	0.7861	0.3100	.127	-0.1216	1.6938
			16	0.0111	0.3335	1.000	-0.9602	0.9823
			48	-0.6819	0.3782	.468	-1.7784	0.4146
			64	-0.1362	0.3766	.999	-1.2283	0.9558
			80	0.2316	0.3372	.983	-0.7498	1.2129
		48	0	1.468044*	0.2570	.000	0.7172	2.2189
			16	0.6930	0.2850	.155	-0.1346	1.5206
			32	0.6819	0.3782	.468	-0.4146	1.7784
			64	0.5457	0.3344	.579	-0.4230	1.5144
			80	.913487*	0.2892	.025	0.0738	1.7531
		64	0	.922339*	0.2546	.007	0.1783	1.6664
			16	0.1473	0.2829	.995	-0.6742	0.9688
			32	0.1362	0.3766	.999	-0.9558	1.2283
			48	-0.5457	0.3344	.579	-1.5144	0.4230
			80	0.3678	0.2872	.795	-0.4658	1.2014
		80	0	0.5546	0.1916	.052	-0.0029	1.1120
			16	-0.2205	0.2277	.927	-0.8803	0.4393
			32	-0.2316	0.3372	.983	-1.2129	0.7498
			48	-.913487*	0.2892	.025	-1.7531	-0.0738
			64	-0.3678	0.2872	.795	-1.2014	0.4658

*. The mean difference is significant at the 0.05 level.

OSDP- Variable 'b'

The greatest amount of change was observed at this variable, where six mean differences were noted. Five of these marked differences were observed at Group 0. Group 0 (M = 36.54) was significantly higher than: Group 16 (M = 32.01), with a mean difference of 4.531 and a p-value .001; Group 32 (M = 31.51), with a mean difference of 5.033 and a p-value .001; Group 48 (M = 34.05), with a mean difference of 2.487 and a p-value .005; Group 64 (M = 32.58), with a mean difference of 3.957 and a p-value .001; and lastly, at Group 80 (M = 30.88) with a mean difference of 5.657 and a p-value of .001. It can then be concluded that with the aging treatment, a change in color saturation in the yellow/blue region was detectable in comparison to its untreated source.

Table 31: Games-Howell test of sample OSDP at variable 'b'

Multiple Comparisons: OSDP

Dependent Variable				Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
b	Games-Howell	0	16	4.531434*	0.6021	.000	2.7751	6.2878
			32	5.032972*	0.8691	.000	2.4866	7.5794
			48	2.486964*	0.6673	.005	0.5375	4.4364
			64	3.956709*	0.8328	.000	1.5176	6.3958
			80	5.657093*	0.5325	.000	4.1064	7.2078
		16	0	-4.531434*	0.6021	.000	-6.2878	-2.7751
			32	0.5015	0.9913	.996	-2.3781	3.3811
			48	-2.0445	0.8202	.135	-4.4213	0.3323
			64	-0.5747	0.9597	.991	-3.3610	2.2116
			80	1.1257	0.7148	.617	-0.9460	3.1973
		32	0	-5.032972*	0.8691	.000	-7.5794	-2.4866
			16	-0.5015	0.9913	.996	-3.3811	2.3781
			48	-2.5460	1.0323	.143	-5.5408	0.4488
			64	-1.0763	1.1463	.936	-4.3972	2.2447
			80	0.6241	0.9507	.986	-2.1425	3.3908
		48	0	-2.486964*	0.6673	.005	-4.4364	-0.5375
			16	2.0445	0.8202	.135	-0.3323	4.4213
			32	2.5460	1.0323	.143	-0.4488	5.5408
			64	1.4697	1.0019	.686	-1.4359	4.3754
			80	3.170128*	0.7706	.001	0.9350	5.4053
		64	0	-3.956709*	0.8328	.000	-6.3958	-1.5176
			16	0.5747	0.9597	.991	-2.2116	3.3610
			32	1.0763	1.1463	.936	-2.2447	4.3972
			48	-1.4697	1.0019	.686	-4.3754	1.4359
			80	1.7004	0.9176	.437	-0.9686	4.3693
		80	0	-5.657093*	0.5325	.000	-7.2078	-4.1064
			16	-1.1257	0.7148	.617	-3.1973	0.9460
			32	-0.6241	0.9507	.986	-3.3908	2.1425
			48	-3.170128*	0.7706	.001	-5.4053	-0.9350
			64	-1.7004	0.9176	.437	-4.3693	0.9686

*. The mean difference is significant at the 0.05 level.

IV. PMCL

With this sample, the same amount of change was observed at variables ‘L’ and ‘a’. It is expected that this sample being pink, would be affected in the red/green region. Therefore, the result obtained could also be contributed to variation in this region. Each variable will be discussed separately.

PMCL- Variable ‘L’

Table 32: Games-Howell test of sample PMCL at variable ‘L’

Multiple Comparisons: PMCL

Dependent Variable		(I) Hours	(J) Hours	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
L	Games-Howell	0	16	3.670063*	1.1225	0.018	.40681*	6.9333
			32	3.766913*	0.9985	0.004	.85219*	6.6816
			48	4.323544*	0.9879	0.001	1.43786*	7.2092
			64	3.447446*	0.9487	0.007	.66857*	6.2263
			80	2.714988*	0.9711	0.069	-.12473*	5.5547
		16	0	-3.670063*	1.1225	0.018	-6.93332*	-0.4068
			32	.096850*	0.9423	1	-2.63712*	2.8308
			48	.653482*	0.9311	0.981	-2.04891*	3.3559
			64	-0.2226	0.8894	1	-2.8082	2.3630
			80	-0.9551	0.9133	0.901	-3.6073	1.6972
		32	0	-3.7669	0.9985	0.004	-6.6816	-0.8522
			16	-0.0969	0.9423	1	-2.8308	2.6371
			48	.556632*	0.7771	0.98	-1.69477*	2.8080
			64	-0.3195	0.7266	0.998	-2.4257	1.7868
			80	-1.0519	0.7556	0.732	-3.2414	1.1376
		48	0	-4.3235	0.9879	0.001	-7.2092	-1.4379
			16	-0.6535	0.9311	0.981	-3.3559	2.0489
			32	-.556632*	0.7771	0.98	-2.80804*	1.6948
			64	-0.8761	0.7120	0.821	-2.9397	1.1875
			80	-1.6086	0.7417	0.26	-3.7573	0.5402
		64	0	-3.4474	0.9487	0.007	-6.2263	-0.6686
			16	0.2226	0.8894	1	-2.3630	2.8082
			32	.319467*	0.7266	0.998	-1.78676*	2.4257
			48	0.8761	0.7120	0.821	-1.1875	2.9397
			80	-0.7325	0.6886	0.895	-2.7276	1.2626
		80	0	-2.7150	0.9711	0.069	-5.5547	0.1247
			16	0.9551	0.9133	0.901	-1.6972	3.6073
			32	1.051925*	0.7556	0.732	-1.13758*	3.2414
			48	1.6086	0.7417	0.26	-0.5402	3.7573
			64	0.7325	0.6886	0.895	-1.2626	2.7276

*. The mean difference is significant at the 0.05 level.

Six significant mean differences were observed at this variable. Similar to sample OSDP, five of these marked differences were observed at Group 0. Group 0 (M = 97.98) was significantly higher than: Group 16 (M = 94.31), with a mean difference of 3.670 and a p-value .018; Group 32 (M = 93.21), with a mean difference of 3.767 and a p-value .004; Group 48 (M = 93.66), with a mean difference of 4.324 and a p-value .001; Group 64 (M = 94.53), with a mean difference of 3.447 and a p-value .007; and lastly, at Group 80 (M = 95.26) with a mean difference of 2.715 and a p-value of .069. An incorrect estimation was observed at Group 80 where it was marked significant but the p-value is actually greater than 0.05 which would conclude as a non-significant value. Upon observing the results from Tukey, a significant p-value of 0.036 was observed. This particular result will not be concluded as significant as the p-value is below the alpha level. It can then be concluded that with the aging treatment, the gloss of the sample was affected in comparison to its untreated source.

PMCL- Variable 'a'

Unlike variable 'L' which observed six marked significant differences, these differences were observed at variable 'a'. Five of these marked differences were observed at Group 16. Group 16 (M = 2.888) was significantly higher from Group 0 (M = 32.01), with a mean difference of 4.531 and a p-value .001; Group 32 (M = 31.51), with a mean difference of 5.033 and a p-value .001; Group 48 (M = 34.05), with a mean difference of 2.487 and a p-value .005; Group 64 (M = 32.58), with a mean difference of 3.957 and a p-value .001; and lastly, at Group 80 (M = 30.88) with a mean difference of 5.657 and a p-value of .001. It can then be concluded that with the aging treatment, the treated fibers were affected in color saturation in the red/green region in comparison to its untreated source.

Table 33: Games-Howell test of sample PMCL at variable 'a'

Multiple Comparisons: PMCL

Dependent Variable	(I) Hours	(J) Hours	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Games-Howell	0	16	0.5615	0.1395	0.002	0.1546	0.9685
		32	0.4408	0.1318	0.016	0.0550	0.8265
		48	0.4351	0.1689	0.113	-0.0554	0.9256
		64	0.5817	0.1514	0.003	0.1415	1.0219
		80	.50534689*	0.1405	0.007	.0956998*	0.9150
	16	0	-.56151839*	0.1395	0.002	-.9684504*	-0.1546
		32	-.12074983*	0.1039	0.854	-.4219258*	0.1804
		48	-.12640933*	0.1482	0.957	-.5569092*	0.3041
		64	.02019917*	0.1278	1	-.3503806*	0.3908
		80	-.05617150*	0.1147	0.996	-.3885597*	0.2762
	32	0	-.44076856*	0.1318	0.016	-.8265240*	-0.0550
		16	.12074983*	0.1039	0.854	-.1804261*	0.4219
		48	-0.0057	0.1409	1	-0.4161	0.4048
		64	0.1409	0.1193	0.845	-0.2057	0.4876
		80	0.0646	0.1052	0.99	-0.2404	0.3696
	48	0	-0.4351	0.1689	0.113	-0.9256	0.0554
		16	.12640933*	0.1482	0.957	-.3040905*	0.5569
		32	0.0057	0.1409	1	-0.4048	0.4161
		64	0.1466	0.1594	0.941	-0.3155	0.6088
		80	0.0702	0.1491	0.997	-0.3628	0.5033
	64	0	-0.5817	0.1514	0.003	-1.0219	-0.1415
		16	-.02019917*	0.1278	1	-.3907789*	0.3504
		32	-0.1409	0.1193	0.845	-0.4876	0.2057
		48	-0.1466	0.1594	0.941	-0.6088	0.3155
		80	-0.0764	0.1289	0.991	-0.4500	0.2973
	80	0	-0.5053	0.1405	0.007	-0.9150	-0.0957
		16	.05617150*	0.1147	0.996	-.2762167*	0.3886
		32	-0.0646	0.1052	0.99	-0.3696	0.2404
		48	-0.0702	0.1491	0.997	-0.5033	0.3628
		64	0.0764	0.1289	0.991	-0.2973	0.4500

*. The mean difference is significant at the 0.05 level.

PMCL- Variable 'b'

The greatest amount of change was observed at this variable, where six mean differences were noted. Five of these marked differences were observed at Group 0. Group 0 (M = 36.54) was significantly higher from Group 16 (M = 32.01), with a mean difference of 4.531 and a p-value .001; Group 32 (M = 31.51), with a mean difference of 5.033 and a p-value .001; Group 48 (M =

34.05), with a mean difference of 2.487 and a p-value .005; Group 64 (M = 32.58), with a mean difference of 3.957 and a p-value .001; and lastly, at Group 80 (M = 30.88) with a mean difference of 5.657 and a p-value of .001. It can then be concluded that with the aging treatment, the treated fibers were affected in comparison to its untreated source.

Table 34: Games-Howell test of sample PMCL at variable 'b'

Multiple Comparisons: PMCL

Dependent Variable		(I) Hours	(J) Hours	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
b	Games-Howell	0	16	1.1255	0.2134	0	0.5020	1.7490
			32	0.5369	0.2040	0.103	-0.0611	1.1348
			48	0.7225	0.2706	0.09	-0.0633	1.5083
			64	.7066339*	0.2361	0.04	.019864*	1.3934
			80	0.7197	0.2649	0.081	-0.0497	1.4891
		16	0	-1.1255	0.2134	0	-1.7490	-0.5020
			32	-0.5887	0.1514	0.002	-1.0275	-0.1498
			48	-0.4030	0.2335	0.518	-1.0824	0.2763
			64	-.4188787*	0.1924	0.257	-.977094*	0.1393
			80	-.4057937*	0.2269	0.478	-1.065603*	0.2540
		32	0	-.5368619*	0.2040	0.103	-1.134822*	0.0611
			16	.5886507*	0.1514	0.002	.149795*	1.0275
			48	.1856385*	0.2249	0.962	-.470238*	0.8415
			64	.1697720*	0.1820	0.937	-.358975*	0.6985
			80	.1828570*	0.2181	0.959	-.452694*	0.8184
		48	0	-.7225004*	0.2706	0.09	-1.508322*	0.0633
			16	0.4030	0.2335	0.518	-0.2763	1.0824
			32	-0.1856	0.2249	0.962	-0.8415	0.4702
			64	-0.0159	0.2544	1	-0.7537	0.7220
			80	-0.0028	0.2813	1	-0.8179	0.8123
		64	0	-.7066339*	0.2361	0.04	-1.393404*	-0.0199
			16	0.4189	0.1924	0.257	-0.1393	0.9771
			32	-0.1698	0.1820	0.937	-0.6985	0.3590
			48	0.0159	0.2544	1	-0.7220	0.7537
			80	0.0131	0.2483	1	-0.7070	0.7332
		80	0	-.7197189*	0.2649	0.081	-1.489096*	0.0497
			16	0.4058	0.2269	0.478	-0.2540	1.0656
			32	-0.1829	0.2181	0.959	-0.8184	0.4527
			48	0.0028	0.2813	1	-0.8123	0.8179
			64	-0.0131	0.2483	1	-0.7332	0.7070

*. The mean difference is significant at the 0.05 level.

V. PMJX

Sample PMJX, in comparison to all the reference samples, observed the greatest amount of change at variable ‘b’ and it was the only sample that didn’t observe any changes at variable ‘L’. Unlike sample PMJX, sample PMJX observed greatest amount of change in the blue/yellow region. This result was not expected as this fiber is pink, and thus variation in the red/green region is more likely.

PMJX- Variable ‘L’

The null hypothesis of each mean group being the same was accepted for the sample at this variable. With supporting evidence, the aging treatment did not alter the gloss of the sample.

PMJX- Variable ‘a’

Five marked significant differences were observed at this variable where four was observed at Group 48.Group 48 (M = 2.412) was significantly lower than: Group 0 (M = 2.947), with a mean difference of -0.5354 and a p-value .002; Group 16 (M = 2.953), with a mean difference of -0.5408 and a p-value .001; Group 64 (M = 3.096), with a mean difference of -0.6843 and a p-value .001; and lastly, at Group 80 (M = 3.123) with a mean difference of -0.7110 and a p-value of .001. It can then be concluded that with the aging treatment, at 16 hours of aging, the greatest amount of change in color saturation occurred in the red/green region.

Table 35: Games-Howell test of sample PMJX at variable ‘a’

Multiple Comparisons: PMJX

Dependent Variable				Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
a	Games-Howell	0	16	-0.0054	0.1439	1.000	-0.4269	0.4160
			32	0.2518	0.1533	.573	-0.1954	0.6990
			48	.53538192*	0.1338	.002	0.1405	0.9303
			64	-0.1490	0.1654	.945	-0.6301	0.3321
			80	-0.1757	0.1407	.811	-0.5885	0.2372
		16	0	0.0054	0.1439	1.000	-0.4160	0.4269
			32	0.2572	0.1128	.211	-0.0698	0.5843
			48	.54083186*	0.0844	.000	0.2956	0.7861
			64	-0.1435	0.1287	.874	-0.5174	0.2304
			80	-0.1702	0.0949	.474	-0.4453	0.1049
		32	0	-0.2518	0.1533	.573	-0.6990	0.1954
			16	-0.2572	0.1128	.211	-0.5843	0.0698
			48	0.2836	0.0997	.059	-0.0067	0.5738
			64	-0.4008	0.1392	.053	-0.8043	0.0027
			80	-.42746017*	0.1087	.002	-0.7429	-0.1121
		48	0	-.53538192*	0.1338	.002	-0.9303	-0.1405
			16	-.54083186*	0.0844	.000	-0.7861	-0.2956
			32	-0.2836	0.0997	.059	-0.5738	0.0067
			64	-.68434686*	0.1174	.000	-1.0271	-0.3416
			80	-.71104470*	0.0789	.000	-0.9400	-0.4821
		64	0	0.1490	0.1654	.945	-0.3321	0.6301
			16	0.1435	0.1287	.874	-0.2304	0.5174
			32	0.4008	0.1392	.053	-0.0027	0.8043
			48	.68434686*	0.1174	.000	0.3416	1.0271
			80	-0.0267	0.1252	1.000	-0.3907	0.3373
		80	0	0.1757	0.1407	.811	-0.2372	0.5885
			16	0.1702	0.0949	.474	-0.1049	0.4453
			32	.42746017*	0.1087	.002	0.1121	0.7429
			48	.71104470*	0.0789	.000	0.4821	0.9400
			64	0.0267	0.1252	1.000	-0.3373	0.3907

*. The mean difference is significant at the 0.05 level.

PMJX –Variable ‘b’

The greatest amount of change was observed at this variable, where nine marked mean differences were noted. This was the only sample that observed a substantial amount of marked mean differences in any variable. Four of these marked differences were observed at Group 32. Group 32 (M = 4.800) was significantly lower than: Group 0 (M = 6.056), with a mean difference of -1.257 and a p-value .001; Group 16 (M = 5.474), with a mean difference of -0.675 and a p-value .031; Group 64 (M = 6.050), with a mean difference of -1.250 and a p-value .001;

and lastly, at Group 80 (M = 6.306) with a mean difference of -1.506 and a p-value of .001. It can then be concluded that with the aging treatment, at 16 hours of aging, the greatest amount of change in color saturation occurred in the yellow/blue region.

Table 36: Games-Howell test of sample PMJX at variable 'b'

Multiple Comparisons: PMJX

Dependent Variable				Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
b	Games-Howell	0	16	0.5819	0.2751	.292	-0.2242	1.3880
			32	1.25650672*	0.2986	.001	0.3858	2.1272
			48	1.41725926*	0.2593	.000	0.6528	2.1817
			64	0.0064	0.3129	1.000	-0.9043	0.9171
			80	-0.2497	0.2679	.937	-1.0366	0.5373
		16	0	-0.5819	0.2751	.292	-1.3880	0.2242
			32	.67460983*	0.2196	.031	0.0375	1.3117
			48	.83536237*	0.1622	.000	0.3646	1.3061
			64	-0.5755	0.2387	.162	-1.2687	0.1177
			80	-.83158417*	0.1756	.000	-1.3403	-0.3228
		32	0	-1.25650672*	0.2986	.001	-2.1272	-0.3858
			16	-.67460983*	0.2196	.031	-1.3117	-0.0375
			48	0.1608	0.1996	.966	-0.4203	0.7418
			64	-1.25012700*	0.2655	.000	-2.0195	-0.4808
			80	-1.50619400*	0.2106	.000	-2.1178	-0.8946
		48	0	-1.41725926*	0.2593	.000	-2.1817	-0.6528
			16	-.83536237*	0.1622	.000	-1.3061	-0.3646
			32	-0.1608	0.1996	.966	-0.7418	0.4203
			64	-1.41087954*	0.2204	.000	-2.0535	-0.7682
			80	-1.66694654*	0.1497	.000	-2.1010	-1.2329
		64	0	-0.0064	0.3129	1.000	-0.9171	0.9043
			16	0.5755	0.2387	.162	-0.1177	1.2687
			32	1.25012700*	0.2655	.000	0.4808	2.0195
			48	1.41087954*	0.2204	.000	0.7682	2.0535
			80	-0.2561	0.2304	.875	-0.9262	0.4140
		80	0	0.2497	0.2679	.937	-0.5373	1.0366
			16	.83158417*	0.1756	.000	0.3228	1.3403
			32	1.50619400*	0.2106	.000	0.8946	2.1178
			48	1.66694654*	0.1497	.000	1.2329	2.1010
			64	0.2561	0.2304	.875	-0.4140	0.9262

*. The mean difference is significant at the 0.05 level.

VI. PMP

Sample PMP met the homogeneity of variance assumption only for variable ‘b’. The Games-Howell test was used to calculate variables ‘L’ and ‘a’, and the Tukey test used to calculate ‘b’.

PMP- Variable ‘L’

This sample observed the greatest amount of mean differences than any other reference samples at this variable. It observed seven marked mean differences in total. Even with the value, there was no one group that truly stood out from the rest. Group 0 and 32 observed three marked differences, where the rest observed two. It can then be concluded that with the aging treatment, loss of gloss in the sample was gradually affected as the sample was aged.

Table 37: Games-Howell test of sample PMP at variable ‘L’

Multiple Comparisons: PMP

Dependent Variable				Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
L	Games-Howell	0	16	2.8909606*	0.9498	.034	0.1320	5.6499
			32	4.2820656*	0.7495	.000	2.0842	6.4800
			48	4.5949556*	0.9057	.000	1.9625	7.2274
			64	2.0040	0.7349	.084	-0.1549	4.1629
			80	1.6833	0.9642	.505	-1.1172	4.4837
		16	0	-2.8909606*	0.9498	.034	-5.6499	-0.1320
			32	1.3911	0.7657	.460	-0.8396	3.6218
			48	1.7040	0.9191	.436	-0.9591	4.3671
			64	-0.8870	0.7514	.845	-3.0787	1.3047
			80	-1.2077	0.9768	.818	-4.0376	1.6222
		32	0	-4.2820656*	0.7495	.000	-6.4800	-2.0842
			16	-1.3911	0.7657	.460	-3.6218	0.8396
			48	0.3129	0.7102	.998	-1.7537	2.3795
			64	-2.2780733*	0.4736	.000	-3.6504	-0.9057
			80	-2.5987733*	0.7835	.016	-4.8821	-0.3154
		48	0	-4.5949556*	0.9057	.000	-7.2274	-1.9625
			16	-1.7040	0.9191	.436	-4.3671	0.9591
			32	-0.3129	0.7102	.998	-2.3795	1.7537
			64	-2.5909633*	0.6948	.004	-4.6151	-0.5668
			80	-2.9116633*	0.9340	.027	-5.6181	-0.2052
		64	0	-2.0040	0.7349	.084	-4.1629	0.1549
			16	0.8870	0.7514	.845	-1.3047	3.0787
			32	2.2780733*	0.4736	.000	0.9057	3.6504
			48	2.5909633*	0.6948	.004	0.5668	4.6151
			80	-0.3207	0.7695	.998	-2.5660	1.9246
		80	0	-1.6833	0.9642	.505	-4.4837	1.1172
			16	1.2077	0.9768	.818	-1.6222	4.0376
			32	2.5987733*	0.7835	.016	0.3154	4.8821
			48	2.9116633*	0.9340	.027	0.2052	5.6181
			64	0.3207	0.7695	.998	-1.9246	2.5660

*. The mean difference is significant at the 0.05 level.

PMP- Variable 'a'

At this variable, five marked mean differences were noted. Four of these marked differences were observed at Group 80. Group 80 (M = 4.800) was significantly lower than: Group 0 (M = 6.660), with a mean difference of -0.8022 and a p-value .03; Group 16 (M = 7.164), with a mean difference of -1.306 and a p-value .001; Group 32 (M = 6.909), with a mean difference of -1.052 and a p-value .005; and lastly, at Group 64 (M = 6.582) with a mean difference of -0.725 and a p-value of .045. Although Group 64 was marked as significantly different, based on the p-values, this result is rejected as being significant. At 80 hours of aging, the greatest amount of change in color saturation occurred in the red/green region.

Table 38: Games-Howell test of sample PMP at variable 'a'

Multiple Comparisons: PMP

Dependent Variable				Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
a	Games-Howell	0	16	-0.5037	0.2058	.151	-1.1022	0.0949
			32	-0.2494	0.2490	.916	-0.9757	0.4768
			48	0.4470	0.2479	.469	-0.2759	1.1699
			64	0.0775	0.2033	.999	-0.5137	0.6688
			80	.80218850*	0.2101	.003	0.1910	1.4134
		16	0	0.5037	0.2058	.151	-0.0949	1.1022
			32	0.2542	0.2828	.946	-0.5658	1.0743
			48	.95063450*	0.2818	.013	0.1335	1.7678
			64	0.5812	0.2435	.169	-0.1242	1.2866
			80	1.30585317*	0.2492	.000	0.5840	2.0277
		32	0	0.2494	0.2490	.916	-0.4768	0.9757
			16	-0.2542	0.2828	.946	-1.0743	0.5658
			48	0.6964	0.3148	.240	-0.2155	1.6083
			64	0.3270	0.2810	.853	-0.4880	1.1419
			80	1.05162583*	0.2859	.005	0.2226	1.8806
		48	0	-0.4470	0.2479	.469	-1.1699	0.2759
			16	-.95063450*	0.2818	.013	-1.7678	-0.1335
			32	-0.6964	0.3148	.240	-1.6083	0.2155
			64	-0.3694	0.2800	.774	-1.1815	0.4426
			80	0.3552	0.2849	.813	-0.4709	1.1814
		64	0	-0.0775	0.2033	.999	-0.6688	0.5137
			16	-0.5812	0.2435	.169	-1.2866	0.1242
			32	-0.3270	0.2810	.853	-1.1419	0.4880
			48	0.3694	0.2800	.774	-0.4426	1.1815
			80	.72464433*	0.2471	.045	0.0087	1.4406
		80	0	-.80218850*	0.2101	.003	-1.4134	-0.1910
			16	-1.30585317*	0.2492	.000	-2.0277	-0.5840
			32	-1.05162583*	0.2859	.005	-1.8806	-0.2226
			48	-0.3552	0.2849	.813	-1.1814	0.4709
			64	-.72464433*	0.2471	.045	-1.4406	-0.0087

*. The mean difference is significant at the 0.05 level.

PMP- Variable 'b'

Table 39: Tukey test of sample PMP at variable 'b'

		Tukey HSD test; Variable: b (PMP spreadsheet) Marked differences are significant at p < .05000					
Hours		{1} M=-8.771	{2} M=-10.02	{3} M=-9.887	{4} M=-8.914	{5} M=-10.91	{6} M=-11.23
0	{1}		0.31114	0.44623	0.99990	***0.00592***	***0.00081***
16	{2}	0.31114		0.99988	0.36140	0.61524	0.27234
32	{3}	0.44623	0.99988		0.51584	0.45394	0.16612
48	{4}	0.99990	0.36140	0.51584		***0.00534***	***0.00061***
64	{5}	***0.00592***	0.61524	0.45394	***0.00534***		0.99383
80	{6}	***0.00081***	0.27234	0.16612	***0.00061***	0.99383	

Table 40: Homogeneous Subset of sample PMP at variable 'b'

Homogeneous Subsets PMP Variable 'b'

Hours		N	Subset for alpha = 0.05	
			1	2
Tukey HSD[a,b]	80	60	-11.226	
	64	60	-10.913	
	16	60	-10.024	-10.024
	32	60	-9.887	-9.887
	48	60		-8.914
	0	45		-8.771
	Sig.		.193	.259

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 56.842.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Both tables will be used to analyze and interpret the Tukey results. Tukey table above was generated using the Statistica software, and the Homogeneous table was generated using the SPSS software. Both tables were used in conjunction because they both show the results of the multiple pair-wise comparisons among the groups but in slightly different ways.

Four marked differences were noted: Group 1 and 4 (0 and 48 hours, respectively), observed significant differences with Groups 5 and 6 (64 and 80 hours, respectively). It can also be observed that the means of Group 1 and 4 are significantly smaller than Group 5 and 6 but are not significantly different within each other. This is better explained using the homogeneous table. Two subsets were created for this variable, meaning that these two subsets were significantly different from each other but not different within each other. The commonalities between these groups are at hours 16 and 32; there is no difference in means in comparison to the remaining hours. However, since hours 64 and 80 hours in subset 1 does not share its values in subset 2, means that these group means are significantly different. And likewise for hours 0 and 48. With such low significant mean differences, it can be concluded that the aging treatment caused detectable, yet trace amounts of change in color saturation in the yellow/blue region.

VII. RMP

Similarly to sample PMP, sample RMP meet the homogeneity of variance assumption for variable 'L'.

RMP- Variable 'L'

Table 41: Tukey test of sample RMP at variable 'L'

	Tukey HSD test; Variable: L (RMP spreadsheet) Marked differences are significant at p < .05000					
Hours	{1} M=80.848	{2} M=81.810	{3} M=82.524	{4} M=82.084	{5} M=83.530	{6} M=80.481
0 {1}		0.8178	0.2579	0.6039	***0.0073***	0.9971
16 {2}	0.8178		0.9205	0.9990	0.1589	0.4348
32 {3}	0.2579	0.9205		0.9903	0.7274	0.0514
48 {4}	0.6039	0.9990	0.9903		0.3362	0.2242
64 {5}	***0.0073***	0.1589	0.7274	0.3362		***0.0003***
80 {6}	0.9971	0.4348	0.0514	0.2242	***0.0003***	

Two marked differences were noted: Group 1 (0 hours, M = 80.85), observed significant differences with Groups 5 (64 hours, M = 83.54), which also observed significant differences with Group 6 (80 hours, M = 80.48). The mean value of Group 5 is significantly greater than Group 1 and 6; hence, Group 5 was placed in a separate subset as observed in the homogeneous table. Two subsets were created for this variable, meaning that these two subsets were significantly different from each other but not different within each other. The commonalities between these groups are at hours 16, 32 and 48; these values share no significant difference in means in comparison to the remaining hours. However, since subset 1 at 0 and 80 hours does not share its values in subset 2, means that these group means are significantly different from 64 hours in subset 2. It can be concluded that trace amount of loss of gloss occurred.

Table 42: Homogeneous Subset of sample RMP at variable 'L'

Homogeneous Subsets: RMP Variable 'L'

Hours		N	Subset for alpha = 0.05	
			1	2
Tukey HSD[a,b]	80	60	80.481	
	0	45	80.848	
	16	60	81.810	81.810
	48	60	82.084	82.084
	32	60	82.524	82.524
	64	60		83.537
	Sig.		.066	.182

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 56.842.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

RMP –Variable 'a'

Only two marked significant mean differences were observed at this variable. At some groups, for example at Group 80, no significant mean differences were observed. There were not one group that was distinctive than the rest. With such low significant mean differences, it can be concluded that the aging treatment caused detectable, yet trace amounts of change in color saturation in the red/green region.

Table 43: Games-Howell test of sample RMP at variable 'a'

Multiple Comparisons: RMP

Dependent Variable				Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
a	Games-Howell	0	16	-2.1713641*	0.4695	.000	-3.5502	-0.7925
			32	0.6646	0.8350	.968	-1.7660	3.0951
			48	-0.9389	0.6320	.674	-2.7742	0.8964
			64	-0.7268	0.9493	.973	-3.4951	2.0415
			80	-1.6709	0.7341	.214	-3.8044	0.4627
		16	0	2.1713641*	0.4695	.000	0.7925	3.5502
			32	2.8359191*	0.7498	.004	0.6376	5.0343
			48	1.2325	0.5142	.170	-0.2685	2.7334
			64	1.4446	0.8754	.569	-1.1248	4.0139
			80	0.5005	0.6356	.969	-1.3599	2.3609
		32	0	-0.6646	0.8350	.968	-3.0951	1.7660
			16	-2.8359191*	0.7498	.004	-5.0343	-0.6376
			48	-1.6034	0.8609	.431	-4.1043	0.8974
			64	-1.3914	1.1149	.812	-4.6228	1.8401
			80	-2.3354	0.9385	.136	-5.0558	0.3849
		48	0	0.9389	0.6320	.674	-0.8964	2.7742
			16	-1.2325	0.5142	.170	-2.7334	0.2685
			32	1.6034	0.8609	.431	-0.8974	4.1043
			64	0.2121	0.9722	1.000	-2.6176	3.0418
			80	-0.7320	0.7635	.930	-2.9459	1.4820
		64	0	0.7268	0.9493	.973	-2.0415	3.4951
			16	-1.4446	0.8754	.569	-4.0139	1.1248
			32	1.3914	1.1149	.812	-1.8401	4.6228
			48	-0.2121	0.9722	1.000	-3.0418	2.6176
			80	-0.9441	1.0415	.944	-3.9670	2.0789
		80	0	1.6709	0.7341	.214	-0.4627	3.8044
			16	-0.5005	0.6356	.969	-2.3609	1.3599
			32	2.3354	0.9385	.136	-0.3849	5.0558
			48	0.7320	0.7635	.930	-1.4820	2.9459
			64	0.9441	1.0415	.944	-2.0789	3.9670

*. The mean difference is significant at the 0.05 level.

RMP- Variable 'b'

Only four marked significant mean differences were observed at this variable. At some groups, for example, at Group 64, no significant mean differences were observed. No one group was distinctive than the other. With such low significant mean differences, it can be concluded that the aging treatment caused detectable, yet trace amounts of change in color saturation in the yellow/blue region.

Table 44: Games-Howell test of sample RMP at variable 'b'

Multiple Comparisons: RMP

Dependent Variable				Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
b	Games-Howell	0	16	-0.6269	0.3088	.335	-1.5299	0.2761
			32	1.4819	0.6551	.222	-0.4311	3.3949
			48	0.5421	0.4290	.804	-0.7039	1.7881
			64	-0.6096	0.6500	.935	-2.5074	1.2882
			80	-1.3973	0.5775	.161	-3.0808	0.2862
		16	0	0.6269	0.3088	.335	-0.2761	1.5299
			32	2.1088410*	0.6213	.014	0.2865	3.9312
			48	1.1690590*	0.3752	.029	0.0748	2.2633
			64	0.0173	0.6159	1.000	-1.7890	1.8236
			80	-0.7703	0.5388	.709	-2.3489	0.8082
		32	0	-1.4819	0.6551	.222	-3.3949	0.4311
			16	-2.1088410*	0.6213	.014	-3.9312	-0.2865
			48	-0.9398	0.6890	.748	-2.9446	1.0650
			64	-2.0915	0.8445	.140	-4.5380	0.3550
			80	-2.8791803*	0.7901	.005	-5.1689	-0.5894
		48	0	-0.5421	0.4290	.804	-1.7881	0.7039
			16	-1.1690590*	0.3752	.029	-2.2633	-0.0748
			32	0.9398	0.6890	.748	-1.0650	2.9446
			64	-1.1517	0.6841	.546	-3.1421	0.8386
			80	-1.9393983*	0.6156	.025	-3.7276	-0.1512
		64	0	0.6096	0.6500	.935	-1.2882	2.5074
			16	-0.0173	0.6159	1.000	-1.8236	1.7890
			32	2.0915	0.8445	.140	-0.3550	4.5380
			48	1.1517	0.6841	.546	-0.8386	3.1421
			80	-0.7877	0.7858	.916	-3.0650	1.4897
		80	0	1.3973	0.5775	.161	-0.2862	3.0808
			16	0.7703	0.5388	.709	-0.8082	2.3489
			32	2.8791803*	0.7901	.005	0.5894	5.1689
			48	1.9393983*	0.6156	.025	0.1512	3.7276
			64	0.7877	0.7858	.916	-1.4897	3.0650

*. The mean difference is significant at the 0.05 level.

2) Post Hoc Comparisons of Lab grouped by 'Sample Area'

Based on the previous ANOVA results, the pink and red colors observed similarities in mean values for variables ‘a’ and ‘b’. The post hoc tests were applied to acknowledge and locate the similarities. Both the Tukey and G-H test was applied depending upon the homogeneity of variance result. The results are discussed separately below by reference samples. The descriptives, and post hoc comparison results can be found in Section 7-11 in the appendix.

DPMP

No significant values were observed at the ‘L’ variable. Sample DPMP observed significant values at sample area A. As the areas are paired; only at area A was significant difference in means was observed. This was observed at both dependent variables. No further mean differences were observed to be significant.

PMCL

No significant values were observed at the ‘L’ variable. Mean significant difference was only observed between the pair-wise groups at sample area B*C for variable ‘a’. This concludes that between these two areas, the mean differences are significant different. For variable ‘b’, marked significant mean differences were observed for any pair-wise groups that contained sample area C.

PMJX

No significant values were observed at the ‘L’ variable. At variable ‘a’, only pair-wise A*B group observed significant mean difference. It can be concluded that at these sample areas, the mean differences between the two groups are significantly different. At variable ‘b’, only pair-wise B*C group observed significant mean difference.

RMP

No significant values were observed at the ‘L’ variable. Significant values were observed at area B and C for all their pair-wise groups, for variable ‘a’ and ‘b’ respectively.

6.4 Summary of Aged Results

Hours

In summary, post hoc comparison tests were applied because these tests are able to determine which groups differ from each other based on the ANOVA results. The majority of the results were interpreted from the G-H test. The results of the G-H test shows that the treatment effect of aging influenced the mean values of the dependent variables. Through the aging study, there were limited recognizable patterns that would assist in understanding how fibers are affected UV exposure.

The variable mostly affected by this treatment was variable ‘a’. Thirty two marked significant differences were observed overall at this variable, 29 was observed for variable ‘b’ and 27 for variable ‘L’. For each sample, the affect varied among the variables. The five samples that are similar in hue produced different results: sample DPMP was equally affected at variables ‘L’ and ‘a’ suggesting that not only was the gloss of the sample affected, the red/green region was also affected. One marked difference was observed at ‘b’, suggesting that the yellow/blue region was not extensively affected by this treatment.

Samples PMCL and PMJX observed differences in how ‘L’ and ‘b’ variables were affected. PMCL observed six marked significant differences at both variables implying that both variables were equally affected by this treatment. Not only was the lightness of the sample affected, the red/green region was also affected. Variable ‘b’ observed four significant differences. Unlike sample PMCL, PMJX did not observe significant difference at variable ‘L’. It can be concluded that the lightness of the sample was not affected by the treatment. Variable ‘b’ observed nine marked significant differences. This sample observed the greatest amount of change in the yellow/blue region. Therefore, at this region, the two samples can be differentiated.

Samples PMP and RMP which are adjacent on the CIELab color space, only observed similarities at the ‘b’ variable where both observed four marked differences. They were equally affected in the yellow/blue region. The opposite is true for the remaining variables; at variable ‘L’, seven and three significant differences were observed, and at variable ‘a’, five and two significant differences were observed for samples PMP and RMP, respectively. The aging treatment had a greater impact on sample PMP.

Sample GMP observed equal effects at variables ‘L’ and ‘a’ concluding that both the lightness of the sample and the red/green region of the color were affected by the treatment. Similar to sample DPMP, only one marked significant difference was observed at variable ‘b’.

Lastly, sample OSDP observed the greatest amount of change at variable ‘b’ where six marked differences was observed. Variable ‘a’, which had four marked differences, was also affected in the red/green region by the aging treatment. Variable ‘L’, which only observed a single difference, was not extensively affected by this treatment.

It is understandable that the greatest amount of variation would occur at variable ‘a’ as most of the colors correspond to the red/green region of the color space. With this in mind, changes observed from the treatment could have been influenced by the variations in the chroma and hue of the colors being analyzed.

Sample Area

Similarity was observed for all the samples at the 'L' variable as the values were all insignificantly different. Upon further evaluation of the sample area, it can be estimated that at variable 'a', sample area B produced the greatest amount of significant differences in means among the samples. At variable 'b', sample area C produced the greatest amount of significant differences in means among the samples. For this reason, even though sample area was used to evaluate inter-variability among the garments, the gloss of the sample was not affected by this variation. On the contrary, the red/green and yellow/blue regions are greatly affected by variations found within a garment.

6.5.1 Analysis of the Washed-Aged Results- Part two of this study focused on understanding the degradation of fibers through a process of washing and aging as one would expect of a garment that is worn and washed repeatedly.

6.5.1a Normality Testing of the Washed-Aged Samples

For normal distribution determination, a chart producing a histogram, normal plot and a box and whisker plot was graphed. The two statistical tests, K-S Lillefors and S-W tests were employed for each variable to check normality. The data analysis was broken down into four separate steps because of the type of analysis that was performed on the samples. These steps were:

1) Normal distribution was calculated for the overall Lab variables;

2) Normal distribution was calculated of 'Hours' and 'Swatch' for each Lab value;

3) Normal distribution was calculated of ‘Hours’, ‘Swatch’, and ‘Sample Area’ for each Lab value;

4) Normal distribution was calculated of ‘Hours’, ‘Swatch’, ‘Sample Area’ and ‘Fiber’ for each Lab value. (Since it is impossible to analyze the same fiber aged at different time interval, the analyzed fiber varied between hours aged);

1) Normal distribution with all groups against variables Lab.

A histogram, normal plot and box and whisker plot was plotted for each CIE value. Based on the calculated p-value, only reference sample OSDP observed normal distribution, however, only at variable ‘L’. No other reference samples were observed to be normally distributed at this level of interaction. It is understandable that normal distribution may not occur at this level of testing.

2) Normal distribution of ‘Hours’ and ‘Swatch’ for each Lab value.

Six reference samples observed normal distribution at one to three places of the analysis. Reference sample GMP observed two significant p-values: first wash and 16 hours aged, swatch 1 at variable ‘L’; fifth wash and 64 hours aged, swatch 1 at variable ‘b’.

3) Normal distribution of ‘Hours’, ‘Swatch’ and ‘Sample Area’ for each Lab value.

On each swatch, two areas were separated and assigned as sample areas A and B. From these areas, different fibers were extracted and analyzed during the wash-aged cycle. In total, 108 charts were plotted with these results. From the results, only six reference samples were observed to be normally distribution.

4) Normal distribution of ‘Hours’, ‘Swatch’, ‘Sample Area’ and ‘Fiber’ for each Lab value.

In total, 69 fibers were analyzed over the washed and aged cycle. Since the same fiber cannot be washed and analyzed because of the difficulty in washing a single fiber, the same fiber was not studied between cycles. Similar to the aged results, normal distribution was observed for all the reference samples but not for all data measurements. Again, at this discrete level, a normal distribution should be expected because the sample set taken from a larger population (in this case, the sample area) should have a smaller variance and standard deviation than from the larger population. However, small discrepancies were still present; normal distribution was rejected for certain measurements when the analysis of the fiber was performed at two locations on that fiber. However, this was not always the case; some variables still observed a normal distribution while others did not.

Based on the results, it can be estimated that the fibers comes from a normally distributed sample although variation within the fibers exist and sometimes will affect this result.

6.5.2 Multifactorial ANOVA of Washed-Aged Results

Multifactorial ANOVA analysis was performed on the samples that were washed and aged during the experiment. The questions addressed in this part of the analysis were:

- Are there significant changes observed in the washed-aged process?
    - If so, what are these changes and where do they occur?

To answer these questions, two hypotheses were created:

- H_o: $\mu_1 = \mu_2 = \mu_3 = \ldots \mu_k$ (no mean difference observed between population);
- H_1: at least one μ is different (at least two of the population means are different).

The analysis was broken down into nine steps:

1) The main effects of 'Sample Area' against the Lab variables;
2) The main effects of 'Swatch' against the Lab variables;
3) The main effects of 'Bleached' against the Lab variables;
4) The main effects of 'Washing' against the Lab variables;
5) The interaction effects of 'Sample Area * Swatch' against the Lab variables;
6) The interaction effects of 'Sample Area * Bleached' against the Lab variables;
7) The interaction effects of 'Washing * Bleached' against the Lab variables;
8) The interaction effects of 'Washing * Swatch' against the Lab variables;

The results were tabulated into four tables; the first table of the output, labeled Between-Subjects Factors, summarized the factors, showing how they were labeled and how many scores were in each group; the second table, labeled Test of Between-Subjects Effects, is a standard ANOVA table that includes an additional column for the sources of variations analyzed. This included the main and interaction effects of the factors chosen for analysis; the third output table generates specific under the heading Estimated Marginal Means. These provide the means of the main effect factors and the pair-wise comparisons for these effects separately, as well as the groups that were chosen to be examined for the interaction effects. In this project, 12 tables were generated; and the last item of the output was the interaction diagrams for each groups of interaction that were analyzed. As an option, the Descriptive Statistics table, analogous to the one produced in the one-way ANOVA method, was also generated and is located in the appendix. The results of these analyses will be independently discussed for specific reference samples of interest. The results and discussion of the remaining samples are located in the appendix.

I. Sample DPMP

DPMP-Variable 'L'

This table summarizes the selected groups, the levels associated within each group or their between-subject factors, their corresponding labels and the total amount of values or scores in each factor. This table can be used as a reference for the samples as all the reference samples shared the same groups, between-subject factors, labels and scores.

Between-Subjects Factors: DPMP Variable L

		Value Label	N
Sample Area	A		440
	B		440
Swatch	1	1 w/ bleach	220
	2	2 w/ bleach	220
	3	3 w/o bleach	220
	4	4 w/o bleach	220
bleached	1	w/ bleach	440
	2	w/o bleach	440
washings	1	1W 0A	80
	2	1W 16A	160
	3	2W 32A	160
	4	3W 48A	160
	5	4W 64A	160
	6	5W 80A	160

In the Test of Between-Subject Effects table below, the first column identifies the sources being used for analysis. This includes the factors investigated for their main and interaction effects.

The Corrected Model takes into account the summarizations of the sum of squares main effects and the sum of squares interaction effects. It accounts for the deviation of the cell means for each main effect plus any deviation present in the form of interactions. In other words, it corresponds to the within- between-group values. The Intercept is the grand mean of all the data squared and multiplied by the total observations. It tests the null hypothesis that the grand mean of all the data is equal to zero. A statistical significant intercept is when the grand mean of the data is not equal to zero. This term, although useful, will not be further explored as it is more meaningful when applied to advanced statistical models. There are four sources of main effects evaluated and 11 potential interaction effects, seven of which produces a result. These potential interactions have a value of 0 in columns 2 and 3, and no values in the remaining columns. This will be discussed further below.

Tests of Between-Subjects Effects: DPMP

Dependent Variable: L

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3353.870[a]	43	77.997	7.235	0.000
Intercept	6044243	1	6044243	560625.5	0.000
SampleArea	0.006	1	0.006	0.001	0.982
Swatch	241.432	2	120.716	11.197	0.000
Bleached	0	0	.	.	.
Washing	693.601	5	138.72	12.867	0.000
SampleArea * Swatch	202.673	2	101.337	9.399	0.000
SampleArea * Bleached	0	0	.	.	.
SampleArea * Washing	185.185	4	46.296	4.294	0.002
Swatch * Bleached	0	0	.	.	.
Swatch * Washing	612.796	8	76.6	7.105	0.000
Bleached * Washing	0	0	.	.	.
SampleArea * Swatch * Bleached	0	0	.	.	.
SampleArea * Swatch * Washing	394.137	8	49.267	4.57	0.000
SampleArea * Bleached * Washing	0	0	.	.	.
Swatch * Bleached * Washing	0	0	.	.	.
SampleArea * Swatch * Bleached * Washing	0	0	.	.	.
Error	9013.125	836	10.781		
Total	6458403	880			
Corrected Total	12367	879			

a. R Squared = .271 (Adjusted R Squared = .234)

The Error noted in column 1 corresponds to the within-group values. The Total and the Corrected Total equals to sum of square values for the main effects, interaction effects and errors, and the summarization of the Corrected model and the Error, respectively. Also note that Type III Sum of Squares is calculated here. Type III gives the SS for each variable as if it was entered last in the model. The effect of each variable is evaluated after the previous factors have been accounted for, and is considered a partial SS. the SS is calculated for all the main and interaction effects being evaluated. The SS value for bleach was calculated as 0.000. Upon observation of the main effects p-values, Sample Area was not significant at p = .982. In other words, there was no significant difference between sample areas A and B. This also suggests that the location of where the fiber was extracted from within the sample area is irrelevant. It is also clear that both the main effect of Swatch were significant at p = 0.001, and that the four interaction effects were also significant at p = .002.

1. Sample Area Estimates: DPMP

Dependent Variable: L

Sample Area	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A	85.656[a]	0.157	85.349	85.963
B	85.517[a]	0.157	85.21	85.824

a. Based on modified population marginal mean.

This table shows the means for the levels within the sample area', together with their standard errors and the 95% confidence intervals. The main effects for this group did not yield significant results. The table below shows the interaction effects of this group. Again, it can be concluded that no significant differences was observed in this pair-wise comparing groups or in the main effects of this group.

Pairwise Comparisons: DPMP

Dependent Variable:L

(I) Sample Area	(J) Sample Area	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	Upper Bound
A	B	.139[a,b]	0.221	0.53	-0.296	0.573
B	A	-.139[a,b]	0.221	0.53	-0.573	0.296

Based on estimated marginal means
a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

2. Swatch Estimates: DPMP

Dependent Variable: L

Swatch	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
1 w/ bleach	85.887[a]	0.221	85.453	86.322
2 w/ bleach	84.908[a]	0.221	84.474	85.343
3 w/o bleach	85.475[a]	0.221	85.041	85.91
4 w/o bleach	86.076[a]	0.221	85.641	86.51

a. Based on modified population marginal mean.

Pairwise Comparisons

Dependent Variable: L

(I) Swatch	(J) Swatch	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach	.979[*,a,b]	0.313	0.002	0.365	1.594
	3 w/o bleach	.412[a,b]	0.313	0.188	-0.202	1.027
	4 w/o bleach	-.188[a,b]	0.313	0.547	-0.803	0.426
2 w/ bleach	1 w/ bleach	-.979[*,a,b]	0.313	0.002	-1.594	-0.365
	3 w/o bleach	-.567[a,b]	0.313	0.07	-1.182	0.047
	4 w/o bleach	-1.168[*,a,b]	0.313	0.00	-1.782	-0.553
3 w/o bleach	1 w/ bleach	-.412[a,b]	0.313	0.188	-1.027	0.202
	2 w/ bleach	.567[a,b]	0.313	0.07	-0.047	1.182
	4 w/o bleach	-.600[a,b]	0.313	0.055	-1.215	0.014
4 w/o bleach	1 w/ bleach	.188[a,b]	0.313	0.547	-0.426	0.803
	2 w/ bleach	1.168[*,a,b]	0.313	0.000	0.553	1.782
	3 w/o bleach	.600[a,b]	0.313	0.055	-0.014	1.215

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The first table above shows the means for the ‘w/ bleach’ and ‘w/o bleach’ swatches factors, together with their standard errors and the 95% confidence intervals. The second table shows the pair-wise comparison between the groups and their significance values. Swatch 1 was observed to be significant with swatch 2, but not with swatches 3 and 4. This is surprising results as one would expect insignificant values to be observed with swatch 2, since both swatches were washed with bleach. A significant difference was expected in the cases where the detergent was consistent between the swatches. Swatch 2, on the other hand, observed a significant difference with swatch 4, but not with swatch 3. Swatch 3 was the only group that did not produce any significant values with the remaining swatches. The results do not produce a recognizable pattern to distinguish whether the detergent used would affect the outcome of the results differently.

3. Bleach Estimates: DPMP

Dependent Variable: L

Bleached	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
w/ bleach	85.398[a]	0.157	85.09	85.705
w/o bleach	85.775[a]	0.157	85.468	86.083

a. Based on modified population marginal mean.

Pairwise Comparisons: DPMP

Dependent Variable: L

(I) Bleached	(J) Bleached	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
w/ bleach	w/o bleach	-.378[a,b]	0.221	0.088	-0.812	0.057
w/o bleach	w/ bleach	.378[a,b]	0.221	0.088	-0.057	0.812

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The first table above shows the means for the ‘w/ bleach’ and ‘w/o bleach’ factors, together with their standard errors and the 95% confidence intervals. The second table shows the pair-wise comparison between the groups and their significance values. It is clear that the groups being investigated do not significantly differ from each other. So, whether the samples were washed with or without bleach, are not significant in affecting the 'L' variable.

The first table below shows the means for the 'Washing' factors, together with their standard errors and the 95% confidence intervals. The second table provides the pair-wise comparisons for this group. The main effects for this group observed significant values at some levels of interaction. Four marked significant values occurred mostly at levels 1W 16A and again at 5W 80A. At 1W 0A, significant values were seen against the next four cycles. The significant interaction values between the two levels convey that the levels changed and that the means explains the nature of this difference.

4. Washing Estimates: DPMP

Dependent Variable: L

Washing	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1W 0A	85.119[a]	0.367	84.398	85.84
1W 16A	86.946[a]	0.26	86.436	87.455
2W 32A	84.440[a]	0.26	83.93	84.949
3W 48A	85.383[a]	0.26	84.874	85.893
4W 64A	84.958[a]	0.26	84.449	85.468
5W 80A	86.439[a]	0.26	85.929	86.948

a. Based on modified population marginal mean.

Pairwise Comparisons: DPMP

Dependent Variable: L

(I) Washing	(J) Washing	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	Upper Bound
1W 0A	1W 16A	-1.827*,a,b	0.45	0.000	-2.709	-0.944
	2W 32A	.679a,b	0.45	0.131	-0.203	1.562
	3W 48A	-.264a,b	0.45	0.557	-1.147	0.618
	4W 64A	.160a,b	0.45	0.721	-0.722	1.043
	5W 80A	-1.320*,a,b	0.45	0.003	-2.202	-0.437
1W 16A	1W 0A	1.827*,a,b	0.45	0.000	0.944	2.709
	2W 32A	2.506*,a,b	0.367	0.000	1.786	3.227
	3W 48A	1.563*,a,b	0.367	0.000	0.842	2.283
	4W 64A	1.987*,a,b	0.367	0.000	1.267	2.708
	5W 80A	.507a,b	0.367	0.167	-0.213	1.228
2W 32A	1W 0A	-.679a,b	0.45	0.131	-1.562	0.203
	1W 16A	-2.506*,a,b	0.367	0.000	-3.227	-1.786
	3W 48A	-.943*,a,b	0.367	0.010	-1.664	-0.223
	4W 64A	-.519a,b	0.367	0.158	-1.239	0.202
	5W 80A	-1.999*,a,b	0.367	0.000	-2.719	-1.278
3W 48A	1W 0A	.264a,b	0.45	0.557	-0.618	1.147
	1W 16A	-1.563*,a,b	0.367	0.000	-2.283	-0.842
	2W 32A	.943*,a,b	0.367	0.010	0.223	1.664
	4W 64A	.425a,b	0.367	0.248	-0.296	1.145
	5W 80A	-1.056*,a,b	0.367	0.004	-1.776	-0.335
4W 64A	1W 0A	-.160a,b	0.45	0.721	-1.043	0.722
	1W 16A	-1.987*,a,b	0.367	0.000	-2.708	-1.267
	2W 32A	.519a,b	0.367	0.158	-0.202	1.239
	3W 48A	-.425a,b	0.367	0.248	-1.145	0.296
	5W 80A	-1.480*,a,b	0.367	0.000	-2.201	-0.76
5W 80A	1W 0A	1.320*,a,b	0.45	0.003	0.437	2.202
	1W 16A	-.507a,b	0.367	0.167	-1.228	0.213
	2W 32A	1.999*,a,b	0.367	0.000	1.278	2.719
	3W 48A	1.056*,a,b	0.367	0.004	0.335	1.776
	4W 64A	1.480*,a,b	0.367	0.000	0.76	2.201

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

5. Sample Area * Swatch: DPMP

Dependent Variable: L

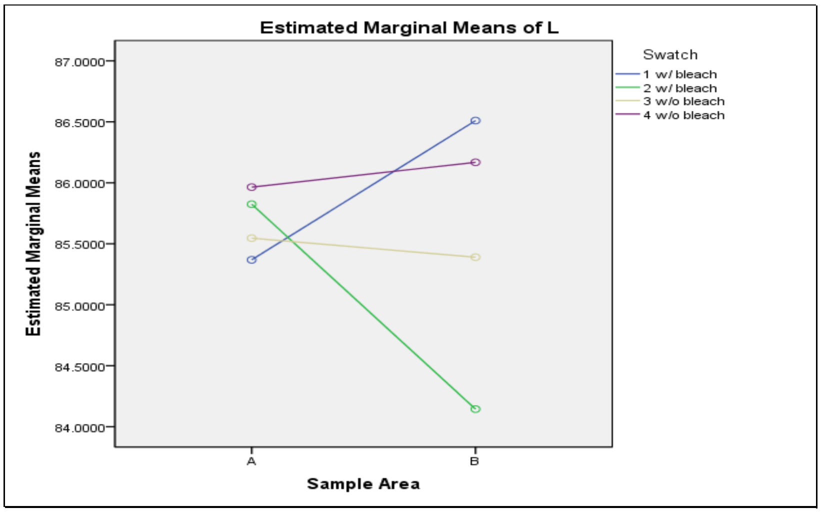
Sample Area	Swatch	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	1 w/ bleach	85.368[a]	0.3	84.78	85.956
	2 w/ bleach	85.824[a]	0.328	85.18	86.469
	3 w/o bleach	85.546[a]	0.3	84.958	86.134
	4 w/o bleach	85.965[a]	0.328	85.32	86.609
B	1 w/ bleach	86.510[a]	0.328	85.865	87.154
	2 w/ bleach	84.144[a]	0.3	83.556	84.733
	3 w/o bleach	85.390[a]	0.328	84.745	86.034
	4 w/o bleach	86.168[a]	0.3	85.58	86.756

a. Based on modified population marginal mean.

This table shows the interaction that was examined between the sample area and the swatch. The interaction between sample area and swatch yielded a significant result suggesting that the interaction effects of these two groups are significant. Although, the main effects for the swatches were not significant, a significant interaction is observed here. The effect of all levels in the group ‘Sample Area’ was not different, whereas, the effect for group ‘Swatch’ was. It can be concluded that interaction takes places between these groups as their means do not overlap or are similar. In fact, in sample area B, the mean values of ‘L’ are clearly different, although this difference might not a significant one.

Below is the interaction plot of these interactions. Although the main effects of the sample area did not produce significant results, the interaction between sample area and swatch did. At this point, it can be assumed that changes in both variables must have an effect on the outcome, regardless of the main effect p-values. The null hypothesis for the interaction is that there is no relationship between the two variables in their effects on the outcome. The alternative hypothesis then is that there is a relationship between the two variables that affects the outcome. Once the p-value is significant, then there is evidence of significant interactions, and not what would be due to random chance or error.

*Figure 46: Interaction Diagram of 'Swatch * Sample Area' for sample DPMP*



The points on this plot show the estimated population means. The lines in the interaction diagram connect the means of each pair of treatment. When the lines are parallel, suggests that no interaction takes place. The opposite is not true but very likely to be significant when the lines intersect. As soon as the lines depart from being parallel, there is indeed and interaction, but not necessarily a significant one. In this graph, only two parallel lines are observed: at swatches 3 and 4. Although these lines slightly deviate from being parallel, it can be concluded with the p-values that there are no significant interactions between these groups. Three intersecting lines are also observed. Swatch 1 intersects with 4, however the results are not produced to be significant with a p-value of 0.055. Swatch 1, also intersects with swatches 2 and 3, but only a significant result was observed within this interaction at swatch 2. And swatch 2 and 3, which intersected each other, also observes a significant p-value.

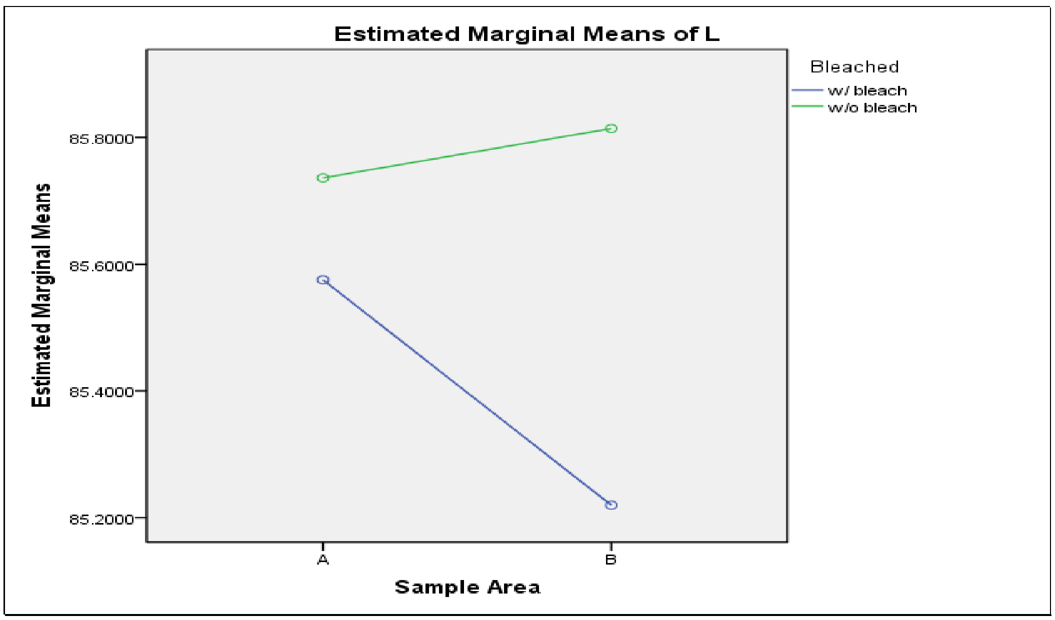
6. Sample Area * Bleached: DPMP

Dependent Variable: L

Sample Area	Bleached	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	w/ bleach	85.575[a]	0.221	85.141	86.01
	w/o bleach	85.736[a]	0.221	85.302	86.171
B	w/ bleach	85.220[a]	0.221	84.785	85.654
	w/o bleach	85.814[a]	0.221	85.38	86.249

a. Based on modified population marginal mean.

*Figure 47: Interaction Diagram of 'Sample Area' * Bleached for sample DPMP*



Based on the interaction plot, the mean values differ greatly at area B.

7. Bleached * Washing: DPMP

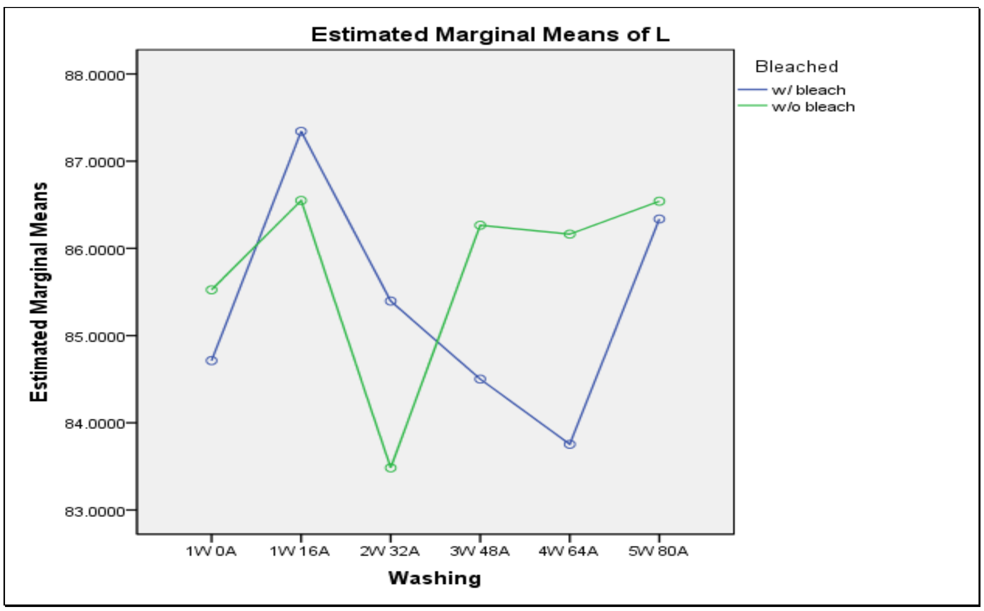
Dependent Variable: L

Bleached	Washing	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
w/ bleach	1W 0A	84.713[a]	0.519	83.694	85.732
	1W 16A	87.342[a]	0.367	86.622	88.063
	2W 32A	85.396[a]	0.367	84.676	86.117
	3W 48A	84.501[a]	0.367	83.781	85.222
	4W 64A	83.754[a]	0.367	83.033	84.474
	5W 80A	86.337[a]	0.367	85.616	87.057
w/o bleach	1W 0A	85.525[a]	0.519	84.506	86.544
	1W 16A	86.549[a]	0.367	85.829	87.27
	2W 32A	83.483[a]	0.367	82.763	84.204
	3W 48A	86.265[a]	0.367	85.545	86.986
	4W 64A	86.163[a]	0.367	85.443	86.884
	5W 80A	86.541[a]	0.367	85.82	87.261

a. Based on modified population marginal mean.

The table above shows the pair-wise comparisons for these two groups.

*Figure 48: Interaction Diagram of 'Bleached * 'Washing' for sample DPMP*



This chart shows interaction between these two groups. No further interpretation can be deferred from this chart without corresponding values to help confirm the results.

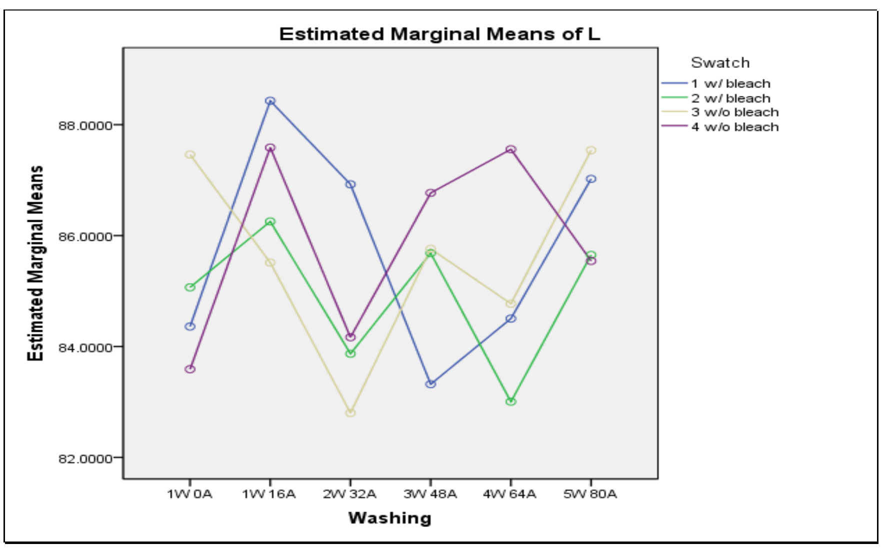
8. Swatch * Washing: DPMP

Dependent Variable: L

Swatch	Washing	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	1W 0A	84.360[a]	0.734	82.919	85.801
	1W 16A	88.431[a]	0.519	87.412	89.45
	2W 32A	86.924[a]	0.519	85.905	87.943
	3W 48A	83.319[a]	0.519	82.3	84.338
	4W 64A	84.503[a]	0.519	83.484	85.522
	5W 80A	87.022[a]	0.519	86.003	88.041
2 w/ bleach	1W 0A	85.066[a]	0.734	83.625	86.507
	1W 16A	86.254[a]	0.519	85.235	87.273
	2W 32A	83.869[a]	0.519	82.85	84.888
	3W 48A	85.683[a]	0.519	84.664	86.702
	4W 64A	83.004[a]	0.519	81.985	84.023
	5W 80A	85.651[a]	0.519	84.632	86.67
3 w/o bleach	1W 0A	87.461[a]	0.734	86.019	88.902
	1W 16A	85.512[a]	0.519	84.493	86.531
	2W 32A	82.801[a]	0.519	81.782	83.82
	3W 48A	85.761[a]	0.519	84.742	86.78
	4W 64A	84.770[a]	0.519	83.751	85.789
	5W 80A	87.539[a]	0.519	86.52	88.558
4 w/o bleach	1W 0A	83.590[a]	0.734	82.149	85.031
	1W 16A	87.587[a]	0.519	86.568	88.606
	2W 32A	84.166[a]	0.519	83.147	85.185
	3W 48A	86.769[a]	0.519	85.75	87.788
	4W 64A	87.556[a]	0.519	86.537	88.575
	5W 80A	85.543[a]	0.519	84.524	86.562

a. Based on modified population marginal mean.

*Figure 49: Interaction Diagram of 'Swatch * Washing' for sample DPMP*



The table above shows the pair-wise comparisons for these two groups. The interaction effects for these two groups seem to be substantial. The overall patterns for swatch 1, 2 and 4 started out consistently, but after the third washing, this pattern started to deteriorate. Swatches 1 and 2 continued to have a similar pattern as their mean values decreased, while, swatch 4 increased in mean values. Swatch 3 started to follow this pattern after the first washed-aged cycle. This difference in means between groups could have created the significant interaction effects that are observed for these groups.

DPMP- Variable 'a'

The same analysis was performed for variables 'a' and 'b'. These variables will not be discussed in such great details as was done for variable 'L' as half of the discussion referred to the understanding and interpretation of the tables and graphs.

Tests of Between-Subjects Effects: DPMP

Dependent Variable: a

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5343.170[a]	43	124.26	9.493	0.000
Intercept	529563.2	1	529563.2	40454.78	0.000
SampleArea	36.625	1	36.625	2.798	0.095
Swatch	349.325	2	174.662	13.343	0.000
Bleached	0	0	.	.	.
Washing	363.548	5	72.71	5.554	0.000
SampleArea * Swatch	246.4	2	123.2	9.412	0.000
SampleArea * Bleached	0	0	.	.	.
SampleArea * Washing	789.774	4	197.444	15.083	0.000
Swatch * Bleached	0	0	.	.	.
Swatch * Washing	860.643	8	107.58	8.218	0.000
Bleached * Washing	0	0	.	.	.
SampleArea * Swatch * Bleached	0	0	.	.	.
SampleArea * Swatch * Washing	1168.235	8	146.029	11.156	0.000
SampleArea * Bleached * Washing	0	0	.	.	.
Swatch * Bleached * Washing	0	0	.	.	.
SampleArea * Swatch * Bleached * Washing	0	0	.	.	.
Error	10943.45	836	13.09		
Total	577505.2	880			
Corrected Total	16286.62	879			

a. R Squared = .328 (Adjusted R Squared = .294)

The main effects of Swatch and Washing observed significant values, whereas Sample Area did not. The estimated marginal means and pair-wise comparison tables of sample area can be found in Section 15 of the appendix.

2. Swatch Estimates: DPMP

Dependent Variable: a

Swatch	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	26.438[a]	0.244	25.959	26.917
2 w/ bleach	24.504[a]	0.244	24.025	24.983
3 w/o bleach	24.733[a]	0.244	24.255	25.212
4 w/o bleach	25.339[a]	0.244	24.86	25.818

a. Based on modified population marginal mean.

Pairwise Comparisons: DPMP

Dependent Variable: a

(I) Swatch	(J) Swatch	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
1 w/ bleach	2 w/ bleach	1.934[*,a,b]	0.345	0.000	1.257	2.611
	3 w/o bleach	1.705[*,a,b]	0.345	0.000	1.028	2.382
	4 w/o bleach	1.099[*,a,b]	0.345	0.001	0.422	1.776
2 w/ bleach	1 w/ bleach	-1.934[*,a,b]	0.345	0.000	-2.611	-1.257
	3 w/o bleach	-.229[a,b]	0.345	0.507	-0.906	0.448
	4 w/o bleach	-.835[*,a,b]	0.345	0.016	-1.512	-0.158
3 w/o bleach	1 w/ bleach	-1.705[*,a,b]	0.345	0.000	-2.382	-1.028
	2 w/ bleach	.229[a,b]	0.345	0.507	-0.448	0.906
	4 w/o bleach	-.606[a,b]	0.345	0.080	-1.283	0.072
4 w/o bleach	1 w/ bleach	-1.099[*,a,b]	0.345	0.001	-1.776	-0.422
	2 w/ bleach	.835[*,a,b]	0.345	0.016	0.158	1.512
	3 w/o bleach	.606[a,b]	0.345	0.080	-0.072	1.283

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Marked significant differences were observed for all levels of group Swatch. The greatest amount of significances was observed at swatch 1 which observed significant mean differences with all swatches. Notice that with the bleached swatches, significant values were observed between them, whereas with the unbleached swatches, no significant values were observed.

3. Bleach Estimates: DPMP

Dependent Variable: a

Bleached	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
w/ bleach	25.471[a]	0.172	25.133	25.81
w/o bleach	25.036[a]	0.172	24.698	25.375

a. Based on modified population marginal mean.

Pairwise Comparisons: DPMP

Dependent Variable: a

(I) Bleached	(J) Bleached	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
w/ bleach	w/o bleach	.435[a,b]	0.244	0.075	-0.044	0.914
w/o bleach	w/ bleach	-.435[a,b]	0.244	0.075	-0.914	0.044

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Although interaction effects cannot be observed with this group, the effects within this group can be investigated. Based on the results, there is no evidence that ‘w/ bleach’ and ‘w/o bleach’ differed in their performance. The p-value clearly shows that there is no significant difference at the 5% level.

4. Washing Estimates: DPMP

Dependent Variable: a

Washing	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1W 0A	25.582[a]	0.405	24.788	26.376
1W 16A	25.625[a]	0.286	25.064	26.186
2W 32A	24.617[a]	0.286	24.056	25.179
3W 48A	26.090[a]	0.286	25.529	26.652
4W 64A	24.392[a]	0.286	23.83	24.953
5W 80A	25.380[a]	0.286	24.818	25.941

a. Based on modified population marginal mean.

Pairwise Comparisons: DPMP

Dependent Variable: a

(I) Washing	(J) Washing	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	Upper Bound
1W 0A	1W 16A	-.043[a,b]	0.495	0.931	-1.015	0.93
	2W 32A	.965[a,b]	0.495	0.052	-0.007	1.938
	3W 48A	-.508[a,b]	0.495	0.306	-1.48	0.465
	4W 64A	1.190[a,b,*]	0.495	0.016	0.218	2.163
	5W 80A	.202[a,b]	0.495	0.683	-0.77	1.175
1W 16A	1W 0A	.043[a,b]	0.495	0.931	-0.93	1.015
	2W 32A	1.008[a,b,*]	0.405	0.013	0.214	1.802
	3W 48A	-.465[a,b]	0.405	0.251	-1.259	0.329
	4W 64A	1.233[a,b,*]	0.405	0.002	0.439	2.027
	5W 80A	.245[a,b]	0.405	0.545	-0.549	1.039
2W 32A	1W 0A	-.965[a,b]	0.495	0.052	-1.938	0.007
	1W 16A	-1.008[a,b,*]	0.405	0.013	-1.802	-0.214
	3W 48A	-1.473[a,b,*]	0.405	0.000	-2.267	-0.679
	4W 64A	.225[a,b]	0.405	0.578	-0.569	1.019
	5W 80A	-.763[a,b]	0.405	0.060	-1.557	0.031
3W 48A	1W 0A	.508[a,b]	0.495	0.306	-0.465	1.48
	1W 16A	.465[a,b]	0.405	0.251	-0.329	1.259
	2W 32A	1.473[a,b,*]	0.405	0.000	0.679	2.267
	4W 64A	1.698[a,b,*]	0.405	0.000	0.904	2.492
	5W 80A	.710[a,b]	0.405	0.079	-0.084	1.504
4W 64A	1W 0A	-1.190[a,b,*]	0.495	0.016	-2.163	-0.218
	1W 16A	-1.233[a,b,*]	0.405	0.002	-2.027	-0.439
	2W 32A	-.225[a,b]	0.405	0.578	-1.019	0.569
	3W 48A	-1.698[a,b,*]	0.405	0.000	-2.492	-0.904
	5W 80A	-.988[a,b,*]	0.405	0.015	-1.782	-0.194
5W 80A	1W 0A	-.202[a,b]	0.495	0.683	-1.175	0.77
	1W 16A	-.245[a,b]	0.405	0.545	-1.039	0.549
	2W 32A	.763[a,b]	0.405	0.060	-0.031	1.557
	3W 48A	-.710[a,b]	0.405	0.079	-1.504	0.084
	4W 64A	.988[a,b,*]	0.405	0.015	0.194	1.782

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

*. The mean difference is significant at the .05 level.

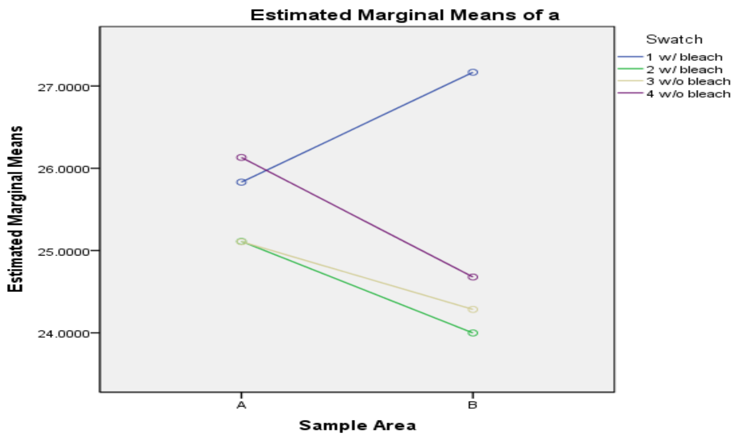
Marked significant differences were observed within levels of this group. Except for 5W 80A which did not observe any significant mean differences, no one level was more prominent than the other.

5. Sample Area * Swatch

Dependent Variable: a

Sample Area	Swatch	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	1 w/ bleach	25.831[a]	0.33	25.182	26.479
	2 w/ bleach	25.111[a]	0.362	24.401	25.822
	3 w/o bleach	25.108[a]	0.33	24.459	25.756
	4 w/o bleach	26.132[a]	0.362	25.421	26.842
B	1 w/ bleach	27.167[a]	0.362	26.457	27.877
	2 w/ bleach	23.998[a]	0.33	23.35	24.646
	3 w/o bleach	24.284[a]	0.362	23.574	24.995
	4 w/o bleach	24.678[a]	0.33	24.03	25.327

a. Based on modified population marginal mean.



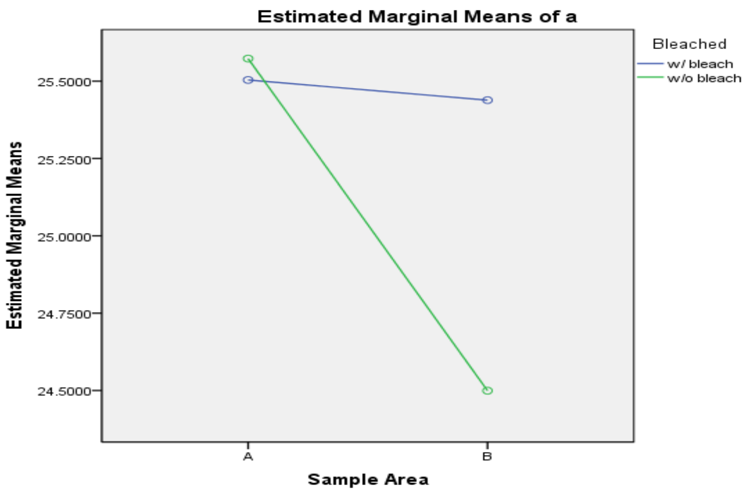
Parallel lines are observed with swatches 2-4 which would suggest that the effect of the mean outcome of a change in one factor is independent on the level of the other factor. The means values for swatches 2 and 3 are roughly the same. On the other hand, the mean for swatch 1 at area B varies greatly with the remaining swatches which possibly contributed to the significant values obtained.

6. Sample Area * Bleached

Dependent Variable: a

Sample Area	Bleached	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	w/ bleach	25.504[a]	0.244	25.025	25.983
	w/o bleach	25.573[a]	0.244	25.094	26.052
B	w/ bleach	25.439[a]	0.244	24.96	25.917
	w/o bleach	24.499[a]	0.244	24.02	24.978

a. Based on modified population marginal mean.



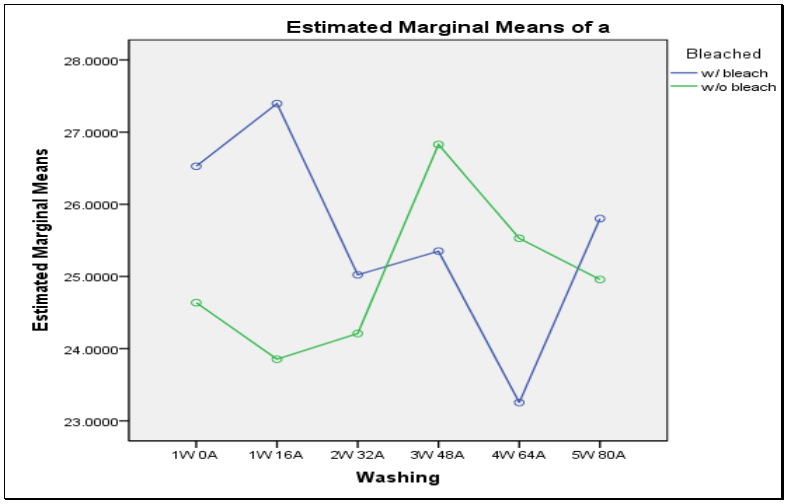
The interactions between these groups seem to be substantial at sample area B as the mean differences between the bleached and unbleached samples varies more than at area A.

7. Bleached * Washing

Dependent Variable: a

Bleached	Washing	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
w/ bleach	1W 0A	26.527[a]	0.572	25.404	27.65
	1W 16A	27.396[a]	0.405	26.602	28.19
	2W 32A	25.023[a]	0.405	24.229	25.817
	3W 48A	25.352[a]	0.405	24.558	26.146
	4W 64A	23.255[a]	0.405	22.461	24.048
	5W 80A	25.802[a]	0.405	25.008	26.596
w/o bleach	1W 0A	24.638[a]	0.572	23.515	25.76
	1W 16A	23.854[a]	0.405	23.06	24.648
	2W 32A	24.211[a]	0.405	23.417	25.005
	3W 48A	26.828[a]	0.405	26.034	27.622
	4W 64A	25.529[a]	0.405	24.735	26.323
	5W 80A	24.958[a]	0.405	24.164	25.752

a. Based on modified population marginal mean.



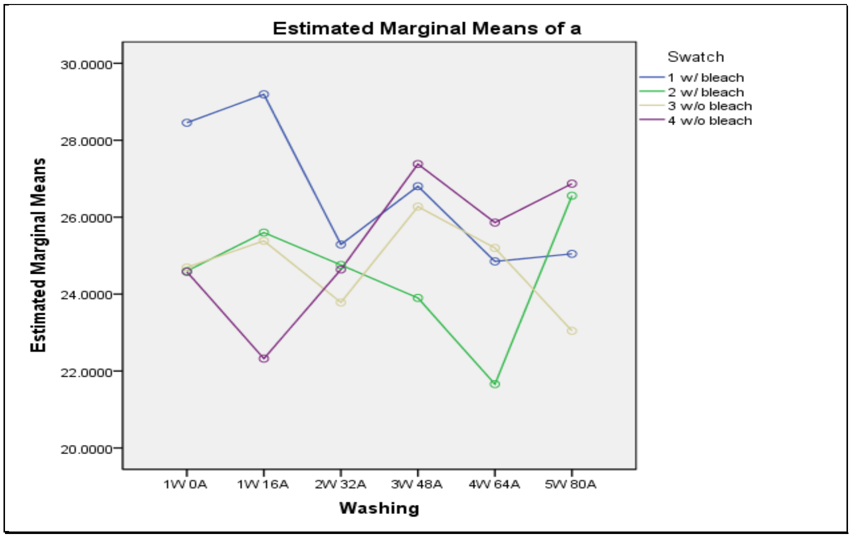
The overall patterns between these two groups are very dissimilar. In fact the mean values decreases as for samples washed with bleach, but increases for the samples washed without bleach. It is evident both groups affect the outcome of the interaction.

8. Swatch * Washing: DPMP

Dependent Variable: a

Swatch	Washing	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	1W 0A	28.455[a]	0.809	26.867	30.043
	1W 16A	29.193[a]	0.572	28.07	30.316
	2W 32A	25.289[a]	0.572	24.166	26.412
	3W 48A	26.804[a]	0.572	25.681	27.927
	4W 64A	24.850[a]	0.572	23.727	25.972
	5W 80A	25.047[a]	0.572	23.924	26.17
2 w/ bleach	1W 0A	24.599[a]	0.809	23.012	26.187
	1W 16A	25.599[a]	0.572	24.476	26.722
	2W 32A	24.757[a]	0.572	23.634	25.88
	3W 48A	23.900[a]	0.572	22.777	25.023
	4W 64A	21.659[a]	0.572	20.537	22.782
	5W 80A	26.557[a]	0.572	25.434	27.68
3 w/o bleach	1W 0A	24.695[a]	0.809	23.107	26.283
	1W 16A	25.385[a]	0.572	24.262	26.508
	2W 32A	23.783[a]	0.572	22.66	24.906
	3W 48A	26.275[a]	0.572	25.152	27.398
	4W 64A	25.199[a]	0.572	24.076	26.322
	5W 80A	23.045[a]	0.572	21.922	24.168
4 w/o bleach	1W 0A	24.580[a]	0.809	22.992	26.168
	1W 16A	22.323[a]	0.572	21.2	23.446
	2W 32A	24.639[a]	0.572	23.516	25.762
	3W 48A	27.382[a]	0.572	26.259	28.505
	4W 64A	25.859[a]	0.572	24.737	26.982
	5W 80A	26.871[a]	0.572	25.748	27.994

a. Based on modified population marginal mean.



The interaction effects for these two groups observe to be substantial. The overall patterns for swatch 1, 2 and 3 started out in a consistent manner, but, after the fourth washing, swatch 4 continued on a different pattern. It was expected that the swatches washed with similar detergent would produce similar results; yet this has not been observed at either dependent variables.

DPMP- Variable 'b'

Tests of Between-Subjects Effects: DPMP

Dependent Variable: b

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1677.875[a]	43	39.02	9.746	0.000
Intercept	44729.07	1	44729.07	11172.26	0.000
SampleArea	6.892	1	6.892	1.721	0.190
Swatch	22.682	2	11.341	2.833	0.059
Bleached	0	0	.	.	.
Washing	115.882	5	23.176	5.789	0.000
SampleArea * Swatch	69.245	2	34.622	8.648	0.000
SampleArea * Bleached	0	0	.	.	.
SampleArea * Washing	425.388	4	106.347	26.563	0.000
Swatch * Bleached	0	0	.	.	.
Swatch * Washing	239.837	8	29.98	7.488	0.000
Bleached * Washing	0	0	.	.	.
SampleArea * Swatch * Bleached	0	0	.	.	.
SampleArea * Swatch * Washing	311.369	8	38.921	9.722	0.000
SampleArea * Bleached * Washing	0	0	.	.	.
Swatch * Bleached * Washing	0	0	.	.	.
SampleArea * Swatch * Bleached * Washing	0	0	.	.	.
Error	3346.996	836	4.004		
Total	52144.15	880			
Corrected Total	5024.871	879			

a. R Squared = .334 (Adjusted R Squared = .300)

Based on the results, the main effects of the group 'Swatch' and 'Sample Area' did not produce significant results, but the main effects of 'Washing' did. Therefore, only the interaction effects of these two groups will be discussed below. The marginal means and pair-wise comparisons tables are located in the appendix.

3. Bleach Estimates: DPMP

Dependent Variable: b

Bleached	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
w/ bleach	7.456[a]	0.095	7.269	7.643
w/o bleach	7.179[a]	0.095	6.991	7.366

a. Based on modified population marginal mean.

Pairwise Comparisons: DPMP

Dependent Variable: b

(I) Bleached	(J) Bleached	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
w/ bleach	w/o bleach	.277[*,a,b]	0.135	0.04	0.013	0.542
w/o bleach	w/ bleach	-.277[*,a,b]	0.135	0.04	-0.542	-0.013

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

At the 5% level, significant mean differences were observed between these two groups. Bleaching samples creates a significant difference in means in comparison to the unbleached samples. Unlike variables 'L' and 'a', the outcome of the means of variable 'b' was affected by the detergents used.

4. Washing Estimates: DPMP

Dependent Variable: b

Washing	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1W 0A	7.509[a]	0.224	7.069	7.948
1W 16A	7.136[a]	0.158	6.826	7.447
2W 32A	7.394[a]	0.158	7.084	7.705
3W 48A	7.921[a]	0.158	7.61	8.231
4W 64A	6.850[a]	0.158	6.539	7.16
5W 80A	7.191[a]	0.158	6.88	7.501

a. Based on modified population marginal mean.

Pairwise Comparisons: DPMP

Dependent Variable: b

(I) Washing	(J) Washing	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
1W 0A	1W 16A	.372[a,b]	0.274	0.175	-0.166	0.91
	2W 32A	.114[a,b]	0.274	0.677	-0.423	0.652
	3W 48A	-.412[a,b]	0.274	0.133	-0.95	0.126
	4W 64A	.659[a,b,*]	0.274	0.016	0.121	1.197
	5W 80A	.318[a,b]	0.274	0.246	-0.22	0.856
1W 16A	1W 0A	-.372[a,b]	0.274	0.175	-0.91	0.166
	2W 32A	-.258[a,b]	0.224	0.250	-0.697	0.181
	3W 48A	-.784[a,b,*]	0.224	0.000	-1.223	-0.345
	4W 64A	.287[a,b]	0.224	0.200	-0.152	0.726
	5W 80A	-.054[a,b]	0.224	0.809	-0.493	0.385
2W 32A	1W 0A	-.114[a,b]	0.274	0.677	-0.652	0.423
	1W 16A	.258[a,b]	0.224	0.250	-0.181	0.697
	3W 48A	-.526[a,b,*]	0.224	0.019	-0.966	-0.087
	4W 64A	.545[a,b,*]	0.224	0.015	0.105	0.984
	5W 80A	.204[a,b]	0.224	0.363	-0.235	0.643
3W 48A	1W 0A	.412[a,b]	0.274	0.133	-0.126	0.95
	1W 16A	.784[a,b,*]	0.224	0.000	0.345	1.223
	2W 32A	.526[a,b,*]	0.224	0.019	0.087	0.966
	4W 64A	1.071[a,b,*]	0.224	0.000	0.632	1.51
	5W 80A	.730[a,b,*]	0.224	0.001	0.291	1.169
4W 64A	1W 0A	-.659[a,b,*]	0.274	0.016	-1.197	-0.121
	1W 16A	-.287[a,b]	0.224	0.200	-0.726	0.152
	2W 32A	-.545[a,b,*]	0.224	0.015	-0.984	-0.105
	3W 48A	-1.071[a,b,*]	0.224	0.000	-1.51	-0.632
	5W 80A	-.341[a,b]	0.224	0.128	-0.78	0.098
5W 80A	1W 0A	-.318[a,b]	0.274	0.246	-0.856	0.22
	1W 16A	.054[a,b]	0.224	0.809	-0.385	0.493
	2W 32A	-.204[a,b]	0.224	0.363	-0.643	0.235
	3W 48A	-.730[a,b,*]	0.224	0.001	-1.169	-0.291
	4W 64A	.341[a,b]	0.224	0.128	-0.098	0.78

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

*. The mean difference is significant at the .05 level.

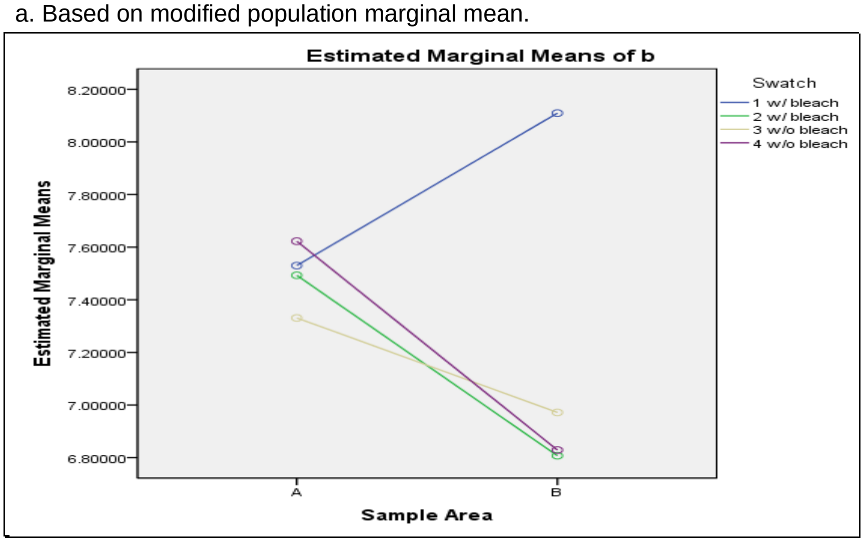
Marked significant differences were observed the greatest at 3W 48A. note that among the three variables, each was significantly affected at the various cycles of treatment.

5. Sample Area * Swatch

Dependent Variable: b

Sample Area	Swatch	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	1 w/ bleach	7.530[a]	0.183	7.171	7.888
	2 w/ bleach	7.493[a]	0.2	7.1	7.886
	3 w/o bleach	7.331[a]	0.183	6.973	7.69
	4 w/o bleach	7.623[a]	0.2	7.23	8.015
B	1 w/ bleach	8.110[a]	0.2	7.717	8.502
	2 w/ bleach	6.807[a]	0.183	6.449	7.166
	3 w/o bleach	6.972[a]	0.2	6.579	7.365
	4 w/o bleach	6.829[a]	0.183	6.47	7.187

a. Based on modified population marginal mean.



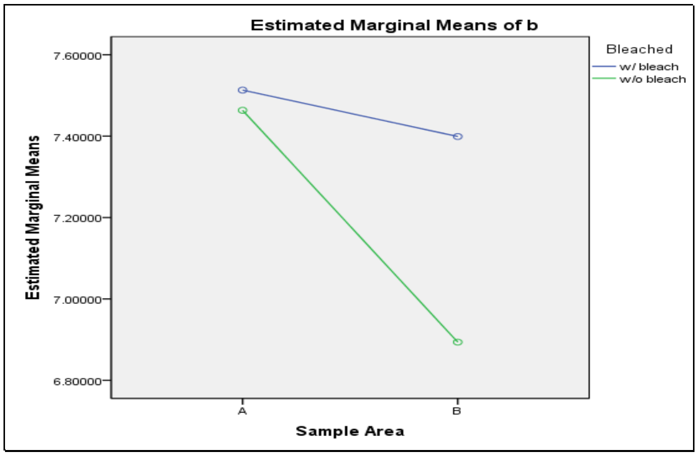
The overall pattern for interaction was similarly observed for variable ‘a’ where the mean difference was greatest with swatch 1 at area B to the remaining swatches. The consistencies observed between these variables suggest that it is more likely that significance is observed at swatch 1 and at sample area B.

6. Sample Area * Bleached

Dependent Variable: b

Sample Area	Bleached	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
A	w/ bleach	7.513[a]	0.135	7.248	7.778
	w/o bleach	7.464[a]	0.135	7.199	7.728
B	w/ bleach	7.399[a]	0.135	7.134	7.664
	w/o bleach	6.894[a]	0.135	6.629	7.159

a. Based on modified population marginal mean.



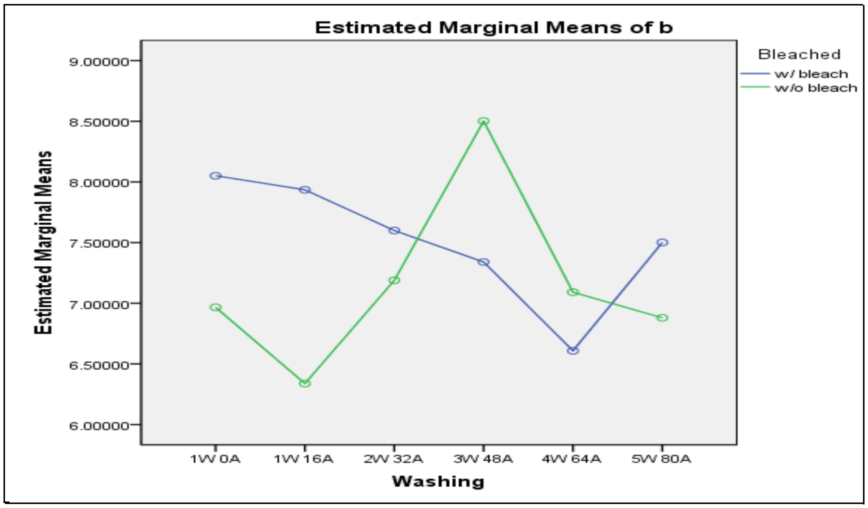
It can be concluded that interaction takes place between these groups as their means do not overlap or are neither similar. In fact, sample area B varies in a greater amount than area A. In addition, the interaction effects of sample area and swatch was also affected at this area.

7. Bleached * Washing

Dependent Variable: b

Bleached	Washing	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
w/ bleach	1W 0A	8.051[a]	0.316	7.43	8.671
	1W 16A	7.935[a]	0.224	7.496	8.374
	2W 32A	7.599[a]	0.224	7.16	8.038
	3W 48A	7.340[a]	0.224	6.901	7.779
	4W 64A	6.608[a]	0.224	6.169	7.047
	5W 80A	7.501[a]	0.224	7.062	7.94
w/o bleach	1W 0A	6.967[a]	0.316	6.346	7.588
	1W 16A	6.338[a]	0.224	5.899	6.777
	2W 32A	7.189[a]	0.224	6.75	7.628
	3W 48A	8.501[a]	0.224	8.062	8.94
	4W 64A	7.091[a]	0.224	6.652	7.53
	5W 80A	6.880[a]	0.224	6.441	7.319

a. Based on modified population marginal mean.



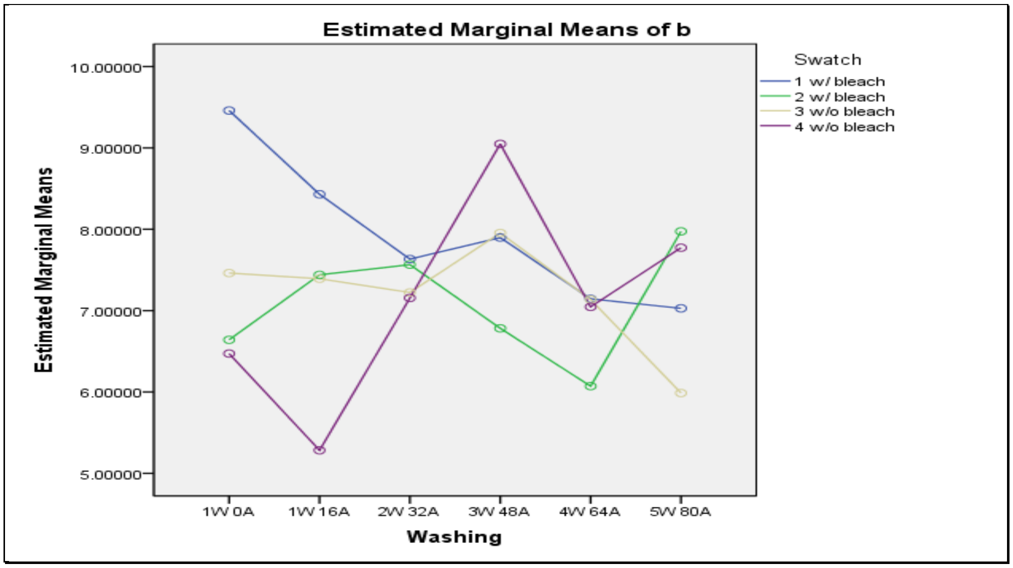
A consistent pattern is observed for the bleached samples. As the samples are further treated, the mean values decreases. This occurs until the fourth cycle in which the mean values then begin to increase. This pattern is a vast contrast from the unbleached samples.

8. Swatch * Washing: DPMP

Dependent Variable: b

Swatch	Washing	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1 w/ bleach	1W 0A	9.460[a]	0.447	8.582	10.338
	1W 16A	8.430[a]	0.316	7.809	9.051
	2W 32A	7.633[a]	0.316	7.012	8.254
	3W 48A	7.898[a]	0.316	7.277	8.519
	4W 64A	7.145[a]	0.316	6.524	7.765
	5W 80A	7.028[a]	0.316	6.407	7.649
2 w/ bleach	1W 0A	6.641[a]	0.447	5.763	7.519
	1W 16A	7.440[a]	0.316	6.819	8.061
	2W 32A	7.565[a]	0.316	6.944	8.186
	3W 48A	6.782[a]	0.316	6.161	7.403
	4W 64A	6.071[a]	0.316	5.45	6.692
	5W 80A	7.974[a]	0.316	7.353	8.595
3 w/o bleach	1W 0A	7.461[a]	0.447	6.583	8.339
	1W 16A	7.392[a]	0.316	6.771	8.013
	2W 32A	7.223[a]	0.316	6.602	7.844
	3W 48A	7.954[a]	0.316	7.333	8.575
	4W 64A	7.136[a]	0.316	6.515	7.757
	5W 80A	5.987[a]	0.316	5.366	6.608
4 w/o bleach	1W 0A	6.472[a]	0.447	5.594	7.35
	1W 16A	5.283[a]	0.316	4.662	5.904
	2W 32A	7.155[a]	0.316	6.534	7.776
	3W 48A	9.049[a]	0.316	8.428	9.67
	4W 64A	7.046[a]	0.316	6.425	7.667
	5W 80A	7.773[a]	0.316	7.152	8.394

a. Based on modified population marginal mean.



There is no consistent pattern observed at this level of interaction. In fact, all lines intersect each other at one point. It can be concluded that significant mean differences are observed at this level of interaction.

II. Sample GMP

Variable 'L'

Tests of Between-Subjects Effects: GMP

Dependent Variable: L

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5004.387[a]	43	116.381	8.122	0
Intercept	7313681.6	1	7313682	510403	0
SampleArea	254.644	1	254.644	17.771	0
Swatch	229.485	2	114.742	8.008	0
bleached	0	0			
washings	969.01	5	193.802	13.525	0
SampleArea * Swatch	164.809	2	82.404	5.751	0.003
SampleArea * bleached	0	0			
SampleArea * washings	610.451	4	152.613	10.65	0
Swatch * bleached	0	0			
Swatch * washings	408.084	8	51.01	3.56	0
bleached * washings	0	0			
SampleArea * Swatch * bleached	0	0			
SampleArea * Swatch * washings	1345.946	8	168.243	11.741	0
SampleArea * bleached * washings	0	0			
Swatch * bleached * washings	0	0			
SampleArea * Swatch * bleached * washings	0	0			
Error	11979.238	836	14.329		
Total	7848825	880			
Corrected Total	16983.625	879			

a. R Squared = .295 (Adjusted R Squared = .258)
b. Computed using alpha = .05

Based on the results, the main effects and interaction effects are all observed to be significant.

1. Sample Area Estimates: GMP

Dependent Variable: L

Sample Area	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	93.939[a]	.180	93.585	94.293
B	94.739[a]	.180	94.385	95.093

a. Based on modified population marginal mean.

Pairwise Comparisons

Dependent Variable: L

(I) Sample Area	(J) Sample Area	Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	95% Confidence Interval for Difference[d] Upper Bound
A	B	-.800[*,b,c]	.255	.002	-1.301	-.299
B	A	.800[*,b,c]	.255	.002	.299	1.301

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
b. An estimate of the modified population marginal mean (I).
c. An estimate of the modified population marginal mean (J).
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Not only is the main effect for the sample area significant, the effects between levels are also significant.

Based on the swatch estimates and pair-wise table below, the greatest amount of marked significances is found at swatch 3. In contrast, swatch 4 which was also washed with the same detergent as swatch 3, only observed a significant difference with swatch 3. Swatch 1 and 2, both washed under the same conditions, did not observe marked significance differences.

2. Swatch Estimates: GMP

Dependent Variable: L

Swatch	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	93.636[a]	0.255	93.135	94.137
2 w/ bleach	93.596[a]	0.255	93.095	94.097
3 w/o bleach	95.784[a]	0.255	95.283	96.285
4 w/o bleach	94.339[a]	0.255	93.838	94.84

a. Based on modified population marginal mean.

Pairwise Comparisons: GMP

Dependent Variable: L

(I) Swatch		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach	.040[a,b]	.361	.913	-.669	.748
	3 w/o bleach	-2.148[a,b,*]	.361	.000	-2.856	-1.440
	4 w/o bleach	-.704[a,b]	.361	.052	-1.412	.005
2 w/ bleach	1 w/ bleach	-.040[a,b]	.361	.913	-.748	.669
	3 w/o bleach	-2.188[a,b,*]	.361	.000	-2.896	-1.479
	4 w/o bleach	-.743[a,b,*]	.361	.040	-1.452	-.035
3 w/o bleach	1 w/ bleach	2.148[a,b,*]	.361	.000	1.440	2.856
	2 w/ bleach	2.188[a,b,*]	.361	.000	1.479	2.896
	4 w/o bleach	1.444[a,b,*]	.361	.000	.736	2.153
4 w/o bleach	1 w/ bleach	.704[a,b]	.361	.052	-.005	1.412
	2 w/ bleach	.743[a,b,*]	.361	.040	.035	1.452
	3 w/o bleach	-1.444[a,b,*]	.361	.000	-2.153	-.736

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

3. Bleach Estimates: GMP

Dependent Variable: L

bleached	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
w/ bleach	93.616[a]	.180	93.262	93.970
w/o bleach	95.062[a]	.180	94.707	95.416

a. Based on modified population marginal mean.

Pairwise Comparisons: GMP

Dependent Variable: L

(I) bleached		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	Upper Bound
w/ bleach	w/o bleach	-1.446[*,b,c]	.255	.000	-1.947	-.945
w/o bleach	w/ bleach	1.446[*,b,c]	.255	.000	.945	1.947

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Both the main effects of this group, and the interacting levels observed significant mean differences. The effects of the detergents affect the outcome of this variable.

4. Washing Estimates: GMP

Dependent Variable: L

washings	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
1W 0A	92.379[a]	.423	91.548	93.210
1W 16A	95.734[a]	.299	95.146	96.321
2W 32A	93.366[a]	.299	92.779	93.954
3W 48A	94.085[a]	.299	93.497	94.672
4W 64A	94.398[a]	.299	93.811	94.985
5W 80A	95.092[a]	.299	94.504	95.679

a. Based on modified population marginal mean.

Pairwise Comparisons: GMP

Dependent Variable: L

(I) washings		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	Upper Bound
1W 0A	1W 16A	-3.355[*,b,c]	.518	.000	-4.372	-2.338
	2W 32A	-.987[b,c]	.518	.057	-2.005	.030
	3W 48A	-1.706[*,b,c]	.518	.001	-2.723	-.688
	4W 64A	-2.019[*,b,c]	.518	.000	-3.036	-1.002
	5W 80A	-2.713[*,b,c]	.518	.000	-3.730	-1.695
1W 16A	1W 0A	3.355[*,b,c]	.518	.000	2.338	4.372
	2W 32A	2.368[*,b,c]	.423	.000	1.537	3.198
	3W 48A	1.649[*,b,c]	.423	.000	.819	2.480
	4W 64A	1.336[*,b,c]	.423	.002	.505	2.167
	5W 80A	.642[b,c]	.423	.130	-.189	1.473
2W 32A	1W 0A	.987[b,c]	.518	.057	-.030	2.005
	1W 16A	-2.368[*,b,c]	.423	.000	-3.198	-1.537
	3W 48A	-.718[b,c]	.423	.090	-1.549	.112
	4W 64A	-1.032[*,b,c]	.423	.015	-1.862	-.201
	5W 80A	-1.726[*,b,c]	.423	.000	-2.556	-.895
3W 48A	1W 0A	1.706[*,b,c]	.518	.001	.688	2.723
	1W 16A	-1.649[*,b,c]	.423	.000	-2.480	-.819
	2W 32A	.718[b,c]	.423	.090	-.112	1.549
	4W 64A	-.313[b,c]	.423	.459	-1.144	.517
	5W 80A	-1.007[*,b,c]	.423	.018	-1.838	-.176
4W 64A	1W 0A	2.019[*,b,c]	.518	.000	1.002	3.036
	1W 16A	-1.336[*,b,c]	.423	.002	-2.167	-.505
	2W 32A	1.032[*,b,c]	.423	.015	.201	1.862
	3W 48A	.313[b,c]	.423	.459	-.517	1.144
	5W 80A	-.694[b,c]	.423	.102	-1.524	.137
5W 80A	1W 0A	2.713[*,b,c]	.518	.000	1.695	3.730
	1W 16A	-.642[b,c]	.423	.130	-1.473	.189
	2W 32A	1.726[*,b,c]	.423	.000	.895	2.556
	3W 48A	1.007[*,b,c]	.423	.018	.176	1.838
	4W 64A	.694[b,c]	.423	.102	-.137	1.524

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

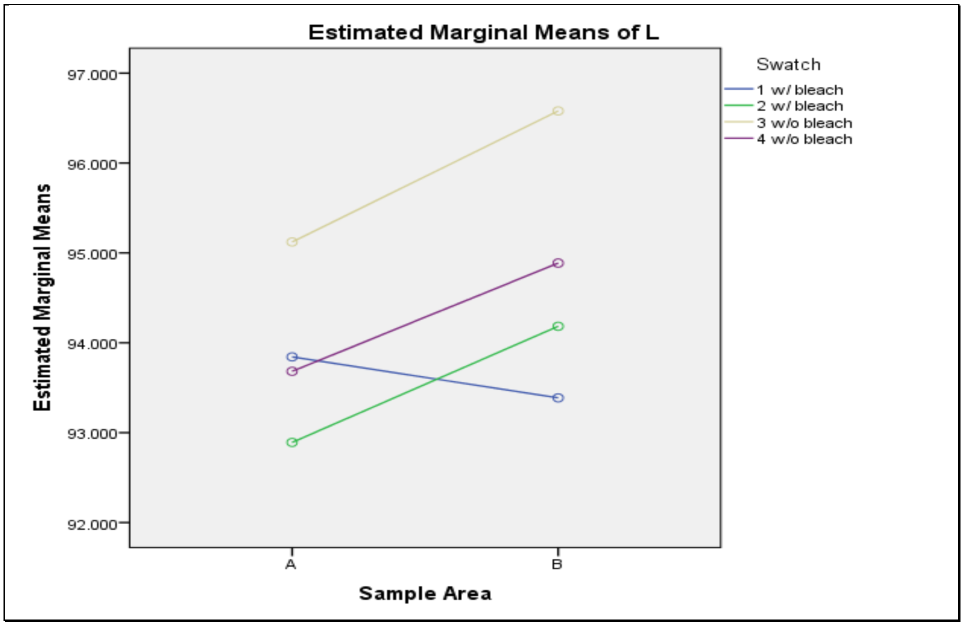
Both the main effects of this group, and the interacting levels observed significant mean differences, although not at all levels of the pair-wise comparing groups.

5. Sample Area * Swatch: GMP

Dependent Variable: L

Sample Area		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	1 w/ bleach	93.843[a]	.346	93.165	94.521
	2 w/ bleach	92.891[a]	.379	92.148	93.634
	3 w/o bleach	95.121[a]	.346	94.443	95.799
	4 w/o bleach	93.683[a]	.379	92.940	94.426
B	1 w/ bleach	93.387[a]	.379	92.644	94.130
	2 w/ bleach	94.184[a]	.346	93.505	94.862
	3 w/o bleach	96.579[a]	.379	95.836	97.322
	4 w/o bleach	94.887[a]	.346	94.209	95.565

a. Based on modified population marginal mean.



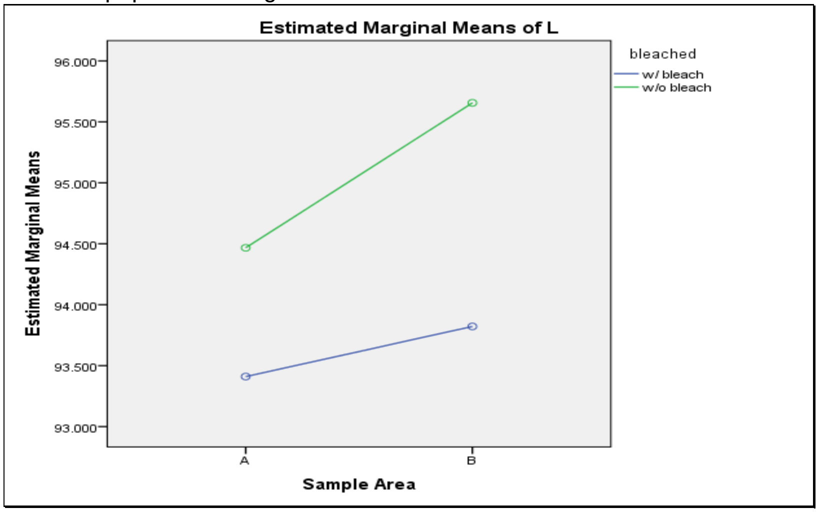
It can be observed that the difference in means is found in swatch 3 and these values increases even more between sample areas. The mean differences between swatches 2 and 4 are similar in that they both increase between the sample areas. Although these values are significant at p=0.04, with this value so close to 0.05, it can be observed that the significance was there but not as abundant. Swatch 1 which intersects swatches 2 and 4, did not observe significant values.

6. Sample Area * bleached: GMP

Dependent Variable: L

Sample Area		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
A	w/ bleach	93.410[a]	.255	92.910	93.911
	w/o bleach	94.467[a]	.255	93.966	94.968
B	w/ bleach	93.822[a]	.255	93.321	94.323
	w/o bleach	95.656[a]	.255	95.155	96.157

a. Based on modified population marginal mean.



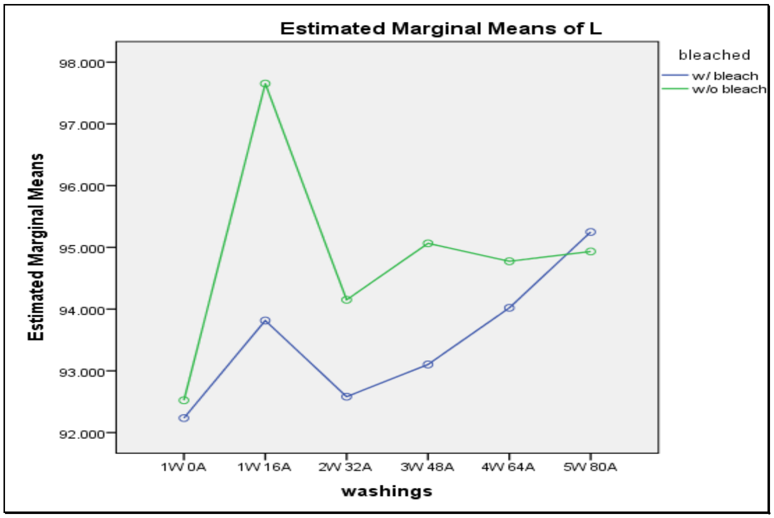
Again a difference is observed between samples at area B.

7. bleached * washings: GMP

Dependent Variable: L

bleached		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
w/ bleach	1W 0A	92.235[a]	.599	91.060	93.410
	1W 16A	93.815[a]	.423	92.984	94.646
	2W 32A	92.582[a]	.423	91.751	93.412
	3W 48A	93.104[a]	.423	92.273	93.934
	4W 64A	94.021[a]	.423	93.190	94.852
	5W 80A	95.250[a]	.423	94.419	96.080
w/o bleach	1W 0A	92.523[a]	.599	91.348	93.697
	1W 16A	97.653[a]	.423	96.822	98.484
	2W 32A	94.151[a]	.423	93.320	94.981
	3W 48A	95.066[a]	.423	94.235	95.896
	4W 64A	94.775[a]	.423	93.944	95.606
	5W 80A	94.934[a]	.423	94.103	95.764

a. Based on modified population marginal mean.



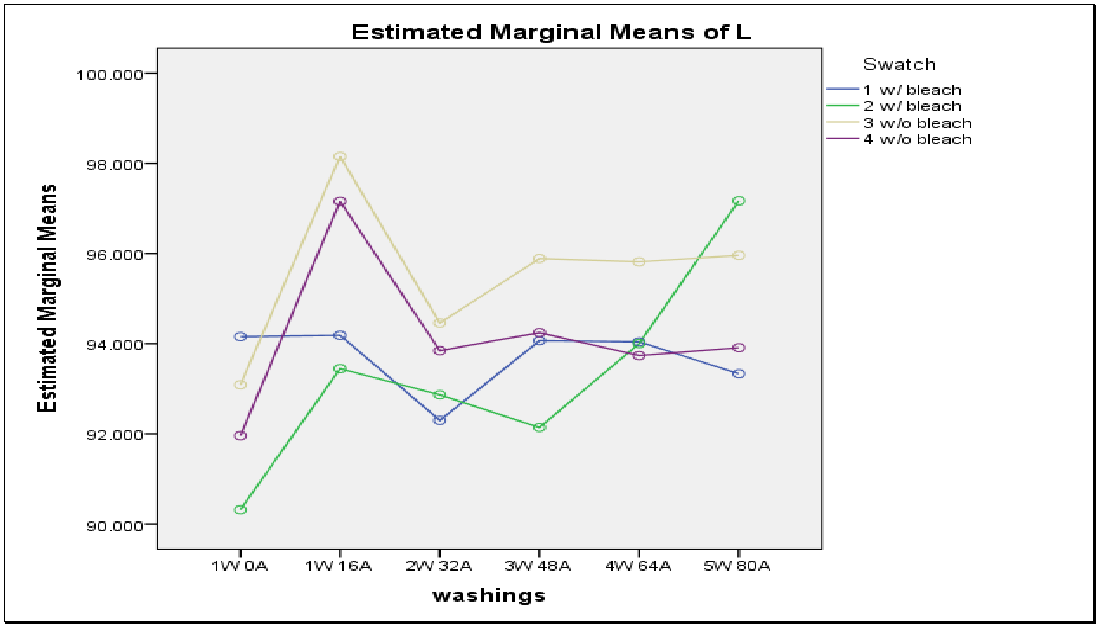
The patterns between these two samples remained consistently until the fifth cycle.

8. Swatch * Washings: GMP

Dependent Variable: L

Swatch		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1 w/ bleach	1W 0A	94.155[a]	.846	92.493	95.816
	1W 16A	94.184[a]	.599	93.009	95.359
	2W 32A	92.298[a]	.599	91.123	93.473
	3W 48A	94.066[a]	.599	92.891	95.241
	4W 64A	94.040[a]	.599	92.865	95.214
	5W 80A	93.332[a]	.599	92.157	94.507
2 w/ bleach	1W 0A	90.315[a]	.846	88.654	91.977
	1W 16A	93.445[a]	.599	92.271	94.620
	2W 32A	92.865[a]	.599	91.691	94.040
	3W 48A	92.141[a]	.599	90.966	93.316
	4W 64A	94.002[a]	.599	92.827	95.177
	5W 80A	97.168[a]	.599	95.993	98.343
3 w/o bleach	1W 0A	93.086[a]	.846	91.425	94.748
	1W 16A	98.150[a]	.599	96.975	99.325
	2W 32A	94.458[a]	.599	93.283	95.633
	3W 48A	95.887[a]	.599	94.713	97.062
	4W 64A	95.814[a]	.599	94.640	96.989
	5W 80A	95.958[a]	.599	94.783	97.133
4 w/o bleach	1W 0A	91.959[a]	.846	90.298	93.620
	1W 16A	97.156[a]	.599	95.981	98.331
	2W 32A	93.843[a]	.599	92.668	95.018
	3W 48A	94.244[a]	.599	93.069	95.419
	4W 64A	93.736[a]	.599	92.561	94.910
	5W 80A	93.909[a]	.599	92.734	95.084

a. Based on modified population marginal mean.



Swatches 2 and 3 follow a consistent pattern which slowly levels off between the fourth to six cycles. Swatches 1 and especially 2, varies greatly in this overall pattern.

Variable 'a'

Tests of Between-Subjects Effects: GMP

Dependent Variable: a

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	77.766[a]	43	1.809	4.665	.000
Intercept	553.273	1	553.273	1427.056	.000
SampleArea	.725	1	.725	1.871	.172
Swatch	1.569	2	.785	2.024	.133
bleached	0.000	0			
washings	13.901	5	2.780	7.171	.000
SampleArea * Swatch	.143	2	.072	.185	.831
SampleArea * bleached	0.000	0			
SampleArea * washings	8.461	4	2.115	5.456	.000
Swatch * bleached	0.000	0			
Swatch * washings	5.534	8	.692	1.784	.077
bleached * washings	0.000	0			
SampleArea * Swatch * bleached	0.000	0			
SampleArea * Swatch * washings	7.155	8	.894	2.307	.019
SampleArea * bleached * washings	0.000	0			
Swatch * bleached * washings	0.000	0			
SampleArea * Swatch * bleached * washings	0.000	0			
Error	324.119	836	.388		
Total	968.101	880			
Corrected Total	401.885	879			

a. R Squared = .194 (Adjusted R Squared = .152)
b. Computed using alpha = .05

The main effects for sample area and swatch, and the interaction effects of sample area versus swatch and swatch versus washing did not observe significant values.

1. Sample Area Estimates: GMP

Dependent Variable: a

Sample Area	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A	.791[a]	.030	.733	.850
B	.813[a]	.030	.755	.871

a. Based on modified population marginal mean.

Pairwise Comparisons: GMP

Dependent Variable: a

(I) Sample Area		Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
A	B	-.022[a,b]	.042	.607	-.104	.061
B	A	.022[a,b]	.042	.607	-.061	.104

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The main effects of sample as well as the variances within each level were not significant.

2. Swatch Estimates: GMP

Dependent Variable: a

Swatch	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1 w/ bleach	.950[a]	.042	.867	1.032
2 w/ bleach	.826[a]	.042	.744	.909
3 w/o bleach	.719[a]	.042	.637	.801
4 w/o bleach	.714[a]	.042	.631	.796

a. Based on modified population marginal mean.

Pairwise Comparisons: GMP

Dependent Variable: a

(I) Swatch		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach	.123[*,b,c]	.059	.038	.007	.240
	3 w/o bleach	.231[*,b,c]	.059	.000	.114	.347
	4 w/o bleach	.236[*,b,c]	.059	.000	.119	.352
2 w/ bleach	1 w/ bleach	-.123[*,b,c]	.059	.038	-.240	-.007
	3 w/o bleach	.107[b,c]	.059	.071	-.009	.224
	4 w/o bleach	.113[b,c]	.059	.058	-.004	.229
3 w/o bleach	1 w/ bleach	-.231[*,b,c]	.059	.000	-.347	-.114
	2 w/ bleach	-.107[b,c]	.059	.071	-.224	.009
	4 w/o bleach	.005[b,c]	.059	.930	-.111	.122
4 w/o bleach	1 w/ bleach	-.236[*,b,c]	.059	.000	-.352	-.119
	2 w/ bleach	-.113[b,c]	.059	.058	-.229	.004
	3 w/o bleach	-.005[b,c]	.059	.930	-.122	.111

Based on estimated marginal means

*. The mean difference is significant at the .05 level.
b. An estimate of the modified population marginal mean (I).
c. An estimate of the modified population marginal mean (J).
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Swatches 2 and 4 and swatches 1 and 2 did not produce significant values, as this was expected since both samples were washed under the same conditions. Of course, discrepancies observed between the samples washed with bleach.

3. Bleach Estimates: GMP

Dependent Variable: a

bleached	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
w/ bleach	.888[a]	.030	.830	.946
w/o bleach	.716[a]	.030	.658	.775

a. Based on modified population marginal mean.

Pairwise Comparisons: GMP

Dependent Variable: a

(I) bleached		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	95% Confidence Interval for Difference[d] Upper Bound
w/ bleach	w/o bleach	.172[*,b,c]	.042	.000	.089	.254
w/o bleach	w/ bleach	-.172[*,b,c]	.042	.000	-.254	-.089

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
b. An estimate of the modified population marginal mean (I).
c. An estimate of the modified population marginal mean (J).
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Within this group, significant differences were observed between levels of pair-wise groups.

4. Washing Estimates: GMP

Dependent Variable: a

washings	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1W 0A	1.018[a]	.070	.882	1.155
1W 16A	.925[a]	.049	.828	1.021
2W 32A	.828[a]	.049	.731	.925
3W 48A	.846[a]	.049	.750	.943
4W 64A	.656[a]	.049	.560	.753
5W 80A	.647[a]	.049	.550	.744

a. Based on modified population marginal mean.

Pairwise Comparisons: GMP

Dependent Variable: a

(I) washings		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
1W 0A	1W 16A	.093[a,b]	.085	.273	-.074	.261
	2W 32A	.190[a,b,*]	.085	.026	.023	.358
	3W 48A	.172[a,b,*]	.085	.044	.005	.339
	4W 64A	.362[a,b,*]	.085	.000	.195	.529
	5W 80A	.371[a,b,*]	.085	.000	.204	.539
1W 16A	1W 0A	-.093[a,b]	.085	.273	-.261	.074
	2W 32A	.097[a,b]	.070	.164	-.040	.234
	3W 48A	.078[a,b]	.070	.260	-.058	.215
	4W 64A	.268[a,b,*]	.070	.000	.132	.405
	5W 80A	.278[a,b,*]	.070	.000	.141	.414
2W 32A	1W 0A	-.190[a,b,*]	.085	.026	-.358	-.023
	1W 16A	-.097[a,b]	.070	.164	-.234	.040
	3W 48A	-.018[a,b]	.070	.791	-.155	.118
	4W 64A	.171[a,b,*]	.070	.014	.035	.308
	5W 80A	.181[a,b,*]	.070	.010	.044	.317
3W 48A	1W 0A	-.172[a,b,*]	.085	.044	-.339	-.005
	1W 16A	-.078[a,b]	.070	.260	-.215	.058
	2W 32A	.018[a,b]	.070	.791	-.118	.155
	4W 64A	.190[a,b,*]	.070	.006	.053	.327
	5W 80A	.199[a,b,*]	.070	.004	.063	.336
4W 64A	1W 0A	-.362[a,b,*]	.085	.000	-.529	-.195
	1W 16A	-.268[a,b,*]	.070	.000	-.405	-.132
	2W 32A	-.171[a,b,*]	.070	.014	-.308	-.035
	3W 48A	-.190[a,b,*]	.070	.006	-.327	-.053
	5W 80A	.009[a,b]	.070	.893	-.127	.146
5W 80A	1W 0A	-.371[a,b,*]	.085	.000	-.539	-.204
	1W 16A	-.278[a,b,*]	.070	.000	-.414	-.141
	2W 32A	-.181[a,b,*]	.070	.010	-.317	-.044
	3W 48A	-.199[a,b,*]	.070	.004	-.336	-.063
	4W 64A	-.009[a,b]	.070	.893	-.146	.127

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Within this group, significant differences were observed between levels of pair-wise groups.

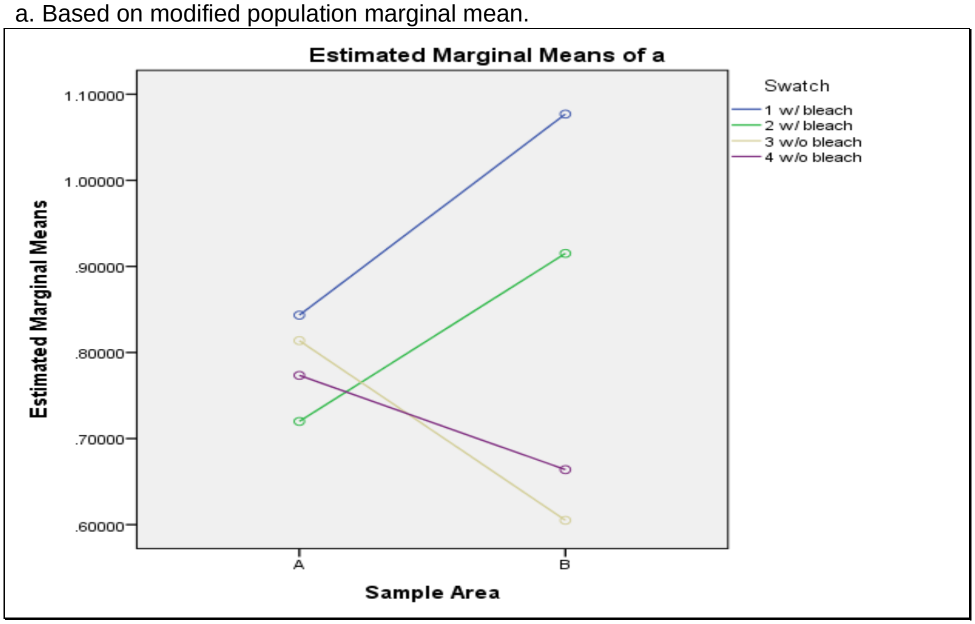
None of the pair-wise group stood out above the other.

5. Sample Area * Swatch: GMP

Dependent Variable: a

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	1 w/ bleach	.843[a]	.057	.732	.955
	2 w/ bleach	.720[a]	.062	.598	.842
	3 w/o bleach	.814[a]	.057	.702	.925
	4 w/o bleach	.773[a]	.062	.651	.896
B	1 w/ bleach	1.077[a]	.062	.955	1.199
	2 w/ bleach	.915[a]	.057	.804	1.027
	3 w/o bleach	.605[a]	.062	.483	.727
	4 w/o bleach	.664[a]	.057	.552	.775

a. Based on modified population marginal mean.



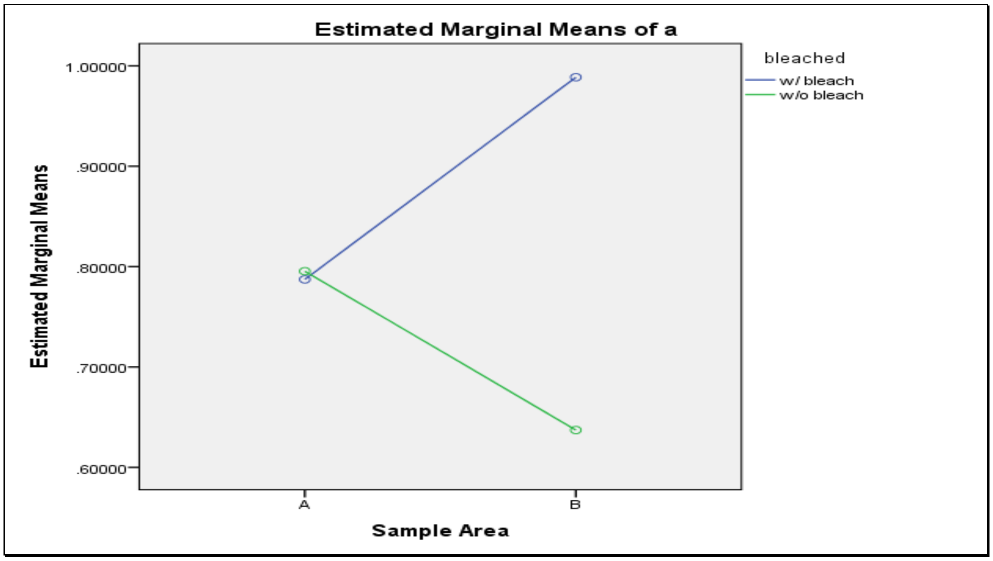
It is obvious that the mean difference between swatch 1 and 3 at sample area A is small but very large at sample area B. It can be expected that at this area, interaction occurs although it is not significant. And the same can be said for swatch 4 at this area.

6. Sample Area * Bleached: GMP

Dependent Variable: a

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	w/ bleach	.787[a]	.042	.705	.870
	w/o bleach	.795[a]	.042	.713	.878
B	w/ bleach	.989[a]	.042	.906	1.071
	w/o bleach	.637[a]	.042	.555	.720

a. Based on modified population marginal mean.



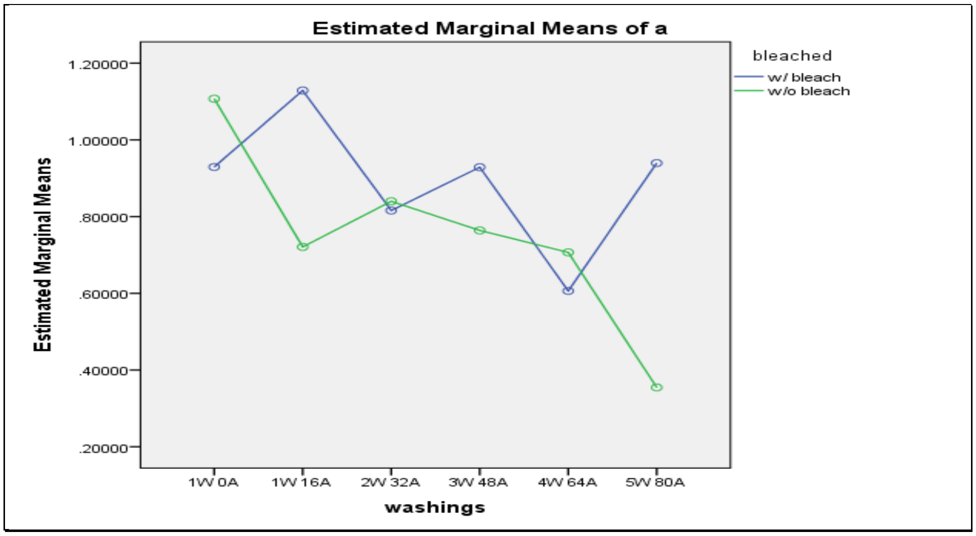
For sample area A, the means are similar between bleached samples. However, for sample area B, this is opposite. It can then be expected that the significant interaction occurs here.

7. Bleached * Washings: GMP

Dependent Variable: a

bleached		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
w/ bleach	1W 0A	.929[a]	.098	.736	1.123
	1W 16A	1.129[a]	.070	.992	1.265
	2W 32A	.816[a]	.070	.679	.953
	3W 48A	.929[a]	.070	.792	1.065
	4W 64A	.606[a]	.070	.470	.743
	5W 80A	.940[a]	.070	.803	1.076
w/o bleach	1W 0A	1.107[a]	.098	.914	1.300
	1W 16A	.721[a]	.070	.584	.858
	2W 32A	.840[a]	.070	.703	.977
	3W 48A	.764[a]	.070	.627	.901
	4W 64A	.707[a]	.070	.570	.843
	5W 80A	.355[a]	.070	.218	.491

a. Based on modified population marginal mean.



Where the means are similar, as observed at 2W 32A, no significant interaction is expected here.

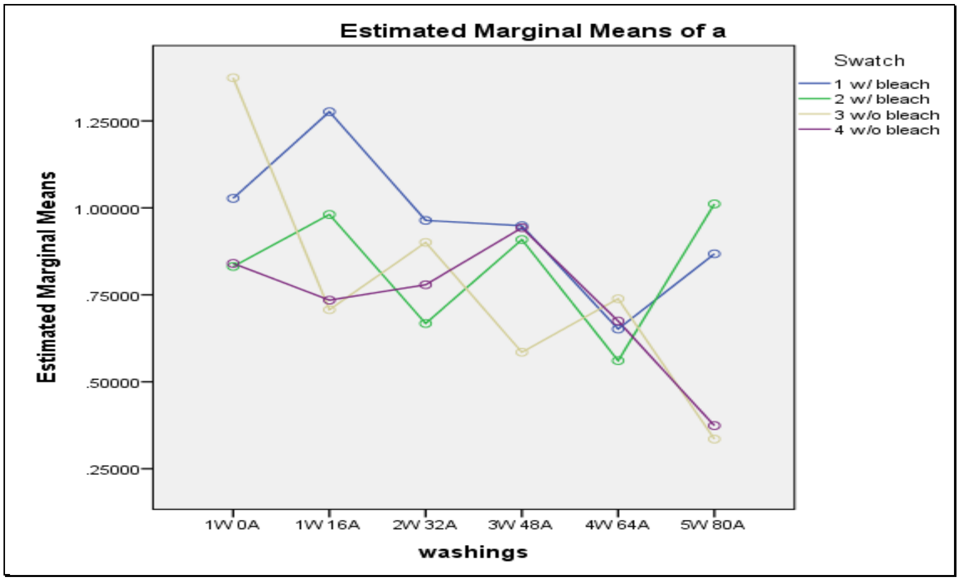
However, where the means differ moderately, significant interaction is expected.

9. Swatch * Washings: GMP

Dependent Variable: a

Swatch		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
1 w/ bleach	1W 0A	1.027[a]	.139	.754	1.301
	1W 16A	1.277[a]	.098	1.083	1.470
	2W 32A	.964[a]	.098	.771	1.157
	3W 48A	.949[a]	.098	.755	1.142
	4W 64A	.652[a]	.098	.458	.845
	5W 80A	.868[a]	.098	.675	1.061
2 w/ bleach	1W 0A	.831[a]	.139	.558	1.105
	1W 16A	.981[a]	.098	.788	1.174
	2W 32A	.668[a]	.098	.474	.861
	3W 48A	.909[a]	.098	.716	1.102
	4W 64A	.561[a]	.098	.367	.754
	5W 80A	1.011[a]	.098	.818	1.205
3 w/o bleach	1W 0A	1.374[a]	.139	1.101	1.647
	1W 16A	.707[a]	.098	.514	.900
	2W 32A	.901[a]	.098	.708	1.094
	3W 48A	.585[a]	.098	.392	.778
	4W 64A	.739[a]	.098	.546	.932
	5W 80A	.335[a]	.098	.142	.528
4 w/o bleach	1W 0A	.840[a]	.139	.567	1.114
	1W 16A	.735[a]	.098	.541	.928
	2W 32A	.779[a]	.098	.586	.972
	3W 48A	.943[a]	.098	.750	1.136
	4W 64A	.675[a]	.098	.481	.868
	5W 80A	.374[a]	.098	.181	.567

a. Based on modified population marginal mean.



The pattern observed for swatch 1 and 2 is fairly consistent. Swatch 3 follows this pattern after the first complete washed-aged cycle. Although swatches 3 and 4 were washed under the same conditions, they had no recognizable patterns.

Variable 'b'

Tests of Between-Subjects Effects: GMP

Dependent Variable: b

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1138.094[a]	43	26.467	5.630	.000
Intercept	88995.007	1	88995.007	18932.141	0.000
SampleArea	67.677	1	67.677	14.397	.000
Swatch	14.243	2	7.121	1.515	.220
bleached	0.000	0			
washings	208.983	5	41.797	8.892	.000
SampleArea * Swatch	1.074	2	.537	.114	.892
SampleArea * bleached	0.000	0			
SampleArea * washings	83.644	4	20.911	4.448	.001
Swatch * bleached	0.000	0			
Swatch * washings	244.618	8	30.577	6.505	.000
bleached * washings	0.000	0			
SampleArea * Swatch * bleached	0.000	0			
SampleArea * Swatch * washings	123.662	8	15.458	3.288	.001
SampleArea * bleached * washings	0.000	0			
Swatch * bleached * washings	0.000	0			
SampleArea * Swatch * bleached * washings	0.000	0			
Error	3929.816	836	4.701		
Total	98882.747	880			
Corrected Total	5067.909	879			

a. R Squared = .225 (Adjusted R Squared = .185)
b. Computed using alpha = .05

The main effects of group 'Swatch' did not observe any significant results.

1. Sample Area Estimates: GMP

Dependent Variable: b

Sample Area	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A	10.097[a]	.103	9.894	10.300
B	10.553[a]	.103	10.350	10.756

a. Based on modified population marginal mean.

Pairwise Comparisons: GMP

Dependent Variable: b

(I) Sample Area		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
A	B	-.456[*,b,c]	.146	.002	-.742	-.169
B	A	.456[*,b,c]	.146	.002	.169	.742

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Although the main effect was not significant, the within group effect was significant.

2. Swatch Estimates: GMP

Dependent Variable: b

Swatch	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1 w/ bleach	10.578[a]	.146	10.291	10.865
2 w/ bleach	10.297[a]	.146	10.010	10.584
3 w/o bleach	10.384[a]	.146	10.097	10.670
4 w/o bleach	10.042[a]	.146	9.756	10.329

a. Based on modified population marginal mean.

Pairwise Comparisons: GMP

Dependent Variable: b

(I) Swatch		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach	.281[a,b]	.207	.174	-.125	.687
	3 w/o bleach	.194[a,b]	.207	.348	-.212	.600
	4 w/o bleach	.535[a,b,*]	.207	.010	.129	.941
2 w/ bleach	1 w/ bleach	-.281[a,b]	.207	.174	-.687	.125
	3 w/o bleach	-.087[a,b]	.207	.674	-.493	.319
	4 w/o bleach	.254[a,b]	.207	.219	-.152	.660
3 w/o bleach	1 w/ bleach	-.194[a,b]	.207	.348	-.600	.212
	2 w/ bleach	.087[a,b]	.207	.674	-.319	.493
	4 w/o bleach	.341[a,b]	.207	.099	-.065	.747
4 w/o bleach	1 w/ bleach	-.535[a,b,*]	.207	.010	-.941	-.129
	2 w/ bleach	-.254[a,b]	.207	.219	-.660	.152
	3 w/o bleach	-.341[a,b]	.207	.099	-.747	.065

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Swatch 2 observed to be the only group that was not significantly difference from the others.

There were no consistent patterns between what was washed with bleach versus what was washed without.

3. Bleach Estimates: GMP

Dependent Variable: b

			95% Confidence Interval	
bleached	Mean	Std. Error	Lower Bound	Upper Bound
w/ bleach	10.437[a]	.103	10.234	10.640
w/o bleach	10.213[a]	.103	10.010	10.416

a. Based on modified population marginal mean.

Pairwise Comparisons: GMP

Dependent Variable: b

					95% Confidence Interval for Difference[c]	
(I) bleached		Mean Difference (I-J)	Std. Error	Sig.[c]	Lower Bound	Upper Bound
w/ bleach	w/o bleach	.224[a,b]	.146	.126	-.063	.511
w/o bleach	w/ bleach	-.224[a,b]	.146	.126	-.511	.063

Based on estimated marginal means
a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

No significant difference was observed between the bleached and unbleached samples. This gives clarity to the previous interpretation where no pattern could be observed among the swatches washed with and without bleach.

4. Washing Estimates: GMP

Dependent Variable: b

			95% Confidence Interval	
washings	Mean	Std. Error	Lower Bound	Upper Bound
1W 0A	11.265[a]	.242	10.789	11.741
1W 16A	10.794[a]	.171	10.457	11.130
2W 32A	9.621[a]	.171	9.284	9.957
3W 48A	10.539[a]	.171	10.203	10.876
4W 64A	9.909[a]	.171	9.572	10.245
5W 80A	10.293[a]	.171	9.957	10.630

a. Based on modified population marginal mean.

Pairwise Comparisons: GMP

Dependent Variable: b

(I) washings		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
1W 0A	1W 16A	.471[a,b]	.297	.113	-.112	1.054
	2W 32A	1.644[a,b,*]	.297	.000	1.061	2.227
	3W 48A	.726[a,b,*]	.297	.015	.143	1.309
	4W 64A	1.356[a,b,*]	.297	.000	.773	1.939
	5W 80A	.972[a,b,*]	.297	.001	.389	1.555
1W 16A	1W 0A	-.471[a,b]	.297	.113	-1.054	.112
	2W 32A	1.173[a,b,*]	.242	.000	.697	1.649
	3W 48A	.255[a,b]	.242	.293	-.221	.731
	4W 64A	.885[a,b,*]	.242	.000	.409	1.361
	5W 80A	.501[a,b,*]	.242	.039	.025	.977
2W 32A	1W 0A	-1.644[a,b,*]	.297	.000	-2.227	-1.061
	1W 16A	-1.173[a,b,*]	.242	.000	-1.649	-.697
	3W 48A	-.918[a,b,*]	.242	.000	-1.394	-.443
	4W 64A	-.288[a,b]	.242	.235	-.764	.188
	5W 80A	-.672[a,b,*]	.242	.006	-1.148	-.197
3W 48A	1W 0A	-.726[a,b,*]	.297	.015	-1.309	-.143
	1W 16A	-.255[a,b]	.242	.293	-.731	.221
	2W 32A	.918[a,b,*]	.242	.000	.443	1.394
	4W 64A	.630[a,b,*]	.242	.009	.154	1.106
	5W 80A	.246[a,b]	.242	.310	-.230	.722
4W 64A	1W 0A	-1.356[a,b,*]	.297	.000	-1.939	-.773
	1W 16A	-.885[a,b,*]	.242	.000	-1.361	-.409
	2W 32A	.288[a,b]	.242	.235	-.188	.764
	3W 48A	-.630[a,b,*]	.242	.009	-1.106	-.154
	5W 80A	-.384[a,b]	.242	.113	-.860	.091
5W 80A	1W 0A	-.972[a,b,*]	.297	.001	-1.555	-.389
	1W 16A	-.501[a,b,*]	.242	.039	-.977	-.025
	2W 32A	.672[a,b,*]	.242	.006	.197	1.148
	3W 48A	-.246[a,b]	.242	.310	-.722	.230
	4W 64A	.384[a,b]	.242	.113	-.091	.860

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

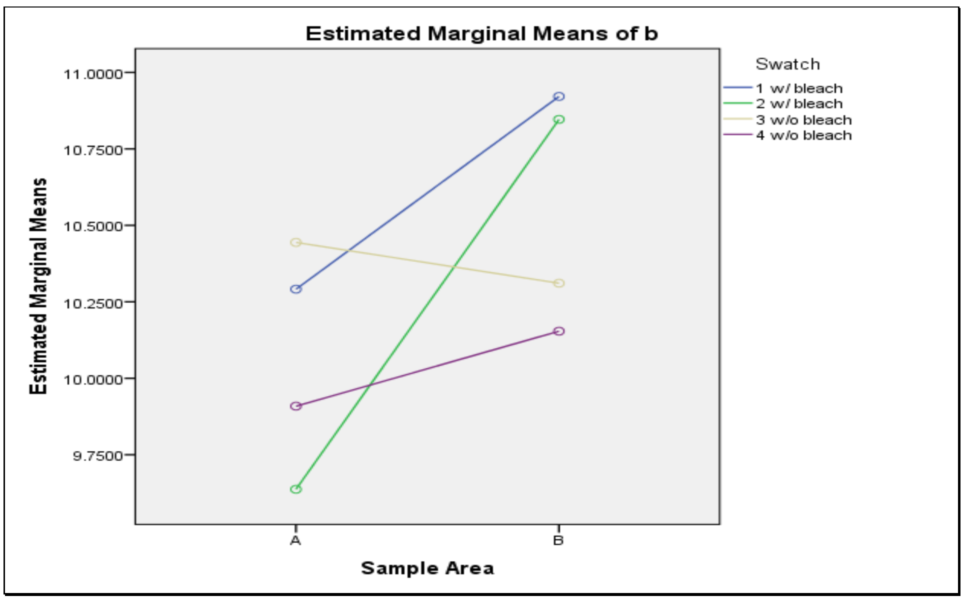
Marked significant differences were observed at all the comparing groups, however not for all measurements. No one pair-wise group stood out from the rest.

5. Sample Area * Swatch: GMP

Dependent Variable: b

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	1 w/ bleach	10.291[a]	.198	9.903	10.680
	2 w/ bleach	9.637[a]	.217	9.211	10.063
	3 w/o bleach	10.444[a]	.198	10.056	10.833
	4 w/o bleach	9.909[a]	.217	9.483	10.334
B	1 w/ bleach	10.921[a]	.217	10.496	11.347
	2 w/ bleach	10.846[a]	.198	10.458	11.235
	3 w/o bleach	10.311[a]	.217	9.885	10.736
	4 w/o bleach	10.154[a]	.198	9.765	10.542

a. Based on modified population marginal mean.



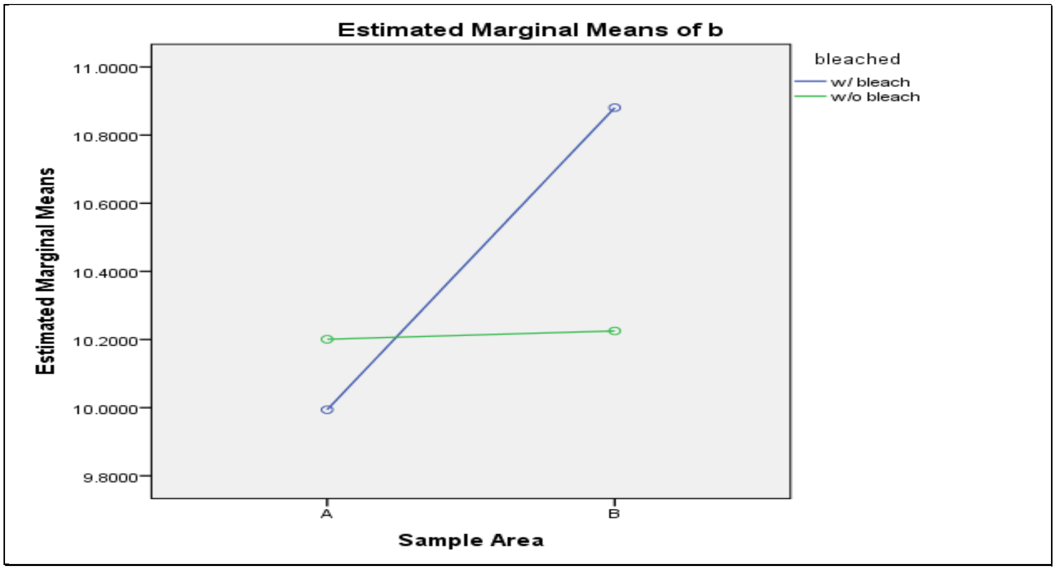
The mean values between swatches 1 and 2, and swatches 3 and 4 at sample area B are close to each other, thus significant interaction is not expected here. However the mean values between swatches 1 and 4 at area B and 1 and 2 at area A, observes to be substantial. Even though the main effects of swatch was not significant, some changes in both factors produced significant results through their interaction.

6. Sample Area * bleached: GMP

Dependent Variable: b

Sample Area		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	w/ bleach	9.994[a]	.146	9.707	10.281
	w/o bleach	10.201[a]	.146	9.914	10.488
B	w/ bleach	10.881[a]	.146	10.594	11.167
	w/o bleach	10.225[a]	.146	9.938	10.512

a. Based on modified population marginal mean.



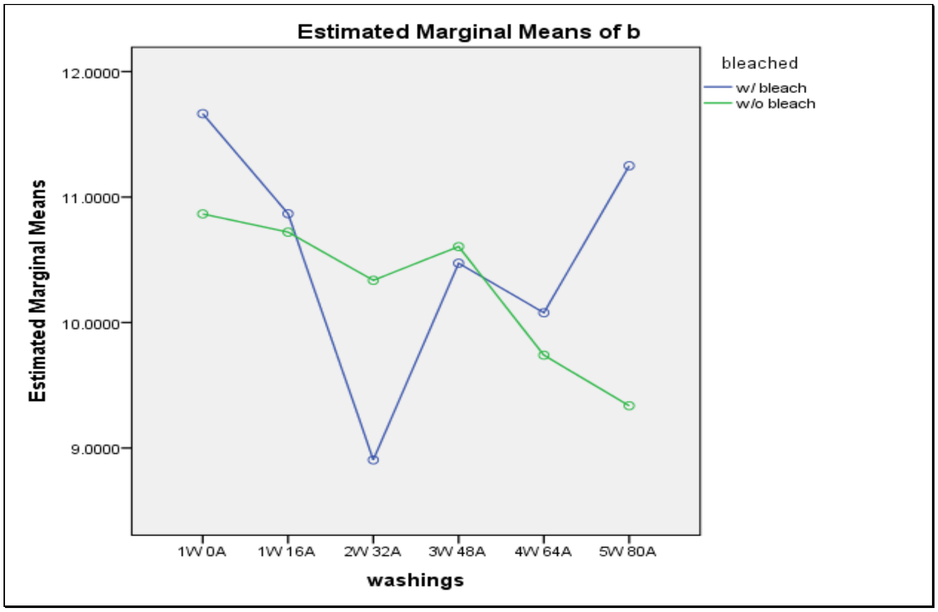
The significant interaction is possibly observed at sample area B as the mean values vary to a greater extent than at sample area A.

7. bleached * washings: GMP

Dependent Variable: b

bleached		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
w/ bleach	1W 0A	11.664[a]	.343	10.992	12.337
	1W 16A	10.867[a]	.242	10.392	11.343
	2W 32A	8.905[a]	.242	8.429	9.381
	3W 48A	10.473[a]	.242	9.997	10.949
	4W 64A	10.078[a]	.242	9.602	10.554
	5W 80A	11.249[a]	.242	10.773	11.725
w/o bleach	1W 0A	10.865[a]	.343	10.193	11.538
	1W 16A	10.720[a]	.242	10.245	11.196
	2W 32A	10.336[a]	.242	9.861	10.812
	3W 48A	10.605[a]	.242	10.130	11.081
	4W 64A	9.740[a]	.242	9.264	10.216
	5W 80A	9.337[a]	.242	8.861	9.813

a. Based on modified population marginal mean.



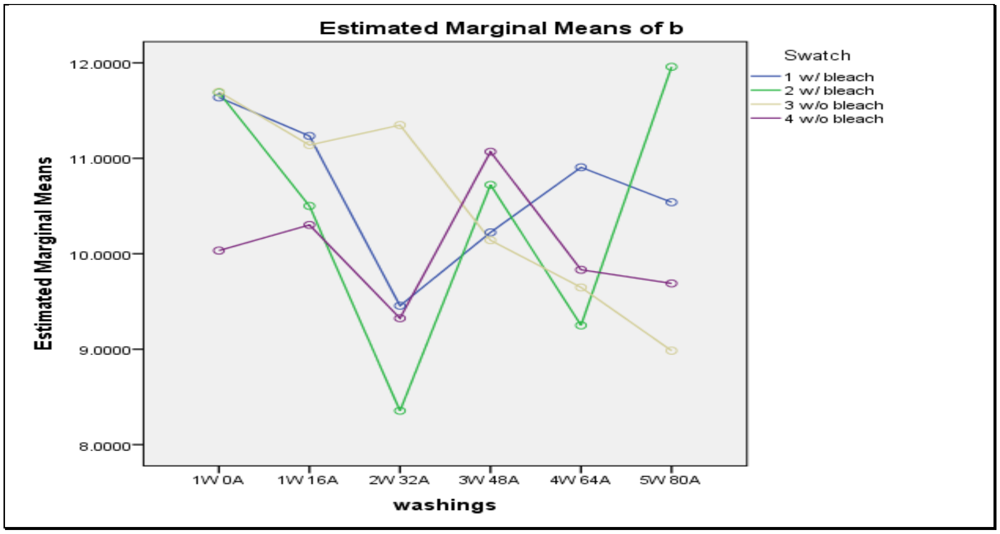
The significance in interactions can be obviously observed both at 2W 32A and 5W 80A where the mean values differ greatly between the bleached and unbleached samples.

8. Swatch * washings: GMP

Dependent Variable: b

Swatch		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1 w/ bleach	1W 0A	11.638[a]	.485	10.687	12.590
	1W 16A	11.234[a]	.343	10.561	11.907
	2W 32A	9.455[a]	.343	8.782	10.128
	3W 48A	10.224[a]	.343	9.551	10.897
	4W 64A	10.906[a]	.343	10.233	11.579
	5W 80A	10.540[a]	.343	9.867	11.212
2 w/ bleach	1W 0A	11.691[a]	.485	10.739	12.642
	1W 16A	10.501[a]	.343	9.828	11.174
	2W 32A	8.355[a]	.343	7.682	9.028
	3W 48A	10.722[a]	.343	10.049	11.395
	4W 64A	9.250[a]	.343	8.577	9.923
	5W 80A	11.959[a]	.343	11.286	12.632
3 w/o bleach	1W 0A	11.698[a]	.485	10.746	12.649
	1W 16A	11.139[a]	.343	10.466	11.811
	2W 32A	11.349[a]	.343	10.676	12.022
	3W 48A	10.142[a]	.343	9.469	10.814
	4W 64A	9.647[a]	.343	8.974	10.320
	5W 80A	8.985[a]	.343	8.312	9.657
4 w/o bleach	1W 0A	10.033[a]	.485	9.082	10.985
	1W 16A	10.302[a]	.343	9.629	10.975
	2W 32A	9.324[a]	.343	8.651	9.997
	3W 48A	11.069[a]	.343	10.396	11.742
	4W 64A	9.832[a]	.343	9.159	10.505
	5W 80A	9.689[a]	.343	9.017	10.362

a. Based on modified population marginal mean.



The main effect of swatch was calculated as an insignificant p-value. This was ignored since the interaction is significant here mainly because there is evidence supporting that changes in the exploring factors had an effect on the outcome, regardless of the main effect p-values.

III. OSDP

Variable 'L'

Tests of Between-Subjects Effects: OSDP

Dependent Variable: L

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4410.649[a]	43	102.573	10.173	.000
Intercept	6892059.036	1	6892059.036	683550.724	0.000
SampleArea	5.842	1	5.842	.579	.447
Swatch	193.787	2	96.893	9.610	.000
Bleached	0.000	0			
Washing	453.649	5	90.730	8.999	.000
SampleArea * Swatch	23.518	2	11.759	1.166	.312
SampleArea * Bleached	0.000	0			
SampleArea * Washing	225.039	4	56.260	5.580	.000
Swatch * Bleached	0.000	0			
Swatch * Washing	354.222	8	44.278	4.391	.000
Bleached * Washing	0.000	0			
SampleArea * Swatch * Bleached	0.000	0			
SampleArea * Swatch * Washing	1666.408	8	208.301	20.659	.000
SampleArea * Bleached * Washing	0.000	0			
Swatch * Bleached * Washing	0.000	0			
SampleArea * Swatch * Bleached * Washing	0.000	0			
Error	8429.164	836	10.083		
Total	7351867.921	880			
Corrected Total	12839.813	879			

a. R Squared = .344 (Adjusted R Squared = .310)

b. Computed using alpha = .05

The main effects of sample area, and the interaction effects of Sample Area * Swatch did not produce significant results. The main effects were not significantly different between two or more means, and that this two-way interaction was not significantly difference between two or more differences between two or more means.

1. Sample Area Estimates: OSDP

Dependent Variable: L

Sample Area	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	91.373[a]	.151	91.076	91.670
B	91.272[a]	.151	90.975	91.569

a. Based on modified population marginal mean.

Pairwise Comparisons: OSDP

Dependent Variable: L

(I) Sample Area		Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
A	B	.101[a,b]	.214	.637	-.319	.521
B	A	-.101[a,b]	.214	.637	-.521	.319

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

It can be observed that the mean values between these two sample areas are only a difference of 0.101 as the mean values are very similar.

2. Swatch Estimates: OSDP

Dependent Variable: L

Swatch	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	92.093[a]	.214	91.673	92.514
2 w/ bleach	91.062[a]	.214	90.642	91.482
3 w/o bleach	90.749[a]	.214	90.329	91.169
4 w/o bleach	91.386[a]	.214	90.965	91.806

a. Based on modified population marginal mean.

Pairwise Comparisons: OSDP

Dependent Variable: L

(I) Swatch		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach	1.031[*,b,c]	.303	.001	.437	1.626
	3 w/o bleach	1.344[*,b,c]	.303	.000	.750	1.939
	4 w/o bleach	.708[*,b,c]	.303	.020	.114	1.302
2 w/ bleach	1 w/ bleach	-1.031[*,b,c]	.303	.001	-1.626	-.437
	3 w/o bleach	.313[b,c]	.303	.302	-.281	.907
	4 w/o bleach	-.324[b,c]	.303	.285	-.918	.271
3 w/o bleach	1 w/ bleach	-1.344[*,b,c]	.303	.000	-1.939	-.750
	2 w/ bleach	-.313[b,c]	.303	.302	-.907	.281
	4 w/o bleach	-.637[*,b,c]	.303	.036	-1.231	-.042
4 w/o bleach	1 w/ bleach	-.708[*,b,c]	.303	.020	-1.302	-.114
	2 w/ bleach	.324[b,c]	.303	.285	-.271	.918
	3 w/o bleach	.637[*,b,c]	.303	.036	.042	1.231

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Swatch 1 observed marked significant differences at all levels of comparisons. No pattern was otherwise observed among the treated swatches.

3. Bleach Estimates: OSDP

Dependent Variable: L

Bleached	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
w/ bleach	91.578[a]	.151	91.281	91.875
w/o bleach	91.067[a]	.151	90.770	91.364

a. Based on modified population marginal mean.

Pairwise Comparisons: OSDP

Dependent Variable: L

(I) Bleached		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
w/ bleach	w/o bleach	.510[*,b,c]	.214	.017	.090	.931
w/o bleach	w/ bleach	-.510[*,b,c]	.214	.017	-.931	-.090

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Significant values were observed for this level of comparison.

4. Washing Estimates: OSDP

Dependent Variable: L

Washing	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1W 0A	92.366[a]	.355	91.669	93.063
1W 16A	92.093[a]	.251	91.600	92.585
2W 32A	90.411[a]	.251	89.918	90.904
3W 48A	91.907[a]	.251	91.414	92.400
4W 64A	91.060[a]	.251	90.567	91.553
5W 80A	90.621[a]	.251	90.128	91.113

a. Based on modified population marginal mean.

Pairwise Comparisons: OSDP

Dependent Variable: L

(I) Washing		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	95% Confidence Interval for Difference[d] Upper Bound
1W 0A	1W 16A	.273[a,b]	.435	.530	-.580	1.127
	2W 32A	1.955[a,b,*]	.435	.000	1.101	2.808
	3W 48A	.459[a,b]	.435	.291	-.394	1.312
	4W 64A	1.306[a,b,*]	.435	.003	.452	2.159
	5W 80A	1.745[a,b,*]	.435	.000	.892	2.599
1W 16A	1W 0A	-.273[a,b]	.435	.530	-1.127	.580
	2W 32A	1.682[a,b,*]	.355	.000	.985	2.379
	3W 48A	.186[a,b]	.355	.601	-.511	.883
	4W 64A	1.033[a,b,*]	.355	.004	.336	1.730
	5W 80A	1.472[a,b,*]	.355	.000	.775	2.169
2W 32A	1W 0A	-1.955[a,b,*]	.435	.000	-2.808	-1.101
	1W 16A	-1.682[a,b,*]	.355	.000	-2.379	-.985
	3W 48A	-1.496[a,b,*]	.355	.000	-2.193	-.799
	4W 64A	-.649[a,b]	.355	.068	-1.346	.048
	5W 80A	-.210[a,b]	.355	.555	-.906	.487
3W 48A	1W 0A	-.459[a,b]	.435	.291	-1.312	.394
	1W 16A	-.186[a,b]	.355	.601	-.883	.511
	2W 32A	1.496[a,b,*]	.355	.000	.799	2.193
	4W 64A	.847[a,b,*]	.355	.017	.150	1.544
	5W 80A	1.286[a,b,*]	.355	.000	.589	1.983
4W 64A	1W 0A	-1.306[a,b,*]	.435	.003	-2.159	-.452
	1W 16A	-1.033[a,b,*]	.355	.004	-1.730	-.336
	2W 32A	.649[a,b]	.355	.068	-.048	1.346
	3W 48A	-.847[a,b,*]	.355	.017	-1.544	-.150
	5W 80A	.439[a,b]	.355	.216	-.258	1.136
5W 80A	1W 0A	-1.745[a,b,*]	.435	.000	-2.599	-.892
	1W 16A	-1.472[a,b,*]	.355	.000	-2.169	-.775
	2W 32A	.210[a,b]	.355	.555	-.487	.906
	3W 48A	-1.286[a,b,*]	.355	.000	-1.983	-.589
	4W 64A	-.439[a,b]	.355	.216	-1.136	.258

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

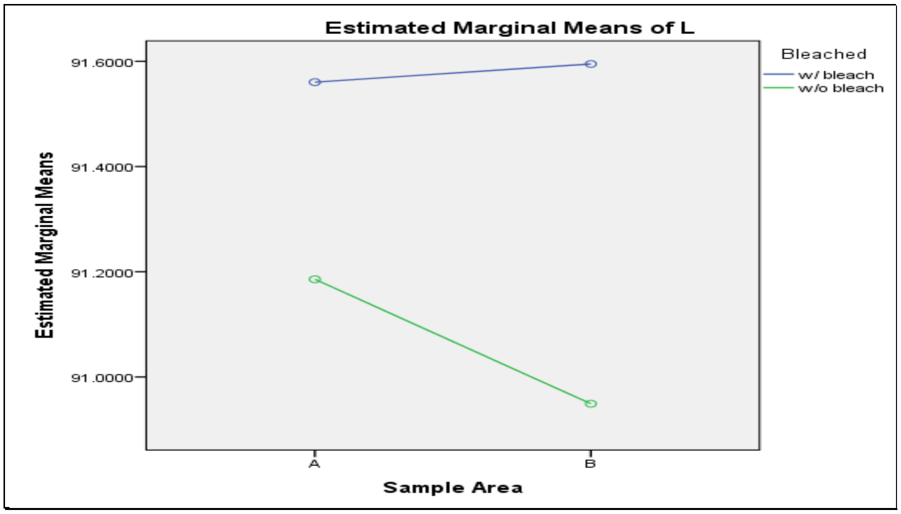
Significant values were observed for all groups but not for all pair-wise levels of this factor.

6. Sample Area * Bleached: OSDP

Dependent Variable: L

Sample Area		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
A	w/ bleach	91.560[a]	.214	91.140	91.981
	w/o bleach	91.186[a]	.214	90.765	91.606
B	w/ bleach	91.595[a]	.214	91.175	92.015
	w/o bleach	90.949[a]	.214	90.529	91.369

a. Based on modified population marginal mean.



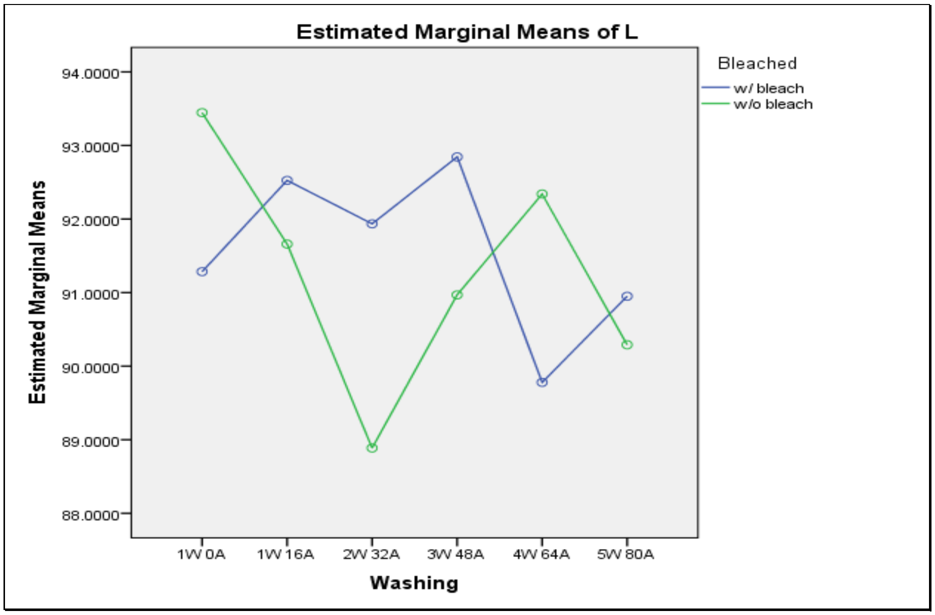
The mean difference for the bleached samples is approximately 0.035 and 0.237 for the unbleached samples. Even though a difference is noticed, without the calculation of the p-values, a significant difference cannot be assumed.

7. Bleached * Washing: OSDP

Dependent Variable: L

Bleached		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
w/ bleach	1W 0A	91.285[a]	.502	90.299	92.270
	1W 16A	92.526[a]	.355	91.829	93.222
	2W 32A	91.935[a]	.355	91.238	92.632
	3W 48A	92.845[a]	.355	92.148	93.541
	4W 64A	89.780[a]	.355	89.083	90.476
	5W 80A	90.951[a]	.355	90.254	91.647
w/o bleach	1W 0A	93.447[a]	.502	92.461	94.432
	1W 16A	91.660[a]	.355	90.963	92.357
	2W 32A	88.887[a]	.355	88.190	89.584
	3W 48A	90.969[a]	.355	90.272	91.666
	4W 64A	92.340[a]	.355	91.643	93.037
	5W 80A	90.291[a]	.355	89.594	90.987

a. Based on modified population marginal mean.



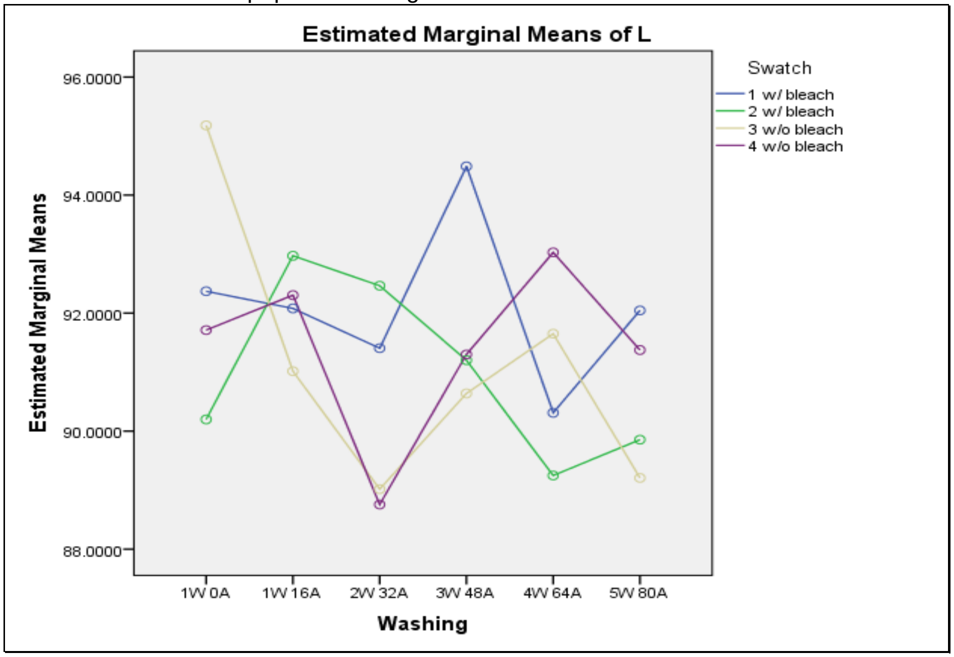
At 2W 32A, the greatest difference in means are observed here for bleached and unbleached samples. It can be assumed that a significant interaction effect occurs at this level of interaction.

8. Swatch * Washing: OSDP

Dependent Variable: L

Swatch		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	1W 0A	92.371[a]	.710	90.977	93.764
	1W 16A	92.080[a]	.502	91.094	93.065
	2W 32A	91.405[a]	.502	90.420	92.391
	3W 48A	94.487[a]	.502	93.502	95.473
	4W 64A	90.311[a]	.502	89.325	91.296
	5W 80A	92.046[a]	.502	91.060	93.031
2 w/ bleach	1W 0A	90.199[a]	.710	88.805	91.593
	1W 16A	92.971[a]	.502	91.986	93.957
	2W 32A	92.464[a]	.502	91.479	93.450
	3W 48A	91.202[a]	.502	90.217	92.187
	4W 64A	89.248[a]	.502	88.263	90.234
	5W 80A	89.856[a]	.502	88.870	90.841
3 w/o bleach	1W 0A	95.181[a]	.710	93.788	96.575
	1W 16A	91.015[a]	.502	90.030	92.001
	2W 32A	89.018[a]	.502	88.032	90.003
	3W 48A	90.639[a]	.502	89.653	91.624
	4W 64A	91.651[a]	.502	90.666	92.637
	5W 80A	89.207[a]	.502	88.221	90.192
4 w/o bleach	1W 0A	91.712[a]	.710	90.319	93.106
	1W 16A	92.304[a]	.502	91.319	93.290
	2W 32A	88.757[a]	.502	87.771	89.742
	3W 48A	91.300[a]	.502	90.314	92.285
	4W 64A	93.029[a]	.502	92.044	94.015
	5W 80A	91.375[a]	.502	90.389	92.360

a. Based on modified population marginal mean.



All four swatches observed different patterns suggesting that the conditions of the detergent had no impact among the swatches. The washed* swatch interaction was also significant at p = .001.

Variable 'a'

Tests of Between-Subjects Effects: OSDP

Dependent Variable: a

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	642.81[a]	43	14.949	6.392	.000
Intercept	77883	1	77883	33300	0.000
SampleArea	10.255	1	10.255	4.385	.037
Swatch	4.728	2	2.364	1.011	.364
Bleached	0.000	0			
Washing	122.766	5	24.553	10.498	.000
SampleArea * Swatch	1.420	2	.710	.304	.738
SampleArea * Bleached	0.000	0			
SampleArea * Washing	73.682	4	18.420	7.876	.000
Swatch * Bleached	0.000	0			
Swatch * Washing	56.166	8	7.021	3.002	.003
Bleached * Washing	0.000	0			
SampleArea * Swatch * Bleached	0.000	0			
SampleArea * Swatch * Washing	77.445	8	9.681	4.139	.000
SampleArea * Bleached * Washing	0.000	0			
Swatch * Bleached * Washing	0.000	0			
SampleArea * Swatch * Bleached * Washing	0.000	0			
Error	1955.2	836	2.339		
Total	86875	880			
Corrected Total	2598	879			

a. R Squared = .247 (Adjusted R Squared = .209)

b. Computed using alpha = .05

The main effect of group 'Swatch' and the interaction effects of Swatch* Sample Area were not significant.

1. Sample Area Estimates: OSDP

Dependent Variable: a

Sample Area	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A	9.710[a]	.073	9.567	9.853
B	9.862[a]	.073	9.719	10.005

a. Based on modified population marginal mean.

Pairwise Comparisons: OSDP

Dependent Variable: a

(I) Sample Area	(J) Sample Area	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
A	B	-.152[a,b]	.103	.140	-.355	.050
B	A	.152[a,b]	.103	.140	-.050	.355

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

No significant difference between the two differences between the two differences in means was observed although the main effect was found to be significantly different between the two means. In other words, differences between the means were observed, but differences between these differences (of the means) were not observed.

2. Swatch Estimates: OSDP

Dependent Variable: a

Swatch	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1 w/ bleach	9.835[a]	.103	9.633	10.038
2 w/ bleach	9.827[a]	.103	9.624	10.029
3 w/o bleach	9.926[a]	.103	9.724	10.128
4 w/o bleach	9.557[a]	.103	9.355	9.759

a. Based on modified population marginal mean.

Pairwise Comparisons: OSDP

Dependent Variable: a

(I) Swatch		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach	.009[a,b]	.146	.952	-.277	.295
	3 w/o bleach	-.091[a,b]	.146	.534	-.377	.195
	4 w/o bleach	.278[a,b]	.146	.057	-.008	.565
2 w/ bleach	1 w/ bleach	-.009[a,b]	.146	.952	-.295	.277
	3 w/o bleach	-.099[a,b]	.146	.495	-.386	.187
	4 w/o bleach	.270[a,b]	.146	.065	-.017	.556
3 w/o bleach	1 w/ bleach	.091[a,b]	.146	.534	-.195	.377
	2 w/ bleach	.099[a,b]	.146	.495	-.187	.386
	4 w/o bleach	.369[a,b,*]	.146	.012	.083	.655
4 w/o bleach	1 w/ bleach	-.278[a,b]	.146	.057	-.565	.008
	2 w/ bleach	-.270[a,b]	.146	.065	-.556	.017
	3 w/o bleach	-.369[a,b,*]	.146	.012	-.655	-.083

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Swatches 1 and 2 did not observe any significant differences, whereas swatch 3 observed a difference with swatch 4.

3. Bleach Estimates: OSDP

Dependent Variable: a

Bleached	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
w/ bleach	9.831[a]	.073	9.688	9.974
w/o bleach	9.741[a]	.073	9.598	9.885

a. Based on modified population marginal mean.

Pairwise Comparisons: OSDP

Dependent Variable: a

(I) Bleached		Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	Upper Bound
w/ bleach	w/o bleach	.089[a,b]	.103	.386	-.113	.292
w/o bleach	w/ bleach	-.089[a,b]	.103	.386	-.292	.113

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

At this level of interaction, no significant differences were observed between the bleached and unbleached samples.

4. Washing Estimates: OSDP

Dependent Variable: a

Washing	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1W 0A	8.697[a]	.171	8.361	9.033
1W 16A	10.198[a]	.121	9.961	10.436
2W 32A	9.922[a]	.121	9.685	10.160
3W 48A	9.872[a]	.121	9.635	10.109
4W 64A	9.929[a]	.121	9.691	10.166
5W 80A	9.554[a]	.121	9.317	9.792

a. Based on modified population marginal mean.

Pairwise Comparisons: OSDP

Dependent Variable: a

(I) Washing		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	95% Confidence Interval for Difference[d] Upper Bound
1W 0A	1W 16A	-1.501[*,b,c]	.209	.000	-1.912	-1.090
	2W 32A	-1.225[*,b,c]	.209	.000	-1.636	-.814
	3W 48A	-1.175[*,b,c]	.209	.000	-1.586	-.764
	4W 64A	-1.232[*,b,c]	.209	.000	-1.643	-.821
	5W 80A	-.857[*,b,c]	.209	.000	-1.268	-.446
1W 16A	1W 0A	1.501[*,b,c]	.209	.000	1.090	1.912
	2W 32A	.276[b,c]	.171	.107	-.060	.611
	3W 48A	.326[b,c]	.171	.057	-.009	.662
	4W 64A	.270[b,c]	.171	.115	-.066	.605
	5W 80A	.644[*,b,c]	.171	.000	.308	.979
2W 32A	1W 0A	1.225[*,b,c]	.209	.000	.814	1.636
	1W 16A	-.276[b,c]	.171	.107	-.611	.060
	3W 48A	.050[b,c]	.171	.769	-.285	.386
	4W 64A	-.006[b,c]	.171	.971	-.342	.329
	5W 80A	.368[*,b,c]	.171	.032	.032	.704
3W 48A	1W 0A	1.175[*,b,c]	.209	.000	.764	1.586
	1W 16A	-.326[b,c]	.171	.057	-.662	.009
	2W 32A	-.050[b,c]	.171	.769	-.386	.285
	4W 64A	-.057[b,c]	.171	.741	-.392	.279
	5W 80A	.318[b,c]	.171	.064	-.018	.653
4W 64A	1W 0A	1.232[*,b,c]	.209	.000	.821	1.643
	1W 16A	-.270[b,c]	.171	.115	-.605	.066
	2W 32A	.006[b,c]	.171	.971	-.329	.342
	3W 48A	.057[b,c]	.171	.741	-.279	.392
	5W 80A	.374[*,b,c]	.171	.029	.039	.710
5W 80A	1W 0A	.857[*,b,c]	.209	.000	.446	1.268
	1W 16A	-.644[*,b,c]	.171	.000	-.979	-.308
	2W 32A	-.368[*,b,c]	.171	.032	-.704	-.032
	3W 48A	-.318[b,c]	.171	.064	-.653	.018
	4W 64A	-.374[*,b,c]	.171	.029	-.710	-.039

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

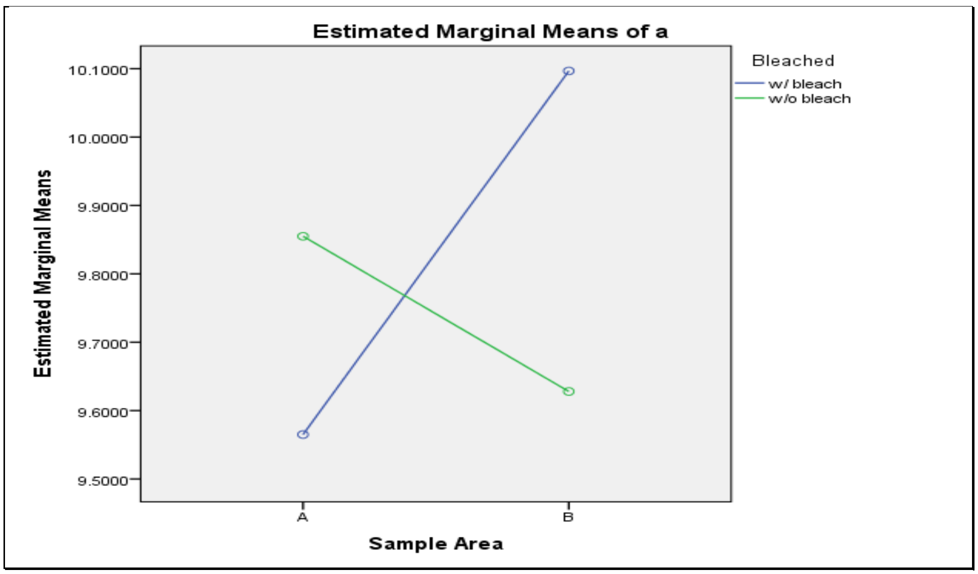
Marked significant differences were observed for all groups but not for all levels of pair-wise comparisons. In fact, group 1W 0A observed significant values for all pair-wise comparisons at a constant p-value at.001.

6. Sample Area * Bleached: OSDP

Dependent Variable: a

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	w/ bleach	9.565[a]	.103	9.363	9.767
	w/o bleach	9.855[a]	.103	9.653	10.057
B	w/ bleach	10.097[a]	.103	9.894	10.299
	w/o bleach	9.628[a]	.103	9.426	9.830

a. Based on modified population marginal mean.



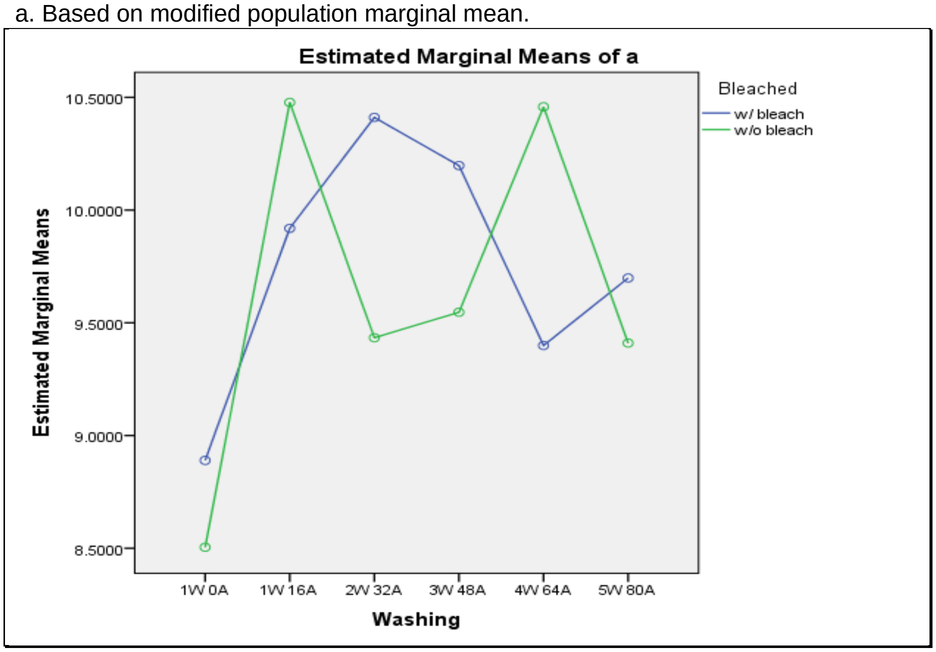
It can be observed that the mean values differed greatly at sample area B, however, since p-values were not calculated for this interaction, no further interpretation can be concluded without proper statistical evidence.

7. Bleached * Washing: OSDP

Dependent Variable: a

Bleached		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
w/ bleach	1W 0A	8.890[a]	.242	8.415	9.364
	1W 16A	9.919[a]	.171	9.583	10.255
	2W 32A	10.411[a]	.171	10.075	10.747
	3W 48A	10.197[a]	.171	9.862	10.533
	4W 64A	9.399[a]	.171	9.064	9.735
	5W 80A	9.699[a]	.171	9.363	10.034
w/o bleach	1W 0A	8.504[a]	.242	8.030	8.979
	1W 16A	10.477[a]	.171	10.142	10.813
	2W 32A	9.434[a]	.171	9.098	9.769
	3W 48A	9.547[a]	.171	9.211	9.882
	4W 64A	10.458[a]	.171	10.122	10.794
	5W 80A	9.410[a]	.171	9.075	9.746

a. Based on modified population marginal mean.



No consistent pattern can be observed for these samples. The mean values between the bleached and unbleached samples differ the greatest at 2W 32 and 4W 64. Significant interaction effects can be assumed.

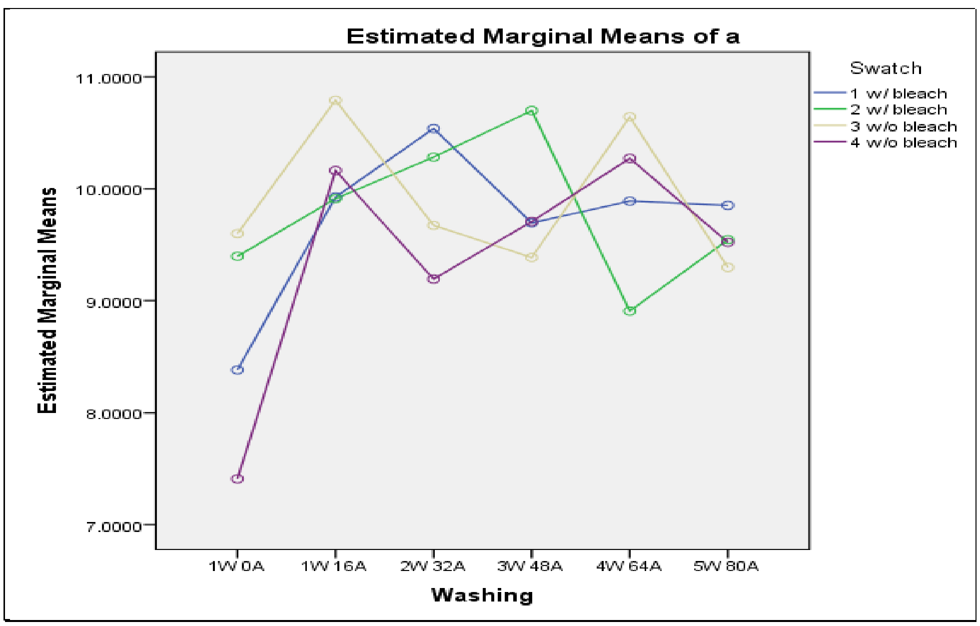
For the swatch* washing interaction, the main effect p-value was ignored for swatch because the interaction was found to be significant. This means that the outcome of the interaction was affected by both factors.

8. Swatch * Washing: OSDP

Dependent Variable: a

Swatch		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
1 w/ bleach	1W 0A	8.382[a]	.342	7.711	9.054
	1W 16A	9.926[a]	.242	9.452	10.401
	2W 32A	10.539[a]	.242	10.064	11.013
	3W 48A	9.696[a]	.242	9.221	10.170
	4W 64A	9.890[a]	.242	9.416	10.365
	5W 80A	9.852[a]	.242	9.377	10.326
2 w/ bleach	1W 0A	9.397[a]	.342	8.726	10.068
	1W 16A	9.912[a]	.242	9.437	10.386
	2W 32A	10.283[a]	.242	9.809	10.758
	3W 48A	10.699[a]	.242	10.224	11.173
	4W 64A	8.908[a]	.242	8.433	9.383
	5W 80A	9.545[a]	.242	9.071	10.020
3 w/o bleach	1W 0A	9.600[a]	.342	8.928	10.271
	1W 16A	10.791[a]	.242	10.316	11.266
	2W 32A	9.673[a]	.242	9.199	10.148
	3W 48A	9.386[a]	.242	8.912	9.861
	4W 64A	10.644[a]	.242	10.169	11.118
	5W 80A	9.299[a]	.242	8.824	9.773
4 w/o bleach	1W 0A	7.409[a]	.342	6.738	8.080
	1W 16A	10.164[a]	.242	9.689	10.638
	2W 32A	9.194[a]	.242	8.719	9.668
	3W 48A	9.707[a]	.242	9.233	10.182
	4W 64A	10.272[a]	.242	9.798	10.747
	5W 80A	9.522[a]	.242	9.047	9.996

a. Based on modified population marginal mean.



Variable 'b'

Tests of Between-Subjects Effects: OSDP

Dependent Variable: b

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4497.1[a]	43	104.58	6.822	.000
Intercept	764924	1	764923	49897	0.000
SampleArea	64.443	1	64.443	4.204	.041
Swatch	12.224	2	6.112	.399	.671
Bleached	0.000	0			
Washing	442.01	5	88.402	5.767	.000
SampleArea * Swatch	34.335	2	17.167	1.120	.327
SampleArea * Bleached	0.000	0			
SampleArea * Washing	522.87	4	130.718	8.527	.000
Swatch * Bleached	0.000	0			
Swatch * Washing	260.74	8	32.592	2.126	.031
Bleached * Washing	0.000	0			
SampleArea * Swatch * Bleached	0.000	0			
SampleArea * Swatch * Washing	1012.3	8	126.539	8.254	.000
SampleArea * Bleached * Washing	0.000	0			
Swatch * Bleached * Washing	0.000	0			
SampleArea * Swatch * Bleached * Washing	0.000	0			
Error	12816	836	15.330		
Total	824477	880			
Corrected Total	17313	879			

a. R Squared = .260 (Adjusted R Squared = .222)

b. Computed using alpha = .05

The main effect of the swatch and the interaction effects of the Swatch* Sample Area were not significant.

1. Sample Area Estimates: OSDP

Dependent Variable: b

Sample Area	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A	30.133[a]	.187	29.767	30.500
B	30.438[a]	.187	30.072	30.805

a. Based on modified population marginal mean.

Pairwise Comparisons: OSDP

Dependent Variable: b

(I) Sample Area		Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
A	B	-.305[a,b]	.264	.249	-.823	.213
B	A	.305[a,b]	.264	.249	-.213	.823

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Although the main effects of sample area were significant, the differences between the levels of pair-wise comparison were not significant. This means that the effects on the outcome of a particular level (A), does not depend on the other level (B).

2. Swatch Estimates: OSDP

Dependent Variable: b

Swatch	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1 w/ bleach	30.449[a]	.264	29.931	30.967
2 w/ bleach	30.379[a]	.264	29.861	30.897
3 w/o bleach	30.557[a]	.264	30.039	31.075
4 w/o bleach	29.758[a]	.264	29.240	30.276

a. Based on modified population marginal mean.

Pairwise Comparisons: OSDP

Dependent Variable: b

(I) Swatch		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach	.070[a,b]	.373	.851	-.663	.803
	3 w/o bleach	-.108[a,b]	.373	.772	-.841	.625
	4 w/o bleach	.691[a,b]	.373	.064	-.042	1.424
2 w/ bleach	1 w/ bleach	-.070[a,b]	.373	.851	-.803	.663
	3 w/o bleach	-.178[a,b]	.373	.633	-.911	.554
	4 w/o bleach	.621[a,b]	.373	.096	-.112	1.354
3 w/o bleach	1 w/ bleach	.108[a,b]	.373	.772	-.625	.841
	2 w/ bleach	.178[a,b]	.373	.633	-.554	.911
	4 w/o bleach	.799[a,b,*]	.373	.033	.067	1.532
4 w/o bleach	1 w/ bleach	-.691[a,b]	.373	.064	-1.424	.042
	2 w/ bleach	-.621[a,b]	.373	.096	-1.354	.112
	3 w/o bleach	-.799[a,b,*]	.373	.033	-1.532	-.067

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The bleached swatches did not observe significant values, however, significant values were observed between the unbleached swatches.

3. Bleach Estimates: OSDP

Dependent Variable: b

Bleached	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
w/ bleach	30.414[a]	.187	30.048	30.780
w/o bleach	30.158[a]	.187	29.791	30.524

a. Based on modified population marginal mean.

Pairwise Comparisons: OSDP

Dependent Variable: b

(I) Bleached		Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
w/ bleach	w/o bleach	.256[a,b]	.264	.332	-.262	.775
w/o bleach	w/ bleach	-.256[a,b]	.264	.332	-.775	.262

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

No marked significances were observed between the bleached and unbleached samples.

4. Washing Estimates: OSDP

Dependent Variable: b

Washing	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1W 0A	32.242[a]	.438	31.383	33.101
1W 16A	30.489[a]	.310	29.881	31.096
2W 32A	30.081[a]	.310	29.474	30.689
3W 48A	30.167[a]	.310	29.559	30.774
4W 64A	30.150[a]	.310	29.543	30.758
5W 80A	29.564[a]	.310	28.957	30.172

a. Based on modified population marginal mean.

At 0W 0A, marked significant differences were observed for all the pair-wise comparing groups. Only one other significant values was observed between 1W 16A and 5W 80A. It can be concluded the washing treatment did not affect the saturation of the color considerably.

Pairwise Comparisons: OSDP

Dependent Variable: b

(I) Washing		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	Upper Bound
1W 0A	1W 16A	1.753[*,b,c]	.536	.001	.701	2.806
	2W 32A	2.161[*,b,c]	.536	.000	1.108	3.213
	3W 48A	2.075[*,b,c]	.536	.000	1.023	3.128
	4W 64A	2.092[*,b,c]	.536	.000	1.039	3.144
	5W 80A	2.677[*,b,c]	.536	.000	1.625	3.730
1W 16A	1W 0A	-1.753[*,b,c]	.536	.001	-2.806	-.701
	2W 32A	.408[b,c]	.438	.352	-.452	1.267
	3W 48A	.322[b,c]	.438	.462	-.537	1.181
	4W 64A	.339[b,c]	.438	.439	-.521	1.198
	5W 80A	.924[*,b,c]	.438	.035	.065	1.783
2W 32A	1W 0A	-2.161[*,b,c]	.536	.000	-3.213	-1.108
	1W 16A	-.408[b,c]	.438	.352	-1.267	.452
	3W 48A	-.085[b,c]	.438	.845	-.945	.774
	4W 64A	-.069[b,c]	.438	.875	-.928	.790
	5W 80A	.517[b,c]	.438	.238	-.343	1.376
3W 48A	1W 0A	-2.075[*,b,c]	.536	.000	-3.128	-1.023
	1W 16A	-.322[b,c]	.438	.462	-1.181	.537
	2W 32A	.085[b,c]	.438	.845	-.774	.945
	4W 64A	.016[b,c]	.438	.970	-.843	.876
	5W 80A	.602[b,c]	.438	.169	-.257	1.461
4W 64A	1W 0A	-2.092[*,b,c]	.536	.000	-3.144	-1.039
	1W 16A	-.339[b,c]	.438	.439	-1.198	.521
	2W 32A	.069[b,c]	.438	.875	-.790	.928
	3W 48A	-.016[b,c]	.438	.970	-.876	.843
	5W 80A	.586[b,c]	.438	.181	-.274	1.445
5W 80A	1W 0A	-2.677[*,b,c]	.536	.000	-3.730	-1.625
	1W 16A	-.924[*,b,c]	.438	.035	-1.783	-.065
	2W 32A	-.517[b,c]	.438	.238	-1.376	.343
	3W 48A	-.602[b,c]	.438	.169	-1.461	.257
	4W 64A	-.586[b,c]	.438	.181	-1.445	.274

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

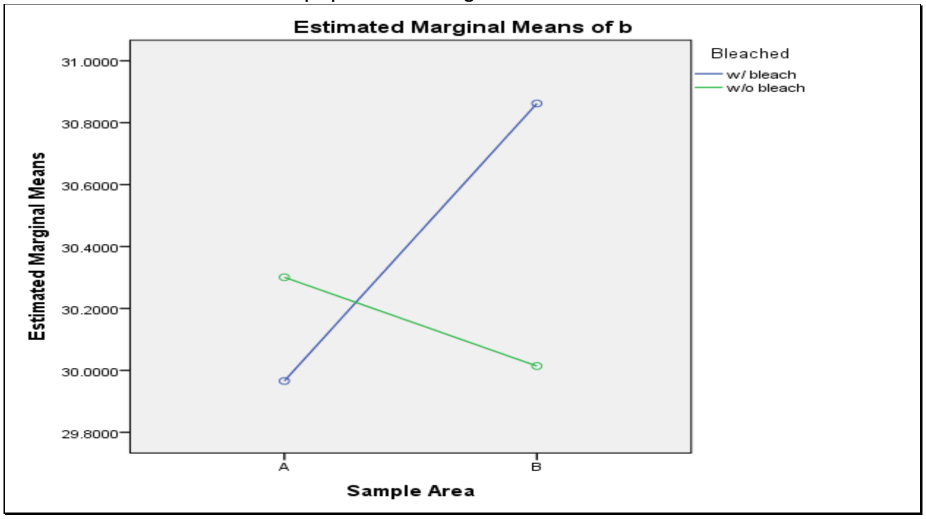
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

6. Sample Area * Bleached: OSDP

Dependent Variable: b

Sample Area		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	w/ bleach	29.966[a]	.264	29.448	30.484
	w/o bleach	30.301[a]	.264	29.783	30.819
B	w/ bleach	30.862[a]	.264	30.344	31.380
	w/o bleach	30.014[a]	.264	29.496	30.532

a. Based on modified population marginal mean.



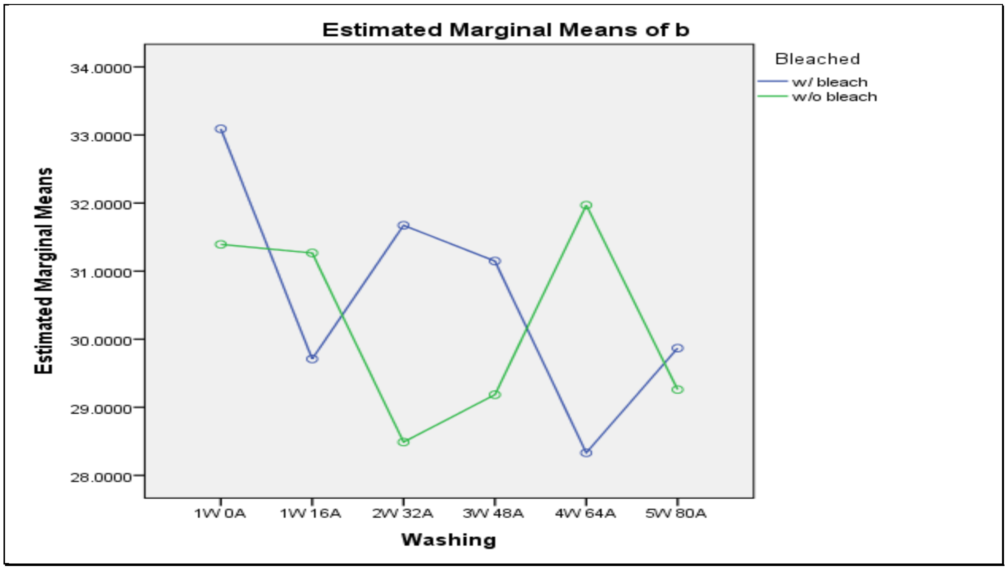
Although it can be observed that the differences in means between the bleached and unbleached sample is evident, without statistical results, only an implication can be made to suggest that the interaction effects here are significant.

7. Bleached * Washing: OSDP

Dependent Variable: b

Bleached		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
w/ bleach	1W 0A	33.091[a]	.619	31.875	34.306
	1W 16A	29.710[a]	.438	28.851	30.570
	2W 32A	31.674[a]	.438	30.814	32.533
	3W 48A	31.148[a]	.438	30.289	32.007
	4W 64A	28.331[a]	.438	27.472	29.190
	5W 80A	29.869[a]	.438	29.010	30.729
w/o bleach	1W 0A	31.393[a]	.619	30.178	32.608
	1W 16A	31.267[a]	.438	30.408	32.126
	2W 32A	28.489[a]	.438	27.630	29.348
	3W 48A	29.185[a]	.438	28.326	30.044
	4W 64A	31.969[a]	.438	31.110	32.829
	5W 80A	29.260[a]	.438	28.400	30.119

a. Based on modified population marginal mean.



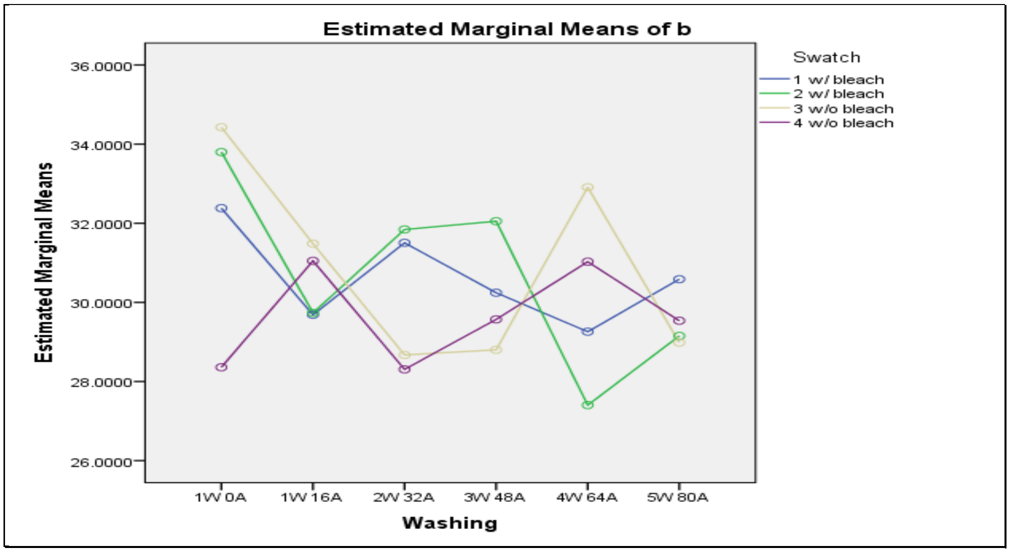
Similar to the above implication, although differences in means can be observed between the samples, without a calculated p-value, this assumption cannot be confirmed.

8. Swatch * Washing: OSDP

Dependent Variable: b

Swatch		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	1W 0A	32.382[a]	.876	30.663	34.100
	1W 16A	29.686[a]	.619	28.471	30.901
	2W 32A	31.505[a]	.619	30.290	32.720
	3W 48A	30.244[a]	.619	29.029	31.459
	4W 64A	29.258[a]	.619	28.043	30.474
	5W 80A	30.586[a]	.619	29.371	31.802
2 w/ bleach	1W 0A	33.800[a]	.876	32.081	35.518
	1W 16A	29.735[a]	.619	28.520	30.950
	2W 32A	31.842[a]	.619	30.627	33.057
	3W 48A	32.052[a]	.619	30.837	33.267
	4W 64A	27.403[a]	.619	26.188	28.618
	5W 80A	29.152[a]	.619	27.937	30.367
3 w/o bleach	1W 0A	34.427[a]	.876	32.709	36.145
	1W 16A	31.485[a]	.619	30.270	32.700
	2W 32A	28.671[a]	.619	27.456	29.886
	3W 48A	28.801[a]	.619	27.586	30.016
	4W 64A	32.911[a]	.619	31.696	34.126
	5W 80A	28.984[a]	.619	27.769	30.199
4 w/o bleach	1W 0A	28.360[a]	.876	26.641	30.078
	1W 16A	31.049[a]	.619	29.834	32.264
	2W 32A	28.306[a]	.619	27.091	29.522
	3W 48A	29.570[a]	.619	28.355	30.785
	4W 64A	31.028[a]	.619	29.813	32.243
	5W 80A	29.535[a]	.619	28.320	30.750

a. Based on modified population marginal mean.



The interaction effect was deemed significant although the main effect of swatch was not.

IV and V. Samples PMCL and PMJX (discussed simultaneously because of their similarity in color)

Variable 'L'

Tests of Between-Subjects Effects: PMCL

Dependent Variable: L

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6764.5[a]	43	157.313	12.097	.000
Intercept	7401034	1	7401034	569100	0.000
SampleArea	30.645	1	30.645	2.356	.125
Swatch	49.137	2	24.568	1.889	.152
Bleached	0.000	0			
Washing	305.35	5	61.069	4.696	.000
SampleArea * Swatch	364.81	2	182.40	14.026	.000
SampleArea * Bleached	0.000	0			
SampleArea * Washing	490.21	4	122.55	9.424	.000
Swatch * Bleached	0.000	0			
Swatch * Washing	2452.3	8	306.54	23.571	.000
Bleached * Washing	0.000	0			
SampleArea * Swatch * Bleached	0.000	0			
SampleArea * Swatch * Washing	1103.0	8	137.89	10.601	.000
SampleArea * Bleached * Washing	0.000	0			
Swatch * Bleached * Washing	0.000	0			
SampleArea * Swatch * Bleached * Washing	0.000	0			
Error	10872	836	13.005		
Total	7912172	880			
Corrected Total	17636	879			

a. R Squared = .384 (Adjusted R Squared = .352)
b. Computed using alpha = .05

Tests of Between-Subjects Effects: PMJX

Dependent Variable: L

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4037.9[a]	43	93.904	7.303	.000
Intercept	7383481	1	7383481	574238	0.000
SampleArea	78.063	1	78.063	6.071	.014
Swatch	119.60	2	59.801	4.651	.010
bleached	0.000	0			
washings	954.92	5	190.99	14.854	.000
SampleArea * Swatch	228.45	2	114.22	8.884	.000
SampleArea * bleached	0.000	0			
SampleArea * washings	75.62	4	18.90	1.470	.209
Swatch * bleached	0.000	0			
Swatch * washings	302.23	8	37.778	2.938	.003
bleached * washings	0.000	0			
SampleArea * Swatch * bleached	0.000	0			
SampleArea * Swatch * washings	774.23	8	96.778	7.527	.000
SampleArea * bleached * washings	0.000	0			
Swatch * bleached * washings	0.000	0			
SampleArea * Swatch * bleached * washings	0.000	0			
Error	10749	836	12.858		
Total	7902539	880			
Corrected Total	14787	879			

a. R Squared = .273 (Adjusted R Squared = .236)

b. Computed using alpha = .05

The main effects of swatch and sample area were observed insignificant at sample PMCL. The interaction effects for sample PMJX was observed to be insignificant at the Sample Area* Washing level. No similarity was observed with these samples at this variable.

1. Sample Area Estimates: PMCL

Dependent Variable: L

Sample Area	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A	94.572[a]	.172	94.234	94.909
B	94.860[a]	.172	94.522	95.197

a. Based on modified population marginal mean.

Pairwise Comparisons: PMCL

Dependent Variable: L

(I) Sample Area		Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
A	B	-.288[a,b]	.243	.237	-.765	.189
B	A	.288[a,b]	.243	.237	-.189	.765

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

1. Sample Area Estimates: PMJX

Dependent Variable: L

Sample Area	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A	95.087[a]	.171	94.752	95.423
B	94.263[a]	.171	93.927	94.598

a. Based on modified population marginal mean.

Pairwise Comparisons: PMJX

Dependent Variable: L

(I) Sample Area		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
A	B	.824[*,b,c]	.242	.001	.350	1.299
B	A	-.824[*,b,c]	.242	.001	-1.299	-.350

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

It can be observed between the samples, that while PMCL did not obtain significant values, PMJX did. At this interaction level, difference between two or more main effects was not observed for sample PMCL but for sample PMJX.

2. Swatch Estimates: PMCL

Dependent Variable: L

Swatch	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1 w/ bleach	95.292[a]	.243	94.815	95.769
2 w/ bleach	95.105[a]	.243	94.628	95.582
3 w/ bleach	93.817[a]	.243	93.340	94.294
4 w/ bleach	94.649[a]	.243	94.171	95.126

a. Based on modified population marginal mean.

Pairwise Comparisons: PMCL

Dependent Variable: L

(I) Swatch		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach'	.187[a,b]	.344	.586	-.488	.862
	3 w/o bleach	1.475[a,b,*]	.344	.000	.800	2.150
	4 w/o bleach	.643[a,b]	.344	.062	-.031	1.318
2 w/ bleach'	1 w/ bleach	-.187[a,b]	.344	.586	-.862	.488
	3 w/o bleach	1.288[a,b,*]	.344	.000	.613	1.963
	4 w/o bleach	.456[a,b]	.344	.185	-.219	1.131
3 w/o bleach	1 w/ bleach	-1.475[a,b,*]	.344	.000	-2.150	-.800
	2 w/ bleach'	-1.288[a,b,*]	.344	.000	-1.963	-.613
	4 w/o bleach	-.832[a,b,*]	.344	.016	-1.506	-.157
4 w/o bleach	1 w/ bleach	-.643[a,b]	.344	.062	-1.318	.031
	2 w/ bleach'	-.456[a,b]	.344	.185	-1.131	.219
	3 w/o bleach	.832[a,b,*]	.344	.016	.157	1.506

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

2. Swatch Estimates: PMJX

Dependent Variable: L

Swatch	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
1 w/ bleach	95.372[a]	.242	94.897	95.846
2 w/ bleach	94.008[a]	.242	93.533	94.482
3 w/o bleach	94.901[a]	.242	94.426	95.375
4 w/o bleach	94.419[a]	.242	93.945	94.894

a. Based on modified population marginal mean.

Pairwise Comparisons: PMJX

Dependent Variable: L

(I) Swatch		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach	1.364[*,b,c]	.342	.000	.693	2.035
	3 w/o bleach	.471[b,c]	.342	.169	-.200	1.142
	4 w/o bleach	.953[*,b,c]	.342	.005	.282	1.624
2 w/ bleach	1 w/ bleach	-1.364[*,b,c]	.342	.000	-2.035	-.693
	3 w/o bleach	-.893[*,b,c]	.342	.009	-1.564	-.222
	4 w/o bleach	-.411[b,c]	.342	.229	-1.082	.260
3 w/o bleach	1 w/ bleach	-.471[b,c]	.342	.169	-1.142	.200
	2 w/ bleach	.893[*,b,c]	.342	.009	.222	1.564
	4 w/o bleach	.482[b,c]	.342	.159	-.189	1.153
4 w/o bleach	1 w/ bleach	-.953[*,b,c]	.342	.005	-1.624	-.282
	2 w/ bleach	.411[b,c]	.342	.229	-.260	1.082
	3 w/o bleach	-.482[b,c]	.342	.159	-1.153	.189

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

For sample PMCL, the bleached swatches were not significantly different from each other; though, the unbleached samples varied. With sample PMJX, no pattern was observed between the bleached and unbleached samples.

3. Bleach Estimates: PMCL

Dependent Variable: L

Bleached	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
w/ bleach	95.198[a]	.172	94.861	95.536
w/o bleach	94.233[a]	.172	93.895	94.570

a. Based on modified population marginal mean.

Pairwise Comparisons: PMCL

Dependent Variable: L

(I) Bleached	(J) Bleached	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
w/ bleach	w/o bleach	.966*,a,b	.243	.000	.488	1.443
w/o bleach	w/ bleach	-.966*,a,b	.243	.000	-1.443	-.488

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

3. Bleach Estimates: PMJX

Dependent Variable: L

bleached	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
w/ bleach	94.690[a]	.171	94.354	95.025
w/o bleach	94.660[a]	.171	94.325	94.996

a. Based on modified population marginal mean.

Pairwise Comparisons: PMJX

Dependent Variable: L

(I) bleached		Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
w/ bleach	w/o bleach	.030[a,b]	.242	.902	-.445	.504
w/o bleach	w/ bleach	-.030[a,b]	.242	.902	-.504	.445

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The type of detergent only mattered for sample PMCL.

4. Washing Estimates: PMCL

Dependent Variable: L

Washing	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
1W 0A	95.802[a]	.403	95.011	96.593
1W 16A	94.625[a]	.285	94.065	95.185
2W 32A	94.739[a]	.285	94.180	95.299
3W 48A	93.773[a]	.285	93.214	94.333
4W 64A	95.591[a]	.285	95.031	96.150
5W 80A	94.307[a]	.285	93.747	94.867

a. Based on modified population marginal mean.

Pairwise Comparisons: PMCL

Dependent Variable: L

(I) Washing		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	Upper Bound
1W 0A	1W 16A	1.177[*,b,c]	.494	.017	.208	2.146
	2W 32A	1.063[*,b,c]	.494	.032	.094	2.032
	3W 48A	2.029[*,b,c]	.494	.000	1.059	2.998
	4W 64A	.211[b,c]	.494	.669	-.758	1.181
	5W 80A	1.495[*,b,c]	.494	.003	.526	2.464
1W 16A	1W 0A	-1.177[*,b,c]	.494	.017	-2.146	-.208
	2W 32A	-.114[b,c]	.403	.777	-.905	.677
	3W 48A	.852[*,b,c]	.403	.035	.060	1.643
	4W 64A	-.966[*,b,c]	.403	.017	-1.757	-.174
	5W 80A	.318[b,c]	.403	.430	-.473	1.110
2W 32A	1W 0A	-1.063[*,b,c]	.494	.032	-2.032	-.094
	1W 16A	.114[b,c]	.403	.777	-.677	.905
	3W 48A	.966[*,b,c]	.403	.017	.174	1.757
	4W 64A	-.852[*,b,c]	.403	.035	-1.643	-.060
	5W 80A	.432[b,c]	.403	.284	-.359	1.224
3W 48A	1W 0A	-2.029[*,b,c]	.494	.000	-2.998	-1.059
	1W 16A	-.852[*,b,c]	.403	.035	-1.643	-.060
	2W 32A	-.966[*,b,c]	.403	.017	-1.757	-.174
	4W 64A	-1.817[*,b,c]	.403	.000	-2.609	-1.026
	5W 80A	-.533[b,c]	.403	.186	-1.325	.258
4W 64A	1W 0A	-.211[b,c]	.494	.669	-1.181	.758
	1W 16A	.966[*,b,c]	.403	.017	.174	1.757
	2W 32A	.852[*,b,c]	.403	.035	.060	1.643
	3W 48A	1.817[*,b,c]	.403	.000	1.026	2.609
	5W 80A	1.284[*,b,c]	.403	.002	.492	2.075
5W 80A	1W 0A	-1.495[*,b,c]	.494	.003	-2.464	-.526
	1W 16A	-.318[b,c]	.403	.430	-1.110	.473
	2W 32A	-.432[b,c]	.403	.284	-1.224	.359
	3W 48A	.533[b,c]	.403	.186	-.258	1.325
	4W 64A	-1.284[*,b,c]	.403	.002	-2.075	-.492

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

For the washing estimates, both reference samples observed marked significant differences for at least at two levels of interactions for sample PMCL, and at least three levels of interactions for sample PMJX.

4. Washing Estimates: PMJX

Dependent Variable: L

washings	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1W 0A	92.656[a]	.401	91.869	93.443
1W 16A	96.299[a]	.283	95.742	96.855
2W 32A	95.313[a]	.283	94.757	95.869
3W 48A	95.140[a]	.283	94.584	95.696
4W 64A	93.493[a]	.283	92.936	94.049
5W 80A	94.140[a]	.283	93.584	94.696

a. Based on modified population marginal mean.

Pairwise Comparisons: PMJX

Dependent Variable: L

(I) washings		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	95% Confidence Interval for Difference[d] Upper Bound
1W 0A	1W 16A	-3.643[*,b,c]	.491	.000	-4.606	-2.679
	2W 32A	-2.657[*,b,c]	.491	.000	-3.621	-1.693
	3W 48A	-2.484[*,b,c]	.491	.000	-3.448	-1.520
	4W 64A	-.836[b,c]	.491	.089	-1.800	.127
	5W 80A	-1.484[*,b,c]	.491	.003	-2.448	-.520
1W 16A	1W 0A	3.643[*,b,c]	.491	.000	2.679	4.606
	2W 32A	.986[*,b,c]	.401	.014	.199	1.773
	3W 48A	1.159[*,b,c]	.401	.004	.372	1.946
	4W 64A	2.806[*,b,c]	.401	.000	2.019	3.593
	5W 80A	2.159[*,b,c]	.401	.000	1.372	2.946
2W 32A	1W 0A	2.657[*,b,c]	.491	.000	1.693	3.621
	1W 16A	-.986[*,b,c]	.401	.014	-1.773	-.199
	3W 48A	.173[b,c]	.401	.666	-.614	.960
	4W 64A	1.821[*,b,c]	.401	.000	1.034	2.607
	5W 80A	1.173[*,b,c]	.401	.004	.386	1.960
3W 48A	1W 0A	2.484[*,b,c]	.491	.000	1.520	3.448
	1W 16A	-1.159[*,b,c]	.401	.004	-1.946	-.372
	2W 32A	-.173[b,c]	.401	.666	-.960	.614
	4W 64A	1.647[*,b,c]	.401	.000	.861	2.434
	5W 80A	1.000[*,b,c]	.401	.013	.213	1.787
4W 64A	1W 0A	.836[b,c]	.491	.089	-.127	1.800
	1W 16A	-2.806[*,b,c]	.401	.000	-3.593	-2.019
	2W 32A	-1.821[*,b,c]	.401	.000	-2.607	-1.034
	3W 48A	-1.647[*,b,c]	.401	.000	-2.434	-.861
	5W 80A	-.648[b,c]	.401	.107	-1.434	.139
5W 80A	1W 0A	1.484[*,b,c]	.491	.003	.520	2.448
	1W 16A	-2.159[*,b,c]	.401	.000	-2.946	-1.372
	2W 32A	-1.173[*,b,c]	.401	.004	-1.960	-.386
	3W 48A	-1.000[*,b,c]	.401	.013	-1.787	-.213
	4W 64A	.648[b,c]	.401	.107	-.139	1.434

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

5. Sample Area * Swatch: PMCL

Dependent Variable: L

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	1 w/ bleach	95.186[a]	.329	94.540	95.832
	2 w/ bleach	93.156[a]	.361	92.448	93.864
	3 w/ bleach	94.900[a]	.329	94.254	95.546
	4 w/ bleach	94.856[a]	.361	94.148	95.564
B	1 w/ bleach	95.419[a]	.361	94.711	96.127
	2 w/ bleach	96.729[a]	.329	96.082	97.375
	3 w/ bleach	92.518[a]	.361	91.810	93.226
	4 w/ bleach	94.476[a]	.329	93.830	95.122

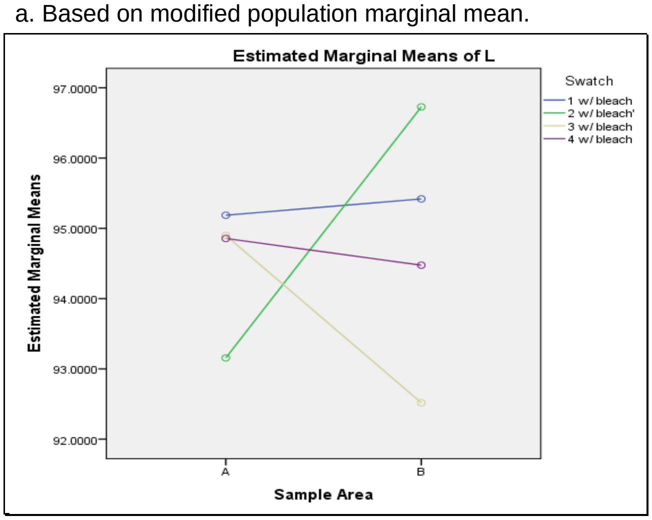
a. Based on modified population marginal mean.

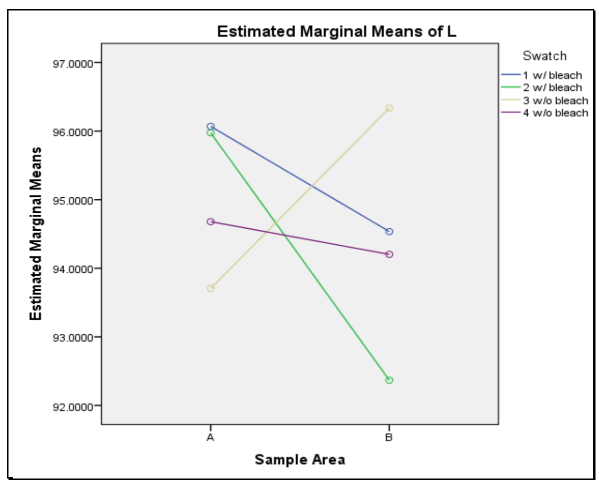
5. Sample Area * Swatch: PMJX

Dependent Variable: L

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	1 w/ bleach	96.069[a]	.327	95.426	96.711
	2 w/ bleach	95.975[a]	.359	95.271	96.679
	3 w/o bleach	93.706[a]	.327	93.063	94.348
	4 w/o bleach	94.679[a]	.359	93.976	95.383
B	1 w/ bleach	94.536[a]	.359	93.832	95.240
	2 w/ bleach	92.369[a]	.327	91.726	93.011
	3 w/o bleach	96.335[a]	.359	95.631	97.039
	4 w/o bleach	94.202[a]	.327	93.560	94.845

a. Based on modified population marginal mean.





The plots above correspond to sample PMCL and PMJX, from left to right, respectively. The patterns between these two charts are different: swatch 4 not only remained consistent observed the lowest difference in means. The greatest difference in mean can be observed at swatch 2 in sample PMCL and swatches 2 and 3 in sample PMJX.

6. Sample Area * Bleached: PMCL

Dependent Variable: L

Sample Area		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	w/ bleach	94.264[a]	.243	93.786	94.741
	w/o bleach	94.880[a]	.243	94.403	95.357
B	w/ bleach	96.133[a]	.243	95.656	96.611
	w/o bleach	93.586[a]	.243	93.109	94.063

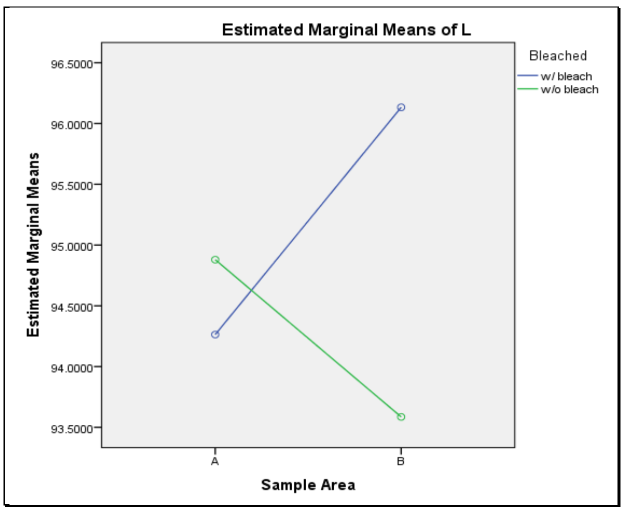
a. Based on modified population marginal mean.

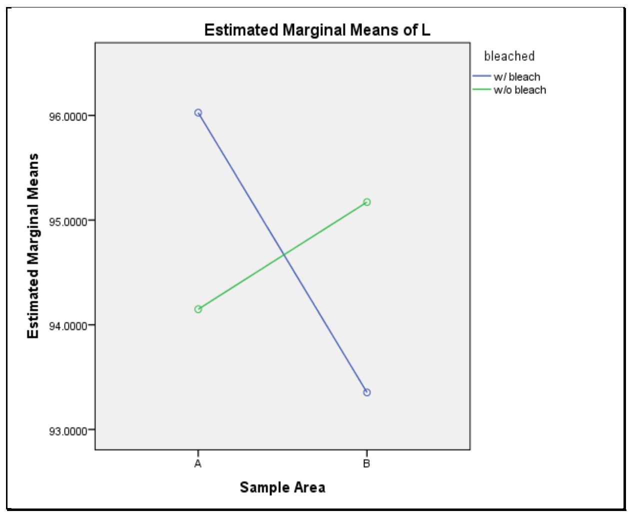
6. Sample Area * Beached: PMJX

Dependent Variable: L

Sample Area		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	w/ bleach	96.026[a]	.242	95.552	96.501
	w/o bleach	94.148[a]	.242	93.674	94.623
B	w/ bleach	93.354[a]	.242	92.879	93.828
	w/o bleach	95.172[a]	.242	94.697	95.646

a. Based on modified population marginal mean.





It can be observed that sample PMCL had a considerable mean difference between bleached and unbleached at sample area B, in comparison to A; whereas, for sample PMJX, this difference seemed to be moderately the same between sample areas.

For the bleached* washing interaction below, it is very obvious that the patterns between these two reference samples are different where the type of detergent affected the outcome of the results for sample PMCL.

7. Bleached * Washing: PMCL

Dependent Variable: L

Bleached		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
w/ bleach	1W 0A	95.425[a]	.570	94.306	96.544
	1W 16A	96.474[a]	.403	95.682	97.265
	2W 32A	95.499[a]	.403	94.707	96.290
	3W 48A	93.551[a]	.403	92.760	94.343
	4W 64A	96.124[a]	.403	95.332	96.915
	5W 80A	94.232[a]	.403	93.440	95.023
w/o bleach	1W 0A	96.179[a]	.570	95.060	97.298
	1W 16A	92.776[a]	.403	91.985	93.568
	2W 32A	93.980[a]	.403	93.188	94.771
	3W 48A	93.995[a]	.403	93.204	94.787
	4W 64A	95.058[a]	.403	94.267	95.849
	5W 80A	94.382[a]	.403	93.591	95.173

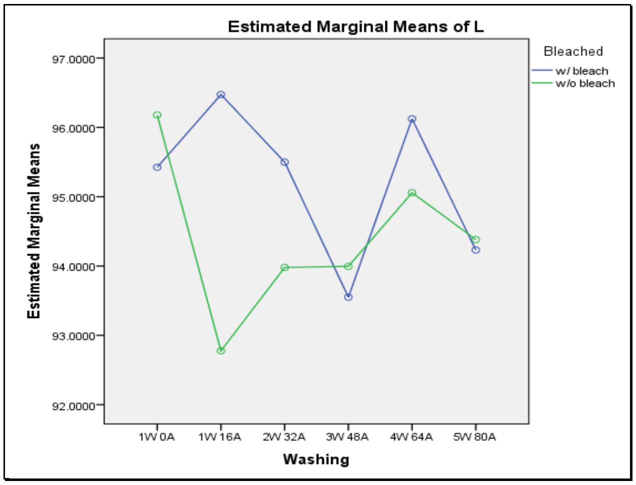
a. Based on modified population marginal mean.

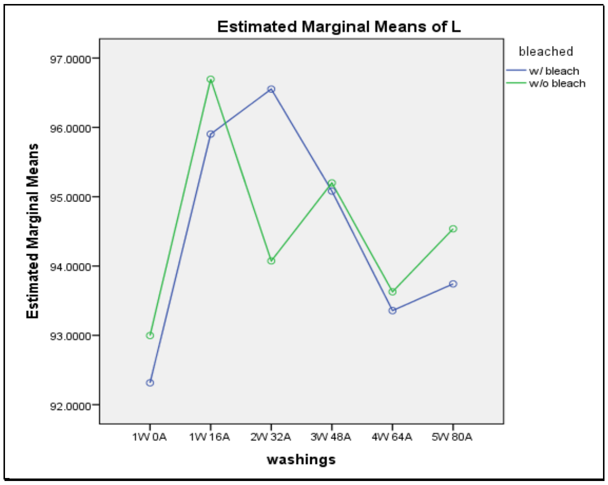
7. Bleached * Washings: PMJX

Dependent Variable: L

bleached		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
w/ bleach	1W 0A	92.315[a]	.567	91.202	93.428
	1W 16A	95.904[a]	.401	95.117	96.691
	2W 32A	96.553[a]	.401	95.766	97.339
	3W 48A	95.081[a]	.401	94.294	95.868
	4W 64A	93.357[a]	.401	92.570	94.144
	5W 80A	93.743[a]	.401	92.956	94.530
w/o bleach	1W 0A	92.997[a]	.567	91.884	94.110
	1W 16A	96.694[a]	.401	95.907	97.481
	2W 32A	94.074[a]	.401	93.287	94.860
	3W 48A	95.199[a]	.401	94.412	95.986
	4W 64A	93.628[a]	.401	92.841	94.415
	5W 80A	94.537[a]	.401	93.751	95.324

a. Based on modified population marginal mean.





8. Swatch * Washing: PMCL

Dependent Variable: L

Swatch		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1 w/ bleach	1W 0A	97.359[a]	.806	95.777	98.942
	1W 16A	97.301[a]	.570	96.182	98.420
	2W 32A	94.971[a]	.570	93.852	96.090
	3W 48A	94.363[a]	.570	93.243	95.482
	4W 64A	95.699[a]	.570	94.580	96.818
	5W 80A	93.094[a]	.570	91.975	94.213
2 w/ bleach'	1W 0A	93.490[a]	.806	91.908	95.073
	1W 16A	95.646[a]	.570	94.527	96.765
	2W 32A	96.027[a]	.570	94.907	97.146
	3W 48A	92.740[a]	.570	91.621	93.860
	4W 64A	96.548[a]	.570	95.429	97.668
	5W 80A	95.370[a]	.570	94.251	96.489
3 w/o bleach	1W 0A	94.992[a]	.806	93.409	96.575
	1W 16A	95.410[a]	.570	94.290	96.529
	2W 32A	94.948[a]	.570	93.829	96.067
	3W 48A	89.699[a]	.570	88.580	90.819
	4W 64A	93.738[a]	.570	92.619	94.857
	5W 80A	94.703[a]	.570	93.584	95.822
4 w/o bleach	1W 0A	97.367[a]	.806	95.784	98.949
	1W 16A	90.143[a]	.570	89.024	91.263
	2W 32A	93.011[a]	.570	91.892	94.130
	3W 48A	98.291[a]	.570	97.172	99.411
	4W 64A	96.378[a]	.570	95.258	97.497
	5W 80A	94.061[a]	.570	92.942	95.180

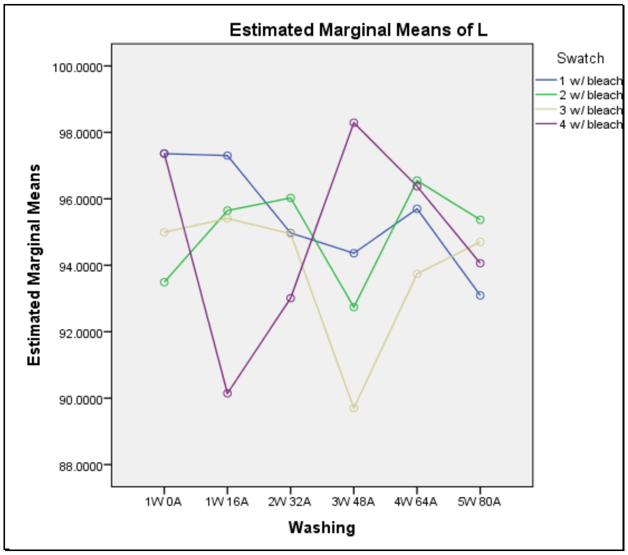
a. Based on modified population marginal mean.

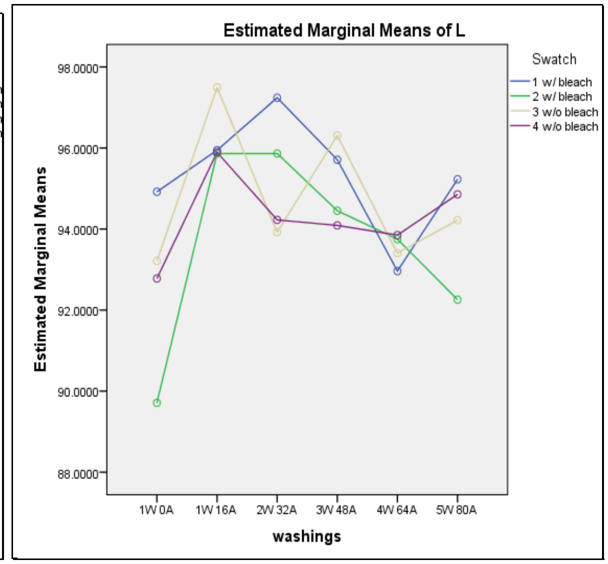
8. Swatch * Washings: PMJX

Dependent Variable: L

Swatch		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1 w/ bleach	1W 0A	94.919[a]	.802	93.345	96.493
	1W 16A	95.945[a]	.567	94.832	97.058
	2W 32A	97.241[a]	.567	96.128	98.354
	3W 48A	95.709[a]	.567	94.597	96.822
	4W 64A	92.963[a]	.567	91.850	94.076
	5W 80A	95.227[a]	.567	94.114	96.340
2 w/ bleach	1W 0A	89.711[a]	.802	88.137	91.285
	1W 16A	95.863[a]	.567	94.750	96.976
	2W 32A	95.864[a]	.567	94.751	96.977
	3W 48A	94.452[a]	.567	93.340	95.565
	4W 64A	93.751[a]	.567	92.638	94.864
	5W 80A	92.258[a]	.567	91.145	93.371
3 w/o bleach	1W 0A	93.214[a]	.802	91.641	94.788
	1W 16A	97.493[a]	.567	96.380	98.606
	2W 32A	93.922[a]	.567	92.809	95.035
	3W 48A	96.308[a]	.567	95.196	97.421
	4W 64A	93.406[a]	.567	92.293	94.518
	5W 80A	94.219[a]	.567	93.107	95.332
4 w/o bleach	1W 0A	92.780[a]	.802	91.206	94.354
	1W 16A	95.895[a]	.567	94.782	97.008
	2W 32A	94.225[a]	.567	93.112	95.338
	3W 48A	94.090[a]	.567	92.977	95.203
	4W 64A	93.851[a]	.567	92.738	94.964
	5W 80A	94.855[a]	.567	93.743	95.968

a. Based on modified population marginal mean.





While large differences in means can be observed for sample PMCL, these differences are not as obvious in sample PMJX. And based on the calculated p-values, the Swatch * Washing interaction is significant at .001 for sample PMCL and at .003 for sample PMJX.

Variable ‘a’

Tests of Between-Subjects Effects: PMCL

Dependent Variable: a

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	209.71[a]	43	4.877	9.729	.000
Intercept	6285.3	1	6285.4	12538	0.000
SampleArea	2.763	1	2.763	5.512	.019
Swatch	29.960	2	14.980	29.883	.000
Bleached	0.000	0			
Washing	13.786	5	2.757	5.500	.000
SampleArea * Swatch	25.559	2	12.779	25.493	.000
SampleArea * Bleached	0.000	0			
SampleArea * Washing	16.970	4	4.242	8.461	.000
Swatch * Bleached	0.000	0			
Swatch * Washing	32.74	8	4.092	8.163	.000
Bleached * Washing	0.000	0			
SampleArea * Swatch * Bleached	0.000	0			
SampleArea * Swatch * Washing	31.70	8	3.962	7.903	.000
SampleArea * Bleached * Washing	0.000	0			
Swatch * Bleached * Washing	0.000	0			
SampleArea * Swatch * Bleached * Washing	0.000	0			
Error	419.08	836	.501		
Total	7385.8	880			
Corrected Total	628.79	879			

a. R Squared = .334 (Adjusted R Squared = .299)
b. Computed using alpha = .05

Tests of Between-Subjects Effects: PMJX

Dependent Variable: a

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	132.37[a]	43	3.078	7.467	.000
Intercept	5763.8	1	5763.8	13980	0.000
SampleArea	.022	1	.022	.054	.816
Swatch	6.742	2	3.371	8.177	.000
bleached	0.000	0			
washings	22.75	5	4.551	11.037	.000
SampleArea * Swatch	1.243	2	.622	1.508	.222
SampleArea * bleached	0.000	0			
SampleArea * washings	8.698	4	2.175	5.274	.000
Swatch * bleached	0.000	0			
Swatch * washings	12.70	8	1.588	3.852	.000
bleached * washings	0.000	0			
SampleArea * Swatch * bleached	0.000	0			
SampleArea * Swatch * washings	22.065	8	2.758	6.690	.000
SampleArea * bleached * washings	0.000	0			
Swatch * bleached * washings	0.000	0			
SampleArea * Swatch * bleached * washings	0.000	0			
Error	344.68	836	.412		
Total	6671	880			
Corrected Total	477.05	879			

a. R Squared = .277 (Adjusted R Squared = .240)

b. Computed using alpha = .05

While the main and interaction effects were all significant for sample PMCL, sample PMJX observed insignificant main effect values for sample area, and its interaction effects Sample Area* Swatch.

1. Sample Area Estimates: PMCL

Dependent Variable: a

Sample Area	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	2.686[a]	.034	2.619	2.752
B	2.856[a]	.034	2.790	2.923

a. Based on modified population marginal mean.

Pairwise Comparisons: PMCL

Dependent Variable: a

(I) Sample Area	(J) Sample Area	Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	95% Confidence Interval for Difference[d] Upper Bound
A	B	-.171[*,b,c]	.048	.000	-.265	-.077
B	A	.171[*,b,c]	.048	.000	.077	.265

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

1. Sample Area Estimates: PMJX

Dependent Variable: a

Sample Area	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A	2.656[a]	.031	2.596	2.716
B	2.650[a]	.031	2.590	2.710

a. Based on modified population marginal mean.

Pairwise Comparisons: PMJX

Dependent Variable: a

(I) Sample Area		Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
A	B	.006[a,b]	.043	.883	-.079	.091
B	A	-.006[a,b]	.043	.883	-.091	.079

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Significant values were observed for sample PMCL but not for sample PMJX. With this result, it is irrelevant as to what area of the sample is being analyzed.

2. Swatch Estimates: PMCL

Dependent Variable: a

Swatch	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1 w/ bleach	2.323[a]	.048	2.230	2.417
2 w/ bleach	2.892[a]	.048	2.798	2.985
3 w/o bleach	2.867[a]	.048	2.773	2.960
4 w/o bleach	3.002[a]	.048	2.909	3.096

a. Based on modified population marginal mean.

Pairwise Comparisons: PMCL

Dependent Variable: a

(I) Swatch		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach	-.568[*,b,c]	.068	.000	-.701	-.436
	3 w/o bleach	-.543[*,b,c]	.068	.000	-.676	-.411
	4 w/o bleach	-.679[*,b,c]	.068	.000	-.812	-.546
2 w/ bleach	1 w/ bleach	.568[*,b,c]	.068	.000	.436	.701
	3 w/o bleach	.025[b,c]	.068	.710	-.107	.158
	4 w/o bleach	-.111[b,c]	.068	.102	-.243	.022
3 w/o bleach	1 w/ bleach	.543[*,b,c]	.068	.000	.411	.676
	2 w/ bleach	-.025[b,c]	.068	.710	-.158	.107
	4 w/o bleach	-.136[*,b,c]	.068	.045	-.268	-.003
4 w/o bleach	1 w/ bleach	.679[*,b,c]	.068	.000	.546	.812
	2 w/ bleach	.111[b,c]	.068	.102	-.022	.243
	3 w/o bleach	.136[*,b,c]	.068	.045	.003	.268

Based on estimated marginal means

*. The mean difference is significant at the .05 level.
b. An estimate of the modified population marginal mean (I).
c. An estimate of the modified population marginal mean (J).
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

2. Swatch Estimates: PMJX

Dependent Variable: a

Swatch	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	2.500[a]	.043	2.415	2.585
2 w/ bleach	2.787[a]	.043	2.702	2.872
3 w/o bleach	2.749[a]	.043	2.664	2.834
4 w/o bleach	2.577[a]	.043	2.492	2.662

a. Based on modified population marginal mean.

Pairwise Comparisons: PMJX

Dependent Variable: a

(I) Swatch		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	95% Confidence Interval for Difference[d] Upper Bound
1 w/ bleach	2 w/ bleach	-.287[*,b,c]	.061	.000	-.407	-.167
	3 w/o bleach	-.249[*,b,c]	.061	.000	-.369	-.129
	4 w/o bleach	-.077[b,c]	.061	.207	-.197	.043
2 w/ bleach	1 w/ bleach	.287[*,b,c]	.061	.000	.167	.407
	3 w/o bleach	.038[b,c]	.061	.535	-.082	.158
	4 w/o bleach	.210[*,b,c]	.061	.001	.090	.330
3 w/o bleach	1 w/ bleach	.249[*,b,c]	.061	.000	.129	.369
	2 w/ bleach	-.038[b,c]	.061	.535	-.158	.082
	4 w/o bleach	.172[*,b,c]	.061	.005	.052	.292
4 w/o bleach	1 w/ bleach	.077[b,c]	.061	.207	-.043	.197
	2 w/ bleach	-.210[*,b,c]	.061	.001	-.330	-.090
	3 w/o bleach	-.172[*,b,c]	.061	.005	-.292	-.052

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
b. An estimate of the modified population marginal mean (I).
c. An estimate of the modified population marginal mean (J).
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Swatch 1 did observe all significant values for sample PMCL. No patterns were observed between the reference samples for the bleached or unbleached samples.

3. Bleach Estimates: PMCL

Dependent Variable:a

Bleached	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
w/ bleach	2.608[a]	.034	2.541	2.674
w/o bleach	2.934[a]	.034	2.868	3.001

a. Based on modified population marginal mean.

Pairwise Comparisons: PMCL

Dependent Variable:a

(I) Bleached	(J) Bleached	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
w/ bleach	w/o bleach	-.327[*],a,b	.048	.000	-.421	-.233
w/o bleach	w/ bleach	.327[*],a,b	.048	.000	.233	.421

Based on estimated marginal means

*. The mean difference is significant at the .05 level.
a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

3. Bleach Estimates: PMJX

Dependent Variable: a

bleached	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
w/ bleach	2.643[a]	.031	2.583	2.703
w/o bleach	2.663[a]	.031	2.603	2.723

a. Based on modified population marginal mean.

Pairwise Comparisons: PMJX

Dependent Variable: a

(I) bleached		Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
w/ bleach	w/o bleach	-.020[a,b]	.043	.650	-.105	.065
w/o bleach	w/ bleach	.020[a,b]	.043	.650	-.065	.105

Based on estimated marginal means
a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Significant values were observed for both samples.

4. Washing Estimates: PMCL

Dependent Variable:a

Washing	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1W 0A	2.896[a]	.079	2.741	3.051
1W 16A	2.727[a]	.056	2.617	2.837
2W 32A	2.606[a]	.056	2.496	2.716
3W 48A	2.731[a]	.056	2.622	2.841
4W 64A	3.003[a]	.056	2.893	3.113
5W 80A	2.725[a]	.056	2.615	2.835

a. Based on modified population marginal mean.

Pairwise Comparisons: PMCL

Dependent Variable:a

(I) Washing	(J) Washing	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	Upper Bound
1W 0A	1W 16A	.169[a],b	.097	.082	-.021	.359
	2W 32A	.290[a],b,*	.097	.003	.100	.480
	3W 48A	.165[a],b	.097	.090	-.026	.355
	4W 64A	-.107[a],b	.097	.268	-.298	.083
	5W 80A	.171[a],b	.097	.078	-.019	.361
1W 16A	1W 0A	-.169[a],b	.097	.082	-.359	.021
	2W 32A	.121[a],b	.079	.127	-.034	.276
	3W 48A	-.004[a],b	.079	.955	-.160	.151
	4W 64A	-.276[a],b,*	.079	.001	-.432	-.121
	5W 80A	.002[a],b	.079	.980	-.153	.157
2W 32A	1W 0A	-.290[a],b,*	.097	.003	-.480	-.100
	1W 16A	-.121[a],b	.079	.127	-.276	.034
	3W 48A	-.125[a],b	.079	.113	-.281	.030
	4W 64A	-.397[a],b,*	.079	.000	-.553	-.242
	5W 80A	-.119[a],b	.079	.133	-.274	.036
3W 48A	1W 0A	-.165[a],b	.097	.090	-.355	.026
	1W 16A	.004[a],b	.079	.955	-.151	.160
	2W 32A	.125[a],b	.079	.113	-.030	.281
	4W 64A	-.272[a],b,*	.079	.001	-.427	-.117
	5W 80A	.006[a],b	.079	.936	-.149	.162
4W 64A	1W 0A	.107[a],b	.097	.268	-.083	.298
	1W 16A	.276[a],b,*	.079	.001	.121	.432
	2W 32A	.397[a],b,*	.079	.000	.242	.553
	3W 48A	.272[a],b,*	.079	.001	.117	.427
	5W 80A	.278[a],b,*	.079	.000	.123	.434
5W 80A	1W 0A	-.171[a],b	.097	.078	-.361	.019
	1W 16A	-.002[a],b	.079	.980	-.157	.153
	2W 32A	.119[a],b	.079	.133	-.036	.274
	3W 48A	-.006[a],b	.079	.936	-.162	.149
	4W 64A	-.278[a],b,*	.079	.000	-.434	-.123

Based on estimated marginal means
a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).
*. The mean difference is significant at the .05 level.

4. Washing Estimates: PMJX

Dependent Variable: a

washings	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
1W 0A	2.471[a]	.072	2.331	2.612
1W 16A	2.857[a]	.051	2.757	2.956
2W 32A	2.800[a]	.051	2.701	2.900
3W 48A	2.618[a]	.051	2.519	2.718
4W 64A	2.683[a]	.051	2.584	2.783
5W 80A	2.398[a]	.051	2.298	2.497

a. Based on modified population marginal mean.

Pairwise Comparisons: PMJX

Dependent Variable: a

(I) washings		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
1W 0A	1W 16A	-.385[*,b,c]	.088	.000	-.558	-.213
	2W 32A	-.329[*,b,c]	.088	.000	-.501	-.156
	3W 48A	-.147[b,c]	.088	.095	-.319	.026
	4W 64A	-.212[*,b,c]	.088	.016	-.384	-.039
	5W 80A	.074[b,c]	.088	.401	-.099	.246
1W 16A	1W 0A	.385[*,b,c]	.088	.000	.213	.558
	2W 32A	.057[b,c]	.072	.430	-.084	.198
	3W 48A	.239[*,b,c]	.072	.001	.098	.380
	4W 64A	.174[*,b,c]	.072	.016	.033	.315
	5W 80A	.459[*,b,c]	.072	.000	.318	.600
2W 32A	1W 0A	.329[*,b,c]	.088	.000	.156	.501
	1W 16A	-.057[b,c]	.072	.430	-.198	.084
	3W 48A	.182[*,b,c]	.072	.011	.041	.323
	4W 64A	.117[b,c]	.072	.104	-.024	.258
	5W 80A	.403[*,b,c]	.072	.000	.262	.543
3W 48A	1W 0A	.147[b,c]	.088	.095	-.026	.319
	1W 16A	-.239[*,b,c]	.072	.001	-.380	-.098
	2W 32A	-.182[*,b,c]	.072	.011	-.323	-.041
	4W 64A	-.065[b,c]	.072	.366	-.206	.076
	5W 80A	.221[*,b,c]	.072	.002	.080	.362
4W 64A	1W 0A	.212[*,b,c]	.088	.016	.039	.384
	1W 16A	-.174[*,b,c]	.072	.016	-.315	-.033
	2W 32A	-.117[b,c]	.072	.104	-.258	.024
	3W 48A	.065[b,c]	.072	.366	-.076	.206
	5W 80A	.286[*,b,c]	.072	.000	.145	.427
5W 80A	1W 0A	-.074[b,c]	.088	.401	-.246	.099
	1W 16A	-.459[*,b,c]	.072	.000	-.600	-.318
	2W 32A	-.403[*,b,c]	.072	.000	-.543	-.262
	3W 48A	-.221[*,b,c]	.072	.002	-.362	-.080
	4W 64A	-.286[*,b,c]	.072	.000	-.427	-.145

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Marked significant differences were observed in greater amounts in sample PMJX than PMCL.

5. Sample Area * Swatch: PMCL

Dependent Variable: a

Sample Area		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	1 w/ bleach	2.506[a]	.065	2.379	2.633
	2 w/ bleach	2.571[a]	.071	2.432	2.710
	3 w/o bleach	2.832[a]	.065	2.705	2.959
	4 w/o bleach	2.840[a]	.071	2.701	2.979
B	1 w/ bleach	2.104[a]	.071	1.965	2.243
	2 w/ bleach	3.159[a]	.065	3.032	3.286
	3 w/o bleach	2.908[a]	.071	2.770	3.047
	4 w/o bleach	3.137[a]	.065	3.011	3.264

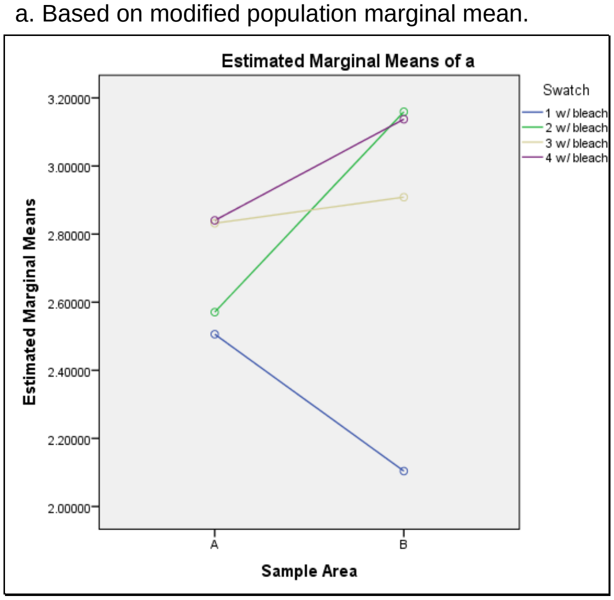
a. Based on modified population marginal mean.

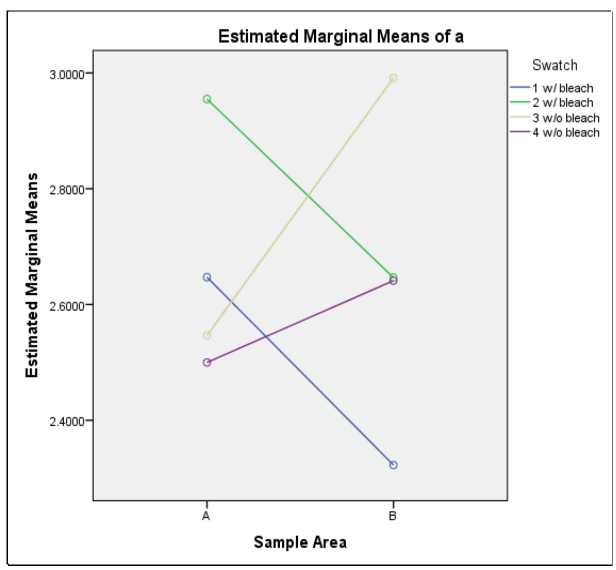
5. Sample Area * Swatch: PMJX

Dependent Variable: a

Sample Area		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	1 w/ bleach	2.647[a]	.059	2.532	2.762
	2 w/ bleach	2.955[a]	.064	2.829	3.081
	3 w/o bleach	2.547[a]	.059	2.431	2.662
	4 w/o bleach	2.500[a]	.064	2.374	2.626
B	1 w/ bleach	2.323[a]	.064	2.197	2.449
	2 w/ bleach	2.647[a]	.059	2.532	2.762
	3 w/o bleach	2.991[a]	.064	2.865	3.117
	4 w/o bleach	2.641[a]	.059	2.526	2.756

a. Based on modified population marginal mean.





The patterns are obviously different between both reference samples. Swatch 1 observes to be consistent between the two diagrams, and closely follows is swatch 3, however, the values differ.

The mean values are slighter greater in sample PMCL. The Swatch* Sample Area interaction is significant at p = .001 for sample PMCL and is insignificant at p = .222 for sample PMJX.

6. Sample Area * Bleached: PMCL

Dependent Variable: a

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	w/ bleach	2.535[a]	.048	2.442	2.629
	w/o bleach	2.836[a]	.048	2.742	2.929
B	w/ bleach	2.680[a]	.048	2.586	2.773
	w/o bleach	3.033[a]	.048	2.940	3.127

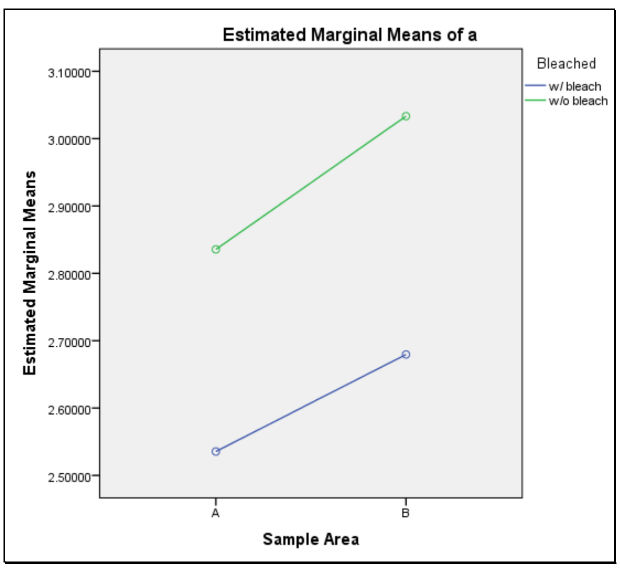
a. Based on modified population marginal mean.

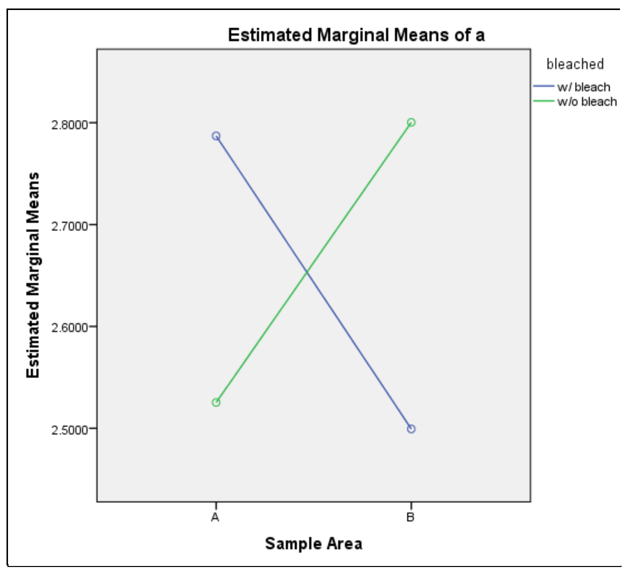
6. Sample Area * Bleached: PMJX

Dependent Variable: a

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	w/ bleach	2.787[a]	.043	2.702	2.872
	w/o bleach	2.525[a]	.043	2.440	2.610
B	w/ bleach	2.499[a]	.043	2.414	2.584
	w/o bleach	2.800[a]	.043	2.715	2.885

a. Based on modified population marginal mean.





Again, the difference between the two patterns are obvious.

For the bleached * washing interaction below, the pattern for sample PMCL is more similar than for sample PMJX.

7. Bleached * Washing: PMCL

Dependent Variable: a

Bleached		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
w/ bleach	1W 0A	2.852[a]	.112	2.632	3.072
	1W 16A	2.646[a]	.079	2.491	2.802
	2W 32A	2.512[a]	.079	2.357	2.667
	3W 48A	2.440[a]	.079	2.285	2.596
	4W 64A	2.916[a]	.079	2.761	3.071
	5W 80A	2.401[a]	.079	2.245	2.556
w/o bleach	1W 0A	2.940[a]	.112	2.720	3.160
	1W 16A	2.807[a]	.079	2.652	2.963
	2W 32A	2.700[a]	.079	2.545	2.855
	3W 48A	3.023[a]	.079	2.867	3.178
	4W 64A	3.091[a]	.079	2.935	3.246
	5W 80A	3.049[a]	.079	2.894	3.204

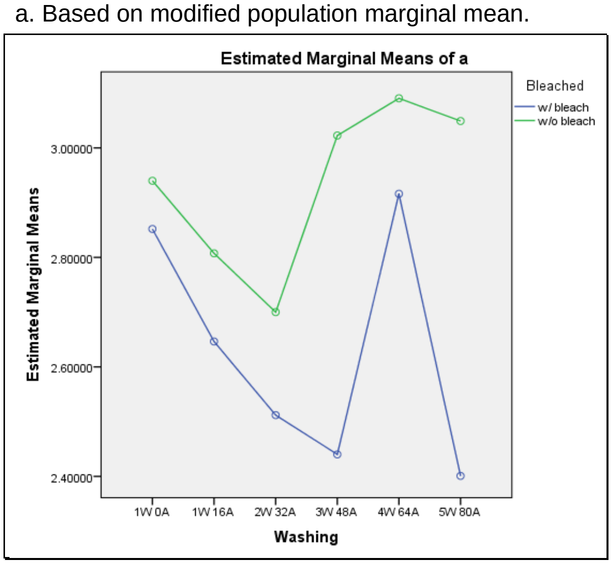
a. Based on modified population marginal mean.

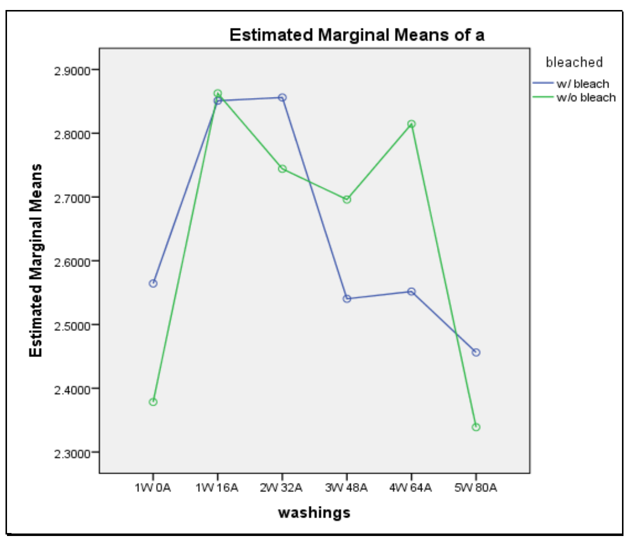
7. Bleached * Washings: PMJX

Dependent Variable: a

bleached		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
w/ bleach	1W 0A	2.564[a]	.102	2.365	2.764
	1W 16A	2.851[a]	.072	2.710	2.992
	2W 32A	2.856[a]	.072	2.715	2.997
	3W 48A	2.540[a]	.072	2.399	2.681
	4W 64A	2.552[a]	.072	2.411	2.693
	5W 80A	2.456[a]	.072	2.315	2.597
w/o bleach	1W 0A	2.378[a]	.102	2.179	2.578
	1W 16A	2.863[a]	.072	2.722	3.003
	2W 32A	2.744[a]	.072	2.603	2.885
	3W 48A	2.696[a]	.072	2.555	2.837
	4W 64A	2.815[a]	.072	2.674	2.956
	5W 80A	2.339[a]	.072	2.198	2.480

a. Based on modified population marginal mean.





8. Swatch * Washing: PMCL

Dependent Variable: a

Swatch		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
1 w/ bleach	1W 0A	2.422[a]	.158	2.111	2.733
	1W 16A	2.303[a]	.112	2.084	2.523
	2W 32A	2.125[a]	.112	1.905	2.344
	3W 48A	2.174[a]	.112	1.955	2.394
	4W 64A	2.763[a]	.112	2.544	2.983
	5W 80A	2.202[a]	.112	1.982	2.421
2 w/ bleach	1W 0A	3.282[a]	.158	2.971	3.593
	1W 16A	2.989[a]	.112	2.770	3.209
	2W 32A	2.899[a]	.112	2.679	3.119
	3W 48A	2.706[a]	.112	2.486	2.926
	4W 64A	3.069[a]	.112	2.849	3.289
	5W 80A	2.600[a]	.112	2.380	2.820
3 w/o bleach	1W 0A	2.665[a]	.158	2.354	2.976
	1W 16A	2.954[a]	.112	2.734	3.174
	2W 32A	3.017[a]	.112	2.797	3.237
	3W 48A	2.679[a]	.112	2.459	2.899
	4W 64A	3.112[a]	.112	2.892	3.331
	5W 80A	2.672[a]	.112	2.453	2.892
4 w/o bleach	1W 0A	3.215[a]	.158	2.904	3.526
	1W 16A	2.661[a]	.112	2.441	2.881
	2W 32A	2.383[a]	.112	2.163	2.603
	3W 48A	3.366[a]	.112	3.146	3.586
	4W 64A	3.069[a]	.112	2.850	3.289
	5W 80A	3.426[a]	.112	3.206	3.646

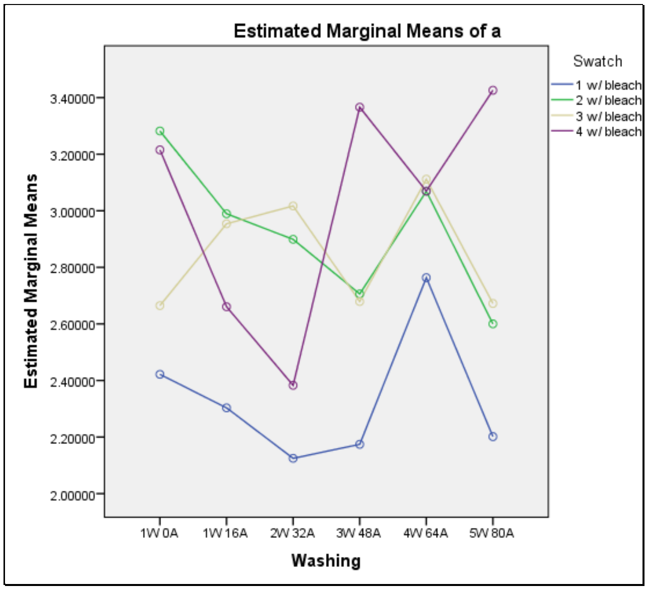
a. Based on modified population marginal mean.

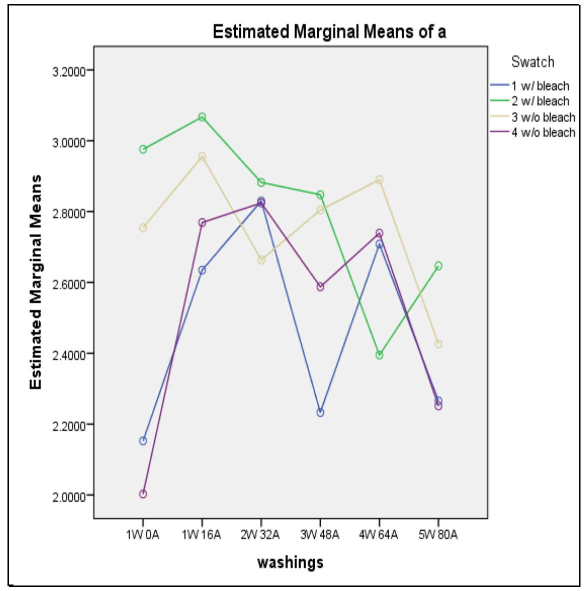
8. Swatch * washings: PMJX

Dependent Variable: a

Swatch		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
1 w/ bleach	1W 0A	2.153[a]	.144	1.871	2.435
	1W 16A	2.635[a]	.102	2.436	2.834
	2W 32A	2.830[a]	.102	2.631	3.029
	3W 48A	2.233[a]	.102	2.034	2.432
	4W 64A	2.708[a]	.102	2.509	2.908
	5W 80A	2.266[a]	.102	2.066	2.465
2 w/ bleach	1W 0A	2.976[a]	.144	2.694	3.258
	1W 16A	3.067[a]	.102	2.868	3.266
	2W 32A	2.882[a]	.102	2.683	3.082
	3W 48A	2.848[a]	.102	2.648	3.047
	4W 64A	2.395[a]	.102	2.196	2.594
	5W 80A	2.647[a]	.102	2.448	2.846
3 w/o bleach	1W 0A	2.754[a]	.144	2.472	3.036
	1W 16A	2.956[a]	.102	2.757	3.155
	2W 32A	2.664[a]	.102	2.465	2.863
	3W 48A	2.804[a]	.102	2.605	3.004
	4W 64A	2.890[a]	.102	2.691	3.089
	5W 80A	2.426[a]	.102	2.227	2.626
4 w/o bleach	1W 0A	2.003[a]	.144	1.721	2.284
	1W 16A	2.769[a]	.102	2.570	2.968
	2W 32A	2.825[a]	.102	2.625	3.024
	3W 48A	2.588[a]	.102	2.388	2.787
	4W 64A	2.739[a]	.102	2.540	2.938
	5W 80A	2.251[a]	.102	2.052	2.451

a. Based on modified population marginal mean.





Swatches 2 and 4 follow a similar pattern in sample PMCL, and swatches 1, 2 and 4 follows their own pattern. In both cases, swatch 3 observed its own individual pattern between both the samples.

Variable 'b'

Tests of Between-Subjects Effects: PMCL

Dependent Variable: b

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	687.42[a]	43	15.987	9.669	.000
Intercept	15946	1	15946	9644.5	.000
Swatch	108.59	2	54.294	32.838	.000
SampleArea	7.673	1	7.673	4.641	.032
Bleached	.000	0	.	.	.
Washing	66.962	5	13.392	8.100	.000
Swatch * SampleArea	68.975	2	34.488	20.859	.000
Swatch * Bleached	.000	0	.	.	.
Swatch * Washing	91.231	8	11.404	6.897	.000
SampleArea * Bleached	.000	0	.	.	.
SampleArea * Washing	78.406	4	19.601	11.855	.000
Bleached * Washing	.000	0	.	.	.
Swatch * SampleArea * Bleached	.000	0	.	.	.
Swatch * SampleArea * Washing	134.02	8	16.752	10.132	.000
Swatch * Bleached * Washing	.000	0	.	.	.
SampleArea * Bleached * Washing	.000	0	.	.	.
Swatch * SampleArea * Bleached * Washing	.000	0	.	.	.
Error	1382.2	836	1.653		
Total	19329	880			
Corrected Total	2069.7	879			

a. R Squared = .332 (Adjusted R Squared = .298)

Tests of Between-Subjects Effects: PMJX

Dependent Variable: b

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	472.78[a]	43	10.995	6.641	.000
Intercept	21506	1	21506	12990	0.000
SampleArea	.586	1	.586	.354	.552
Swatch	26.126	2	13.063	7.890	.000
bleached	0.000	0			
washings	92.907	5	18.581	11.223	.000
SampleArea * Swatch	2.054	2	1.027	.620	.538
SampleArea * bleached	0.000	0			
SampleArea * washings	15.132	4	3.783	2.285	.059
Swatch * bleached	0.000	0			
Swatch * washings	30.702	8	3.838	2.318	.018
bleached * washings	0.000	0			
SampleArea * Swatch * bleached	0.000	0			
SampleArea * Swatch * washings	98.557	8	12.320	7.441	.000
SampleArea * bleached * washings	0.000	0			
Swatch * bleached * washings	0.000	0			
SampleArea * Swatch * bleached * washings	0.000	0			
Error	1384.1	836	1.656		
Total	25135	880			
Corrected Total	1856.9	879			

a. R Squared = .255 (Adjusted R Squared = .216)

b. Computed using alpha = .05

Both samples produced insignificant values for the main effect of the sample area. In addition, sample PMJX also produced insignificant results for Sample Area* Swatch and Sample Area* Washing interactions at p-values of .538 and .059, respectively.

2. Swatch Estimates: PMCL

Dependent Variable: b

Swatch	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1 w/ bleach	3.618[a]	.087	3.447	3.788
2 w/ bleach	4.713[a]	.087	4.543	4.883
3 w/o bleach	4.618[a]	.087	4.447	4.788
4 w/o bleach	4.767[a]	.087	4.597	4.937

a. Based on modified population marginal mean.

Pairwise Comparisons: PMCL

Dependent Variable: b

(I) Swatch		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach	-1.095[*,b,c]	.123	.000	-1.336	-.855
	3 w/o bleach	-1.000[*,b,c]	.123	.000	-1.241	-.759
	4 w/o bleach	-1.149[*,b,c]	.123	.000	-1.390	-.909
2 w/ bleach	1 w/ bleach	1.095[*,b,c]	.123	.000	.855	1.336
	3 w/o bleach	.095[b,c]	.123	.438	-.146	.336
	4 w/o bleach	-.054[b,c]	.123	.659	-.295	.187
3 w/o bleach	1 w/ bleach	1.000[*,b,c]	.123	.000	.759	1.241
	2 w/ bleach	-.095[b,c]	.123	.438	-.336	.146
	4 w/o bleach	-.149[b,c]	.123	.224	-.390	.091
4 w/o bleach	1 w/ bleach	1.149[*,b,c]	.123	.000	.909	1.390
	2 w/ bleach	.054[b,c]	.123	.659	-.187	.295
	3 w/o bleach	.149[b,c]	.123	.224	-.091	.390

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

2. Swatch Estimates: PMJX

Dependent Variable: b

Swatch	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1 w/ bleach	4.842[a]	.087	4.672	5.012
2 w/ bleach	5.435[a]	.087	5.265	5.606
3 w/o bleach	5.260[a]	.087	5.090	5.430
4 w/o bleach	5.035[a]	.087	4.865	5.206

a. Based on modified population marginal mean.

Pairwise Comparisons: PMJX

Dependent Variable: b

(I) Swatch		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach	-.593[*,b,c]	.123	.000	-.834	-.353
	3 w/o bleach	-.418[*,b,c]	.123	.001	-.659	-.177
	4 w/o bleach	-.193[b,c]	.123	.115	-.434	.047
2 w/ bleach	1 w/ bleach	.593[*,b,c]	.123	.000	.353	.834
	3 w/o bleach	.175[b,c]	.123	.153	-.065	.416
	4 w/o bleach	.400[*,b,c]	.123	.001	.159	.641
3 w/o bleach	1 w/ bleach	.418[*,b,c]	.123	.001	.177	.659
	2 w/ bleach	-.175[b,c]	.123	.153	-.416	.065
	4 w/o bleach	.225[b,c]	.123	.067	-.016	.465
4 w/o bleach	1 w/ bleach	.193[b,c]	.123	.115	-.047	.434
	2 w/ bleach	-.400[*,b,c]	.123	.001	-.641	-.159
	3 w/o bleach	-.225[b,c]	.123	.067	-.465	.016

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Similar to variable ‘a’, no observed pattern was developed.

3. Bleach Estimates: PMCL

Dependent Variable: b

Bleached	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
w/ bleach	4.165[a]	.061	4.045	4.285
w/o bleach	4.692[a]	.061	4.572	4.812

a. Based on modified population marginal mean.

Pairwise Comparisons: PMCL

Dependent Variable: b

(I) Bleached	(J) Bleached	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	Upper Bound
w/ bleach	w/o bleach	-.527[*,a,b]	.087	.000	-.697	-.357
w/o bleach	w/ bleach	.527[*,a,b]	.087	.000	.357	.697

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

3. Bleach Estimates: PMJX

Dependent Variable: b

bleached	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
w/ bleach	5.139[a]	.061	5.018	5.259
w/o bleach	5.148[a]	.061	5.027	5.268

a. Based on modified population marginal mean.

Pairwise Comparisons: PMJX

Dependent Variable: b

(I) bleached		Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	Upper Bound
w/ bleach	w/o bleach	-.009[a,b]	.087	.917	-.179	.161
w/o bleach	w/ bleach	.009[a,b]	.087	.917	-.161	.179

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Based on the significant values, the type of detergent used affected the outcome of PMCL samples.

4. Washing Estimates: PMCL

Dependent Variable: b

Washing	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
1W 0A	4.397[a]	.144	4.114	4.679
1W 16A	4.518[a]	.102	4.319	4.718
2W 32A	4.199[a]	.102	4.000	4.399
3W 48A	4.176[a]	.102	3.976	4.375
4W 64A	4.933[a]	.102	4.734	5.133
5W 80A	4.333[a]	.102	4.134	4.533

a. Based on modified population marginal mean.

Pairwise Comparisons: PMCL

Dependent Variable: b

(I) Washing		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	Upper Bound
1W 0A	1W 16A	-.122[a,b]	.176	.490	-.467	.224
	2W 32A	.197[a,b]	.176	.262	-.148	.543
	3W 48A	.221[a,b]	.176	.210	-.125	.566
	4W 64A	-.537[a,b,*]	.176	.002	-.882	-.191
	5W 80A	.063[a,b]	.176	.719	-.282	.409
1W 16A	1W 0A	.122[a,b]	.176	.490	-.224	.467
	2W 32A	.319[a,b,*]	.144	.027	.037	.601
	3W 48A	.342[a,b,*]	.144	.017	.060	.625
	4W 64A	-.415[a,b,*]	.144	.004	-.697	-.133
	5W 80A	.185[a,b]	.144	.198	-.097	.467
2W 32A	1W 0A	-.197[a,b]	.176	.262	-.543	.148
	1W 16A	-.319[a,b,*]	.144	.027	-.601	-.037
	3W 48A	.023[a,b]	.144	.871	-.259	.305
	4W 64A	-.734[a,b,*]	.144	.000	-1.016	-.452
	5W 80A	-.134[a,b]	.144	.351	-.416	.148
3W 48A	1W 0A	-.221[a,b]	.176	.210	-.566	.125
	1W 16A	-.342[a,b,*]	.144	.017	-.625	-.060
	2W 32A	-.023[a,b]	.144	.871	-.305	.259
	4W 64A	-.757[a,b,*]	.144	.000	-1.039	-.475
	5W 80A	-.157[a,b]	.144	.274	-.440	.125
4W 64A	1W 0A	.537[a,b,*]	.176	.002	.191	.882
	1W 16A	.415[a,b,*]	.144	.004	.133	.697
	2W 32A	.734[a,b,*]	.144	.000	.452	1.016
	3W 48A	.757[a,b,*]	.144	.000	.475	1.039
	5W 80A	.600[a,b,*]	.144	.000	.318	.882
5W 80A	1W 0A	-.063[a,b]	.176	.719	-.409	.282
	1W 16A	-.185[a,b]	.144	.198	-.467	.097
	2W 32A	.134[a,b]	.144	.351	-.148	.416
	3W 48A	.157[a,b]	.144	.274	-.125	.440
	4W 64A	-.600[a,b,*]	.144	.000	-.882	-.318

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

4. Washing Estimates: PMJX

Dependent Variable: b

washings	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
1W 0A	4.557[a]	.144	4.275	4.840
1W 16A	5.419[a]	.102	5.219	5.618
2W 32A	5.359[a]	.102	5.160	5.559
3W 48A	5.319[a]	.102	5.119	5.519
4W 64A	5.283[a]	.102	5.083	5.482
5W 80A	4.629[a]	.102	4.429	4.829

a. Based on modified population marginal mean.

Pairwise Comparisons: PMJX

Dependent Variable: b

(I) washings		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	Upper Bound
1W 0A	1W 16A	-.861*,b,c	.176	.000	-1.207	-.516
	2W 32A	-.802*,b,c	.176	.000	-1.148	-.456
	3W 48A	-.762*,b,c	.176	.000	-1.108	-.416
	4W 64A	-.725*,b,c	.176	.000	-1.071	-.380
	5W 80A	-.072b,c	.176	.684	-.418	.274
1W 16A	1W 0A	.861*,b,c	.176	.000	.516	1.207
	2W 32A	.059b,c	.144	.680	-.223	.342
	3W 48A	.100b,c	.144	.489	-.183	.382
	4W 64A	.136b,c	.144	.345	-.146	.418
	5W 80A	.790*,b,c	.144	.000	.507	1.072
2W 32A	1W 0A	.802*,b,c	.176	.000	.456	1.148
	1W 16A	-.059b,c	.144	.680	-.342	.223
	3W 48A	.040b,c	.144	.780	-.242	.323
	4W 64A	.077b,c	.144	.594	-.206	.359
	5W 80A	.730*,b,c	.144	.000	.448	1.013
3W 48A	1W 0A	.762*,b,c	.176	.000	.416	1.108
	1W 16A	-.100b,c	.144	.489	-.382	.183
	2W 32A	-.040b,c	.144	.780	-.323	.242
	4W 64A	.036b,c	.144	.800	-.246	.319
	5W 80A	.690*,b,c	.144	.000	.408	.972
4W 64A	1W 0A	.725*,b,c	.176	.000	.380	1.071
	1W 16A	-.136b,c	.144	.345	-.418	.146
	2W 32A	-.077b,c	.144	.594	-.359	.206
	3W 48A	-.036b,c	.144	.800	-.319	.246
	5W 80A	.654*,b,c	.144	.000	.371	.936
5W 80A	1W 0A	.072b,c	.176	.684	-.274	.418
	1W 16A	-.790*,b,c	.144	.000	-1.072	-.507
	2W 32A	-.730*,b,c	.144	.000	-1.013	-.448
	3W 48A	-.690*,b,c	.144	.000	-.972	-.408
	4W 64A	-.654*,b,c	.144	.000	-.936	-.371

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Marked significant differences were observed between both reference samples. No prominent pattern was observed between the two samples.

Foe the swatch* washing interaction below, differences in means can be observed. The mean values are more conjugated for sample PMJX than for PMCL. Similarly to variable ‘a’, the patterns for swatches 1, 2 and 3 are roughly consistent between the reference samples.

8. Swatch * Washing: PMCL

Dependent Variable: b

Swatch		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1 w/ bleach	1W 0A	3.477[a]	.288	2.913	4.041
	1W 16A	3.734[a]	.203	3.335	4.133
	2W 32A	3.121[a]	.203	2.722	3.520
	3W 48A	3.171[a]	.203	2.772	3.570
	4W 64A	4.449[a]	.203	4.049	4.848
	5W 80A	3.684[a]	.203	3.285	4.083
2 w/ bleach'	1W 0A	5.266[a]	.288	4.702	5.831
	1W 16A	5.096[a]	.203	4.697	5.495
	2W 32A	4.355[a]	.203	3.956	4.754
	3W 48A	4.402[a]	.203	4.003	4.801
	4W 64A	4.969[a]	.203	4.570	5.368
	5W 80A	4.465[a]	.203	4.066	4.864
3 w/ bleach	1W 0A	4.519[a]	.288	3.954	5.083
	1W 16A	4.850[a]	.203	4.451	5.249
	2W 32A	5.170[a]	.203	4.771	5.569
	3W 48A	4.194[a]	.203	3.795	4.593
	4W 64A	5.108[a]	.203	4.709	5.507
	5W 80A	3.816[a]	.203	3.417	4.215
4 w/ bleach	1W 0A	4.324[a]	.288	3.760	4.888
	1W 16A	4.393[a]	.203	3.994	4.792
	2W 32A	4.151[a]	.203	3.752	4.550
	3W 48A	4.936[a]	.203	4.537	5.336
	4W 64A	5.207[a]	.203	4.808	5.606
	5W 80A	5.368[a]	.203	4.969	5.767

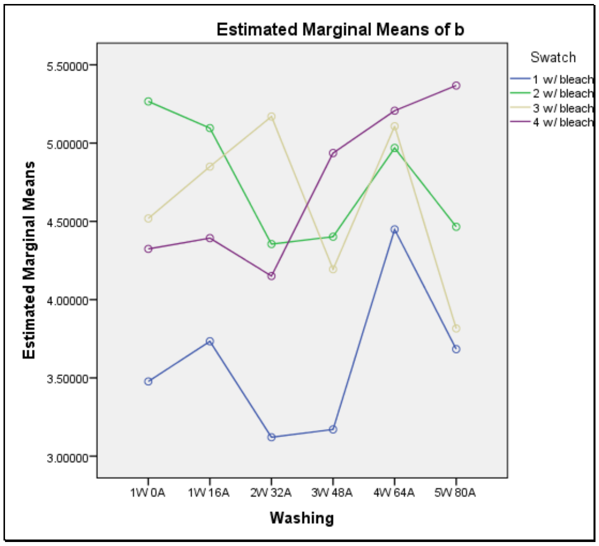
a. Based on modified population marginal mean.

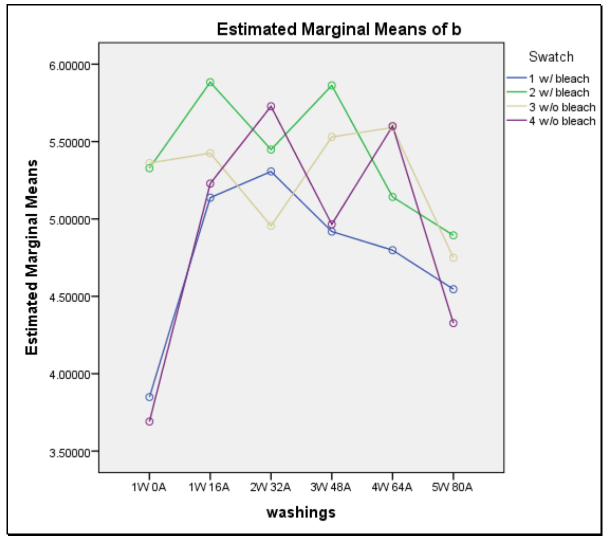
8. Swatch * Washings: PMJX

Dependent Variable: b

Swatch		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1 w/ bleach	1W 0A	3.849[a]	.288	3.285	4.414
	1W 16A	5.137[a]	.203	4.738	5.537
	2W 32A	5.307[a]	.203	4.907	5.706
	3W 48A	4.918[a]	.203	4.519	5.318
	4W 64A	4.798[a]	.203	4.399	5.197
	5W 80A	4.546[a]	.203	4.147	4.945
2 w/ bleach	1W 0A	5.328[a]	.288	4.763	5.893
	1W 16A	5.884[a]	.203	5.484	6.283
	2W 32A	5.448[a]	.203	5.049	5.847
	3W 48A	5.863[a]	.203	5.463	6.262
	4W 64A	5.142[a]	.203	4.743	5.542
	5W 80A	4.894[a]	.203	4.495	5.293
3 w/o bleach	1W 0A	5.361[a]	.288	4.797	5.926
	1W 16A	5.425[a]	.203	5.026	5.824
	2W 32A	4.955[a]	.203	4.556	5.354
	3W 48A	5.530[a]	.203	5.131	5.929
	4W 64A	5.590[a]	.203	5.191	5.990
	5W 80A	4.749[a]	.203	4.350	5.149
4 w/o bleach	1W 0A	3.691[a]	.288	3.126	4.256
	1W 16A	5.229[a]	.203	4.830	5.628
	2W 32A	5.728[a]	.203	5.328	6.127
	3W 48A	4.966[a]	.203	4.566	5.365
	4W 64A	5.600[a]	.203	5.201	6.000
	5W 80A	4.327[a]	.203	3.928	4.726

a. Based on modified population marginal mean.





VI and VII. Samples PMP and RMP (compared simultaneously because of their close proximity on the color space for the purposes of examining if the Lab values might be similar in regards to this distance).

Variable 'L'

Tests of Between-Subjects Effects: PMP

Dependent Variable: L

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	11081[a]	43	257.69	16.551	.000
Intercept	5739882	1	5739883	368672	0.000
SampleArea	2.924	1	2.924	.188	.665
Swatch	332.92	2	166.46	10.692	.000
Bleached	0.000	0			
Washings	5895.7	5	1179.1	75.736	.000
SampleArea * Swatch	358.42	2	179.21	11.511	.000
SampleArea * Bleached	0.000	0			
SampleArea * Washings	281.75	4	70.436	4.524	.001
Swatch * Bleached	0.000	0			
Swatch * Washings	463.82	8	57.978	3.724	.000
Bleached * Washings	0.000	0			
SampleArea * Swatch * Bleached	0.000	0			
SampleArea * Swatch * Washings	1230.8	8	153.84	9.881	.000
SampleArea * Bleached * Washings	0.000	0			
Swatch * Bleached * Washings	0.000	0			
SampleArea * Swatch * Bleached * Washings	0.000	0			
Error	13016	836	15.569		
Total	6192628	880			
Corrected Total	24096	879			

a. R Squared = .460 (Adjusted R Squared = .432)
b. Computed using alpha = .05

Tests of Between-Subjects Effects: RMP

Dependent Variable: L

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3784.841[a]	43	88.020	7.825	.000
Intercept	5867578.864	1	5867578.864	521618.405	0.000
SampleArea	.457	1	.457	.041	.840
Swatch	50.816	2	25.408	2.259	.105
Bleached	0.000	0			
Washings	335.960	5	67.192	5.973	.000
SampleArea * Swatch	231.034	2	115.517	10.269	.000
SampleArea * Bleached	0.000	0			
SampleArea * Washings	163.125	4	40.781	3.625	.006
Swatch * Bleached	0.000	0			
Swatch * Washings	686.919	8	85.865	7.633	.000
Bleached * Washings	0.000	0			
SampleArea * Swatch * Bleached	0.000	0			
SampleArea * Swatch * Washings	387.426	8	48.428	4.305	.000
SampleArea * Bleached * Washings	0.000	0			
Swatch * Bleached * Washings	0.000	0			
SampleArea * Swatch * Bleached * Washings	0.000	0			
Error	9403.993	836	11.249		
Total	6266988.817	880			
Corrected Total	13188.834	879			

a. R Squared = .287 (Adjusted R Squared = .250)

b. Computed using alpha = .05

Insignificant results were observed for the main effects of sample area for both reference samples, as well as for swatch for sample RMP.

2. Swatch Estimates: PMP

Dependent Variable: L

Swatch	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	84.240[a]	.266	83.718	84.762
2 w/ bleach	84.527[a]	.266	84.005	85.050
3 w/o bleach	84.188[a]	.266	83.666	84.710
4 w/o bleach	81.941[a]	.266	81.418	82.463

a. Based on modified population marginal mean.

Pairwise Comparisons

Dependent Variable: L

(I) Swatch		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach	-.288[a,b]	.376	.445	-1.026	.451
	3 w/o bleach	.052[a,b]	.376	.891	-.687	.790
	4 w/o bleach	2.299[a,b,*]	.376	.000	1.561	3.038
2 w/ bleach	1 w/ bleach	.288[a,b]	.376	.445	-.451	1.026
	3 w/o bleach	.339[a,b]	.376	.367	-.399	1.078
	4 w/o bleach	2.587[a,b,*]	.376	.000	1.848	3.325
3 w/o bleach	1 w/ bleach	-.052[a,b]	.376	.891	-.790	.687
	2 w/ bleach	-.339[a,b]	.376	.367	-1.078	.399
	4 w/o bleach	2.248[a,b,*]	.376	.000	1.509	2.986
4 w/o bleach	1 w/ bleach	-2.299[a,b,*]	.376	.000	-3.038	-1.561
	2 w/ bleach	-2.587[a,b,*]	.376	.000	-3.325	-1.848
	3 w/o bleach	-2.248[a,b,*]	.376	.000	-2.986	-1.509

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Significant results were only observed for sample PMP. The unbleached swatches observed significant differences for all levels of interactions.

4. Washing Estimates: PMP

Dependent Variable: L

Washings	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1W 0A	79.053[a]	.441	78.187	79.918
1W 16A	81.055[a]	.312	80.443	81.668
2W 32A	87.708[a]	.312	87.095	88.320
3W 48A	82.592[a]	.312	81.980	83.204
4W 64A	84.226[a]	.312	83.614	84.838
5W 80A	85.374[a]	.312	84.762	85.986

a. Based on modified population marginal mean.

Pairwise Comparisons: PMP

Dependent Variable: L

(I) Washings		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	Upper Bound
1W 0A	1W 16A	-2.003[*,b,c]	.540	.000	-3.063	-.942
	2W 32A	-8.655[*,b,c]	.540	.000	-9.716	-7.595
	3W 48A	-3.539[*,b,c]	.540	.000	-4.600	-2.479
	4W 64A	-5.174[*,b,c]	.540	.000	-6.234	-4.113
	5W 80A	-6.322[*,b,c]	.540	.000	-7.382	-5.261
1W 16A	1W 0A	2.003[*,b,c]	.540	.000	.942	3.063
	2W 32A	-6.652[*,b,c]	.441	.000	-7.518	-5.786
	3W 48A	-1.537[*,b,c]	.441	.001	-2.403	-.671
	4W 64A	-3.171[*,b,c]	.441	.000	-4.037	-2.305
	5W 80A	-4.319[*,b,c]	.441	.000	-5.185	-3.453
2W 32A	1W 0A	8.655[*,b,c]	.540	.000	7.595	9.716
	1W 16A	6.652[*,b,c]	.441	.000	5.786	7.518
	3W 48A	5.116[*,b,c]	.441	.000	4.250	5.981
	4W 64A	3.481[*,b,c]	.441	.000	2.616	4.347
	5W 80A	2.333[*,b,c]	.441	.000	1.468	3.199
3W 48A	1W 0A	3.539[*,b,c]	.540	.000	2.479	4.600
	1W 16A	1.537[*,b,c]	.441	.001	.671	2.403
	2W 32A	-5.116[*,b,c]	.441	.000	-5.981	-4.250
	4W 64A	-1.634[*,b,c]	.441	.000	-2.500	-.768
	5W 80A	-2.782[*,b,c]	.441	.000	-3.648	-1.916
4W 64A	1W 0A	5.174[*,b,c]	.540	.000	4.113	6.234
	1W 16A	3.171[*,b,c]	.441	.000	2.305	4.037
	2W 32A	-3.481[*,b,c]	.441	.000	-4.347	-2.616
	3W 48A	1.634[*,b,c]	.441	.000	.768	2.500
	5W 80A	-1.148[*,b,c]	.441	.009	-2.014	-.282
5W 80A	1W 0A	6.322[*,b,c]	.540	.000	5.261	7.382
	1W 16A	4.319[*,b,c]	.441	.000	3.453	5.185
	2W 32A	-2.333[*,b,c]	.441	.000	-3.199	-1.468
	3W 48A	2.782[*,b,c]	.441	.000	1.916	3.648
	4W 64A	1.148[*,b,c]	.441	.009	.282	2.014

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
b. An estimate of the modified population marginal mean (I).
c. An estimate of the modified population marginal mean (J).
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

4. Washing Estimates: RMP

Dependent Variable: L

Washings	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1W 0A	84.026[a]	.375	83.290	84.762
1W 16A	85.253[a]	.265	84.733	85.774
2W 32A	84.496[a]	.265	83.975	85.016
3W 48A	84.099[a]	.265	83.578	84.619
4W 64A	83.269[a]	.265	82.748	83.789
5W 80A	84.524[a]	.265	84.003	85.044

a. Based on modified population marginal mean.

Pairwise Comparisons: RMP

Dependent Variable: L

(I) Washings		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	95% Confidence Interval for Difference[d] Upper Bound
1W 0A	1W 16A	-1.227[*,b,c]	.459	.008	-2.129	-.326
	2W 32A	-.470[b,c]	.459	.307	-1.371	.432
	3W 48A	-.073[b,c]	.459	.874	-.974	.829
	4W 64A	.757[b,c]	.459	.100	-.144	1.659
	5W 80A	-.498[b,c]	.459	.279	-1.399	.404
1W 16A	1W 0A	1.227[*,b,c]	.459	.008	.326	2.129
	2W 32A	.757[*,b,c]	.375	.044	.021	1.493
	3W 48A	1.154[*,b,c]	.375	.002	.418	1.890
	4W 64A	1.984[*,b,c]	.375	.000	1.248	2.720
	5W 80A	.729[b,c]	.375	.052	-.007	1.465
2W 32A	1W 0A	.470[b,c]	.459	.307	-.432	1.371
	1W 16A	-.757[*,b,c]	.375	.044	-1.493	-.021
	3W 48A	.397[b,c]	.375	.290	-.339	1.133
	4W 64A	1.227[*,b,c]	.375	.001	.491	1.963
	5W 80A	-.028[b,c]	.375	.940	-.764	.708
3W 48A	1W 0A	.073[b,c]	.459	.874	-.829	.974
	1W 16A	-1.154[*,b,c]	.375	.002	-1.890	-.418
	2W 32A	-.397[b,c]	.375	.290	-1.133	.339
	4W 64A	.830[*,b,c]	.375	.027	.094	1.566
	5W 80A	-.425[b,c]	.375	.257	-1.161	.311
4W 64A	1W 0A	-.757[b,c]	.459	.100	-1.659	.144
	1W 16A	-1.984[*,b,c]	.375	.000	-2.720	-1.248
	2W 32A	-1.227[*,b,c]	.375	.001	-1.963	-.491
	3W 48A	-.830[*,b,c]	.375	.027	-1.566	-.094
	5W 80A	-1.255[*,b,c]	.375	.001	-1.991	-.519
5W 80A	1W 0A	.498[b,c]	.459	.279	-.404	1.399
	1W 16A	-.729[b,c]	.375	.052	-1.465	.007
	2W 32A	.028[b,c]	.375	.940	-.708	.764
	3W 48A	.425[b,c]	.375	.257	-.311	1.161
	4W 64A	1.255[*,b,c]	.375	.001	.519	1.991

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Out of all the reference samples, sample PMP obtained significant values at all levels of pair-wise groups. The main effects for washing were significant throughout the washed-aged process. It can be concluded that PMP was tremendously affected by washing. Significant values were also observed for sample RMP.

8. Swatch * Washings: PMP

Dependent Variable: L

Swatch		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	1W 0A	78.822[a]	.882	77.091	80.554
	1W 16A	82.351[a]	.624	81.126	83.575
	2W 32A	89.409[a]	.624	88.185	90.634
	3W 48A	82.655[a]	.624	81.430	83.879
	4W 64A	83.419[a]	.624	82.195	84.644
	5W 80A	86.073[a]	.624	84.848	87.297
2 w/ bleach	1W 0A	81.441[a]	.882	79.709	83.173
	1W 16A	81.244[a]	.624	80.019	82.468
	2W 32A	91.774[a]	.624	90.549	92.999
	3W 48A	82.359[a]	.624	81.134	83.583
	4W 64A	84.379[a]	.624	83.154	85.603
	5W 80A	84.425[a]	.624	83.200	85.649
3 w/o bleach	1W 0A	81.216[a]	.882	79.484	82.948
	1W 16A	79.780[a]	.624	78.556	81.005
	2W 32A	85.629[a]	.624	84.404	86.853
	3W 48A	84.246[a]	.624	83.021	85.470
	4W 64A	85.570[a]	.624	84.345	86.794
	5W 80A	87.203[a]	.624	85.978	88.427
4 w/o bleach	1W 0A	74.731[a]	.882	72.999	76.462
	1W 16A	80.846[a]	.624	79.622	82.071
	2W 32A	84.018[a]	.624	82.794	85.243
	3W 48A	81.109[a]	.624	79.885	82.334
	4W 64A	83.537[a]	.624	82.312	84.762
	5W 80A	83.797[a]	.624	82.572	85.021

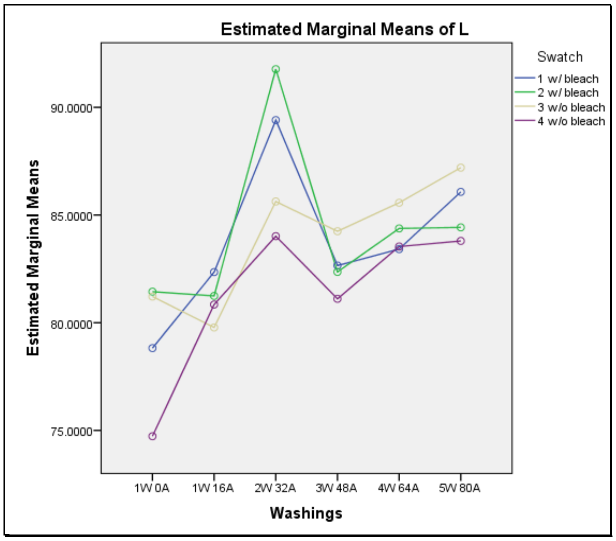
a. Based on modified population marginal mean.

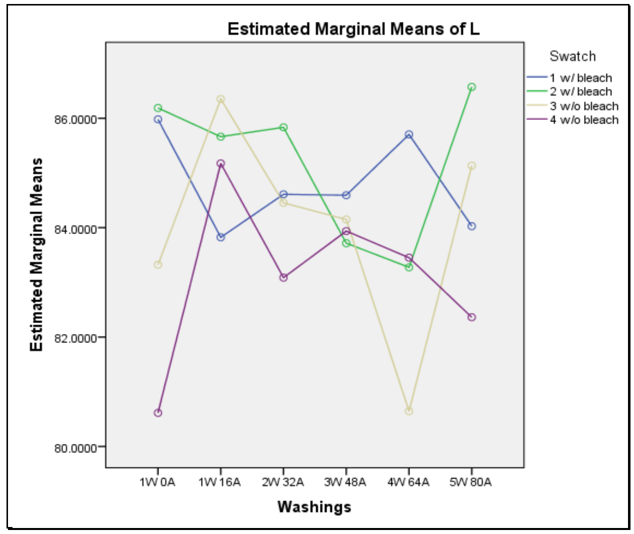
8. Swatch * Washings: RMP

Dependent Variable: L

Swatch		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	1W 0A	85.981[a]	.750	84.509	87.453
	1W 16A	83.823[a]	.530	82.782	84.864
	2W 32A	84.609[a]	.530	83.568	85.650
	3W 48A	84.593[a]	.530	83.552	85.633
	4W 64A	85.704[a]	.530	84.664	86.745
	5W 80A	84.027[a]	.530	82.986	85.068
2 w/ bleach	1W 0A	86.187[a]	.750	84.715	87.659
	1W 16A	85.663[a]	.530	84.622	86.704
	2W 32A	85.834[a]	.530	84.793	86.875
	3W 48A	83.716[a]	.530	82.675	84.757
	4W 64A	83.275[a]	.530	82.234	84.316
	5W 80A	86.573[a]	.530	85.532	87.614
3 w/o bleach	1W 0A	83.322[a]	.750	81.850	84.794
	1W 16A	86.352[a]	.530	85.311	87.393
	2W 32A	84.453[a]	.530	83.412	85.494
	3W 48A	84.149[a]	.530	83.108	85.190
	4W 64A	80.644[a]	.530	79.604	81.685
	5W 80A	85.133[a]	.530	84.092	86.174
4 w/o bleach	1W 0A	80.614[a]	.750	79.141	82.086
	1W 16A	85.175[a]	.530	84.134	86.215
	2W 32A	83.086[a]	.530	82.046	84.127
	3W 48A	83.938[a]	.530	82.897	84.979
	4W 64A	83.451[a]	.530	82.410	84.492
	5W 80A	82.362[a]	.530	81.321	83.403

a. Based on modified population marginal mean.





The plots above represent PMP and RMP from left to right, respectively. Unlike sample RMP which did not exhibit a particular pattern, sample PMP observed a more consistent pattern. This pattern has not been observed for any of the reference samples.

Variable 'a'

Main effects were insignificant at sample area for both samples, and at swatch for sample PMP.

Tests of Between-Subjects Effects: PMP

Dependent Variable: a

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	482.74[a]	43	11.227	6.762	.000
Intercept	34207	1	34207	20605	0.000
SampleArea	.337	1	.337	.203	.652
Swatch	7.199	2	3.600	2.168	.115
Bleached	0.000	0			
Washings	32.867	5	6.573	3.960	.001
SampleArea * Swatch	32.736	2	16.368	9.859	.000
SampleArea * Bleached	0.000	0			
SampleArea * Washings	17.987	4	4.497	2.709	.029
Swatch * Bleached	0.000	0			
Swatch * Washings	122.15	8	15.269	9.197	.000
Bleached * Washings	0.000	0			
SampleArea * Swatch * Bleached	0.000	0			
SampleArea * Swatch * Washings	83.981	8	10.498	6.323	.000
SampleArea * Bleached * Washings	0.000	0			
Swatch * Bleached * Washings	0.000	0			
SampleArea * Swatch * Bleached * Washings	0.000	0			
Error	1387.89	836	1.660		
Total	37789	880			
Corrected Total	1870.6	879			

a. R Squared = .258 (Adjusted R Squared = .220). b. Computed using alpha = .05

Tests of Between-Subjects Effects: RMP

Dependent Variable: a

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4998.0[a]	43	116.23	7.043	.000
Intercept	614669	1	614669	37246	0.000
SampleArea	55.971	1	55.971	3.392	.066
Swatch	278.62	2	139.31	8.441	.000
Bleached	0.000	0			
Washings	308.54	5	61.709	3.739	.002
SampleArea * Swatch	397.01	2	198.51	12.029	.000
SampleArea * Bleached	0.000	0			
SampleArea * Washings	832.21	4	208.05	12.607	.000
Swatch * Bleached	0.000	0			
Swatch * Washings	1280.9	8	160.12	9.702	.000
Bleached * Washings	0.000	0			
SampleArea * Swatch * Bleached	0.000	0			
SampleArea * Swatch * Washings	713.31	8	89.164	5.403	.000
SampleArea * Bleached * Washings	0.000	0			
Swatch * Bleached * Washings	0.000	0			
SampleArea * Swatch * Bleached * Washings	0.000	0			
Error	13796	836	16.503		
Total	679347	880			
Corrected Total	18794	879			

a. R Squared = .266 (Adjusted R Squared = .228)

b. Computed using alpha = .05

2. Swatch Estimates: RMP

Dependent Variable: a

Swatch	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	28.069[a]	.274	27.531	28.607
2 w/ bleach	26.121[a]	.274	25.583	26.658
3 w/o bleach	27.888[a]	.274	27.350	28.425
4 w/o bleach	27.513[a]	.274	26.975	28.050

a. Based on modified population marginal mean.

Pairwise Comparisons: RMP

Dependent Variable: a

(I) Swatch		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	95% Confidence Interval for Difference[d] Upper Bound
1 w/ bleach	2 w/ bleach	1.948[*,b,c]	.387	.000	1.188	2.708
	3 w/o bleach	.181[b,c]	.387	.640	-.579	.942
	4 w/o bleach	.556[b,c]	.387	.151	-.204	1.317
2 w/ bleach	1 w/ bleach	-1.948[*,b,c]	.387	.000	-2.708	-1.188
	3 w/o bleach	-1.767[*,b,c]	.387	.000	-2.527	-1.007
	4 w/o bleach	-1.392[*,b,c]	.387	.000	-2.152	-.631
3 w/o bleach	1 w/ bleach	-.181[b,c]	.387	.640	-.942	.579
	2 w/ bleach	1.767[*,b,c]	.387	.000	1.007	2.527
	4 w/o bleach	.375[b,c]	.387	.333	-.385	1.135
4 w/o bleach	1 w/ bleach	-.556[b,c]	.387	.151	-1.317	.204
	2 w/ bleach	1.392[*,b,c]	.387	.000	.631	2.152
	3 w/o bleach	-.375[b,c]	.387	.333	-1.135	.385

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
b. An estimate of the modified population marginal mean (I).
c. An estimate of the modified population marginal mean (J).
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Swatch 1 was marked as significant with swatch 2, but insignificant with swatches 3 and 4.

4. Washing Estimates: PMP

Dependent Variable: a

Washings	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1W 0A	6.909[a]	.144	6.626	7.192
1W 16A	6.311[a]	.102	6.111	6.511
2W 32A	6.297[a]	.102	6.097	6.496
3W 48A	6.433[a]	.102	6.233	6.633
4W 64A	6.316[a]	.102	6.116	6.516
5W 80A	6.327[a]	.102	6.127	6.527

a. Based on modified population marginal mean.

Pairwise Comparisons: PMP

Dependent Variable: a

(I) Washings		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	95% Confidence Interval for Difference[d] Upper Bound
1W 0A	1W 16A	.597[*,b,c]	.176	.001	.251	.944
	2W 32A	.612[*,b,c]	.176	.001	.266	.959
	3W 48A	.476[*,b,c]	.176	.007	.130	.822
	4W 64A	.593[*,b,c]	.176	.001	.247	.939
	5W 80A	.582[*,b,c]	.176	.001	.235	.928
1W 16A	1W 0A	-.597[*,b,c]	.176	.001	-.944	-.251
	2W 32A	.015[b,c]	.144	.918	-.268	.298
	3W 48A	-.121[b,c]	.144	.400	-.404	.161
	4W 64A	-.004[b,c]	.144	.975	-.287	.278
	5W 80A	-.016[b,c]	.144	.913	-.298	.267
2W 32A	1W 0A	-.612[*,b,c]	.176	.001	-.959	-.266
	1W 16A	-.015[b,c]	.144	.918	-.298	.268
	3W 48A	-.136[b,c]	.144	.345	-.419	.146
	4W 64A	-.019[b,c]	.144	.893	-.302	.263
	5W 80A	-.031[b,c]	.144	.832	-.313	.252
3W 48A	1W 0A	-.476[*,b,c]	.176	.007	-.822	-.130
	1W 16A	.121[b,c]	.144	.400	-.161	.404
	2W 32A	.136[b,c]	.144	.345	-.146	.419
	4W 64A	.117[b,c]	.144	.417	-.166	.400
	5W 80A	.106[b,c]	.144	.463	-.177	.388
4W 64A	1W 0A	-.593[*,b,c]	.176	.001	-.939	-.247
	1W 16A	.004[b,c]	.144	.975	-.278	.287
	2W 32A	.019[b,c]	.144	.893	-.263	.302
	3W 48A	-.117[b,c]	.144	.417	-.400	.166
	5W 80A	-.011[b,c]	.144	.938	-.294	.271
5W 80A	1W 0A	-.582[*,b,c]	.176	.001	-.928	-.235
	1W 16A	.016[b,c]	.144	.913	-.267	.298
	2W 32A	.031[b,c]	.144	.832	-.252	.313
	3W 48A	-.106[b,c]	.144	.463	-.388	.177
	4W 64A	.011[b,c]	.144	.938	-.271	.294

Based on estimated marginal means
*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).
c. An estimate of the modified population marginal mean (J).
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

4. Washing Estimates: RMP

Dependent Variable: a

Washings	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1W 0A	27.211[a]	.454	26.320	28.103
1W 16A	28.248[a]	.321	27.617	28.878
2W 32A	27.374[a]	.321	26.743	28.004
3W 48A	26.531[a]	.321	25.901	27.161
4W 64A	27.234[a]	.321	26.604	27.865
5W 80A	27.695[a]	.321	27.064	28.325

a. Based on modified population marginal mean.

Pairwise Comparisons: RMP

Dependent Variable: a

(I) Washings		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	95% Confidence Interval for Difference[d] Upper Bound
1W 0A	1W 16A	-1.036[a,b]	.556	.063	-2.128	.055
	2W 32A	-.162[a,b]	.556	.770	-1.254	.929
	3W 48A	.680[a,b]	.556	.222	-.412	1.772
	4W 64A	-.023[a,b]	.556	.967	-1.115	1.069
	5W 80A	-.483[a,b]	.556	.385	-1.575	.608
1W 16A	1W 0A	1.036[a,b]	.556	.063	-.055	2.128
	2W 32A	.874[a,b]	.454	.055	-.018	1.765
	3W 48A	1.717[a,b,*]	.454	.000	.825	2.608
	4W 64A	1.013[a,b,*]	.454	.026	.122	1.905
	5W 80A	.553[a,b]	.454	.224	-.339	1.444
2W 32A	1W 0A	.162[a,b]	.556	.770	-.929	1.254
	1W 16A	-.874[a,b]	.454	.055	-1.765	.018
	3W 48A	.843[a,b]	.454	.064	-.049	1.734
	4W 64A	.139[a,b]	.454	.759	-.752	1.031
	5W 80A	-.321[a,b]	.454	.480	-1.212	.571
3W 48A	1W 0A	-.680[a,b]	.556	.222	-1.772	.412
	1W 16A	-1.717[a,b,*]	.454	.000	-2.608	-.825
	2W 32A	-.843[a,b]	.454	.064	-1.734	.049
	4W 64A	-.703[a,b]	.454	.122	-1.595	.188
	5W 80A	-1.164[a,b,*]	.454	.011	-2.055	-.272
4W 64A	1W 0A	.023[a,b]	.556	.967	-1.069	1.115
	1W 16A	-1.013[a,b,*]	.454	.026	-1.905	-.122
	2W 32A	-.139[a,b]	.454	.759	-1.031	.752
	3W 48A	.703[a,b]	.454	.122	-.188	1.595
	5W 80A	-.460[a,b]	.454	.311	-1.352	.431
5W 80A	1W 0A	.483[a,b]	.556	.385	-.608	1.575
	1W 16A	-.553[a,b]	.454	.224	-1.444	.339
	2W 32A	.321[a,b]	.454	.480	-.571	1.212
	3W 48A	1.164[a,b,*]	.454	.011	.272	2.055
	4W 64A	.460[a,b]	.454	.311	-.431	1.352

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Marked significant values were observed at all levels of interactions for sample PMP at 0W 0A. However, for sample RMP, the most significant results were observed at 4W 64A.

7. Bleached * Washings: PMP

Dependent Variable: a

Bleached		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
w/ bleach	1W 0A	6.120[a]	.204	5.720	6.520
	1W 16A	6.502[a]	.144	6.219	6.785
	2W 32A	6.727[a]	.144	6.444	7.010
	3W 48A	6.637[a]	.144	6.354	6.920
	4W 64A	6.110[a]	.144	5.827	6.393
	5W 80A	6.556[a]	.144	6.274	6.839
w/o bleach	1W 0A	7.698[a]	.204	7.298	8.098
	1W 16A	6.121[a]	.144	5.838	6.404
	2W 32A	5.866[a]	.144	5.583	6.149
	3W 48A	6.229[a]	.144	5.946	6.511
	4W 64A	6.522[a]	.144	6.239	6.805
	5W 80A	6.098[a]	.144	5.815	6.381

a. Based on modified population marginal mean.

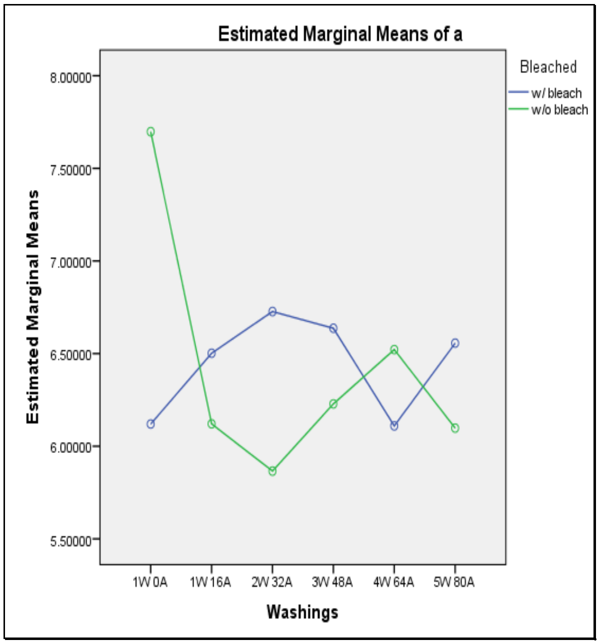
7. Bleached * Washings: RMP

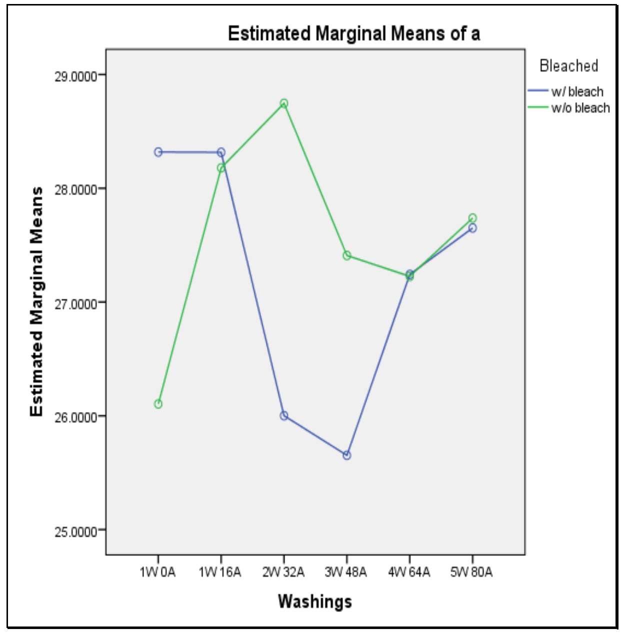
Dependent Variable: a

Bleached		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
w/ bleach	1W 0A	28.319[a]	.642	27.058	29.579
	1W 16A	28.316[a]	.454	27.424	29.207
	2W 32A	26.001[a]	.454	25.109	26.892
	3W 48A	25.653[a]	.454	24.761	26.544
	4W 64A	27.243[a]	.454	26.351	28.134
	5W 80A	27.651[a]	.454	26.760	28.543
w/o bleach	1W 0A	26.104[a]	.642	24.843	27.365
	1W 16A	28.179[a]	.454	27.288	29.071
	2W 32A	28.747[a]	.454	27.855	29.638
	3W 48A	27.409[a]	.454	26.518	28.301
	4W 64A	27.226[a]	.454	26.334	28.117
	5W 80A	27.738[a]	.454	26.847	28.630

a. Based on modified population marginal mean.

The plots below represent PMP and RMP from left to right, respectively. No consistent patterns are observed between these two samples at this level of interaction. Evident difference in means can be estimated at 1W 0A, 2W 32 and 3W 48 for both samples.





8. Swatch * Washings: PMP

Dependent Variable: a

Swatch		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1 w/ bleach	1W 0A	5.449[a]	.288	4.883	6.014
	1W 16A	6.386[a]	.204	5.986	6.786
	2W 32A	7.438[a]	.204	7.038	7.838
	3W 48A	6.697[a]	.204	6.297	7.097
	4W 64A	5.702[a]	.204	5.302	6.102
	5W 80A	6.906[a]	.204	6.506	7.306
2 w/ bleach	1W 0A	6.791[a]	.288	6.225	7.356
	1W 16A	6.618[a]	.204	6.218	7.018
	2W 32A	6.016[a]	.204	5.617	6.416
	3W 48A	6.577[a]	.204	6.177	6.977
	4W 64A	6.517[a]	.204	6.117	6.917
	5W 80A	6.207[a]	.204	5.807	6.607
3 w/o bleach	1W 0A	7.510[a]	.288	6.945	8.076
	1W 16A	5.828[a]	.204	5.428	6.228
	2W 32A	6.067[a]	.204	5.667	6.467
	3W 48A	6.843[a]	.204	6.443	7.243
	4W 64A	6.040[a]	.204	5.640	6.440
	5W 80A	6.364[a]	.204	5.964	6.764
4 w/o bleach	1W 0A	7.886[a]	.288	7.320	8.451
	1W 16A	6.414[a]	.204	6.014	6.814
	2W 32A	5.665[a]	.204	5.265	6.065
	3W 48A	5.614[a]	.204	5.215	6.014
	4W 64A	7.004[a]	.204	6.604	7.404
	5W 80A	5.832[a]	.204	5.432	6.231

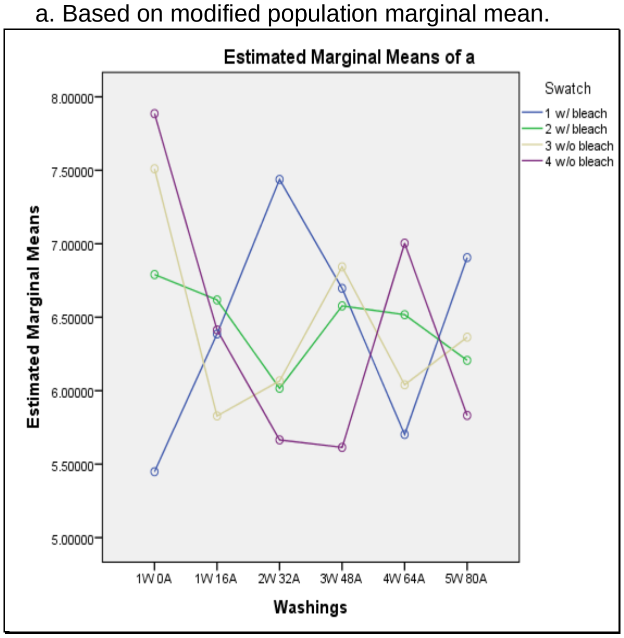
a. Based on modified population marginal mean.

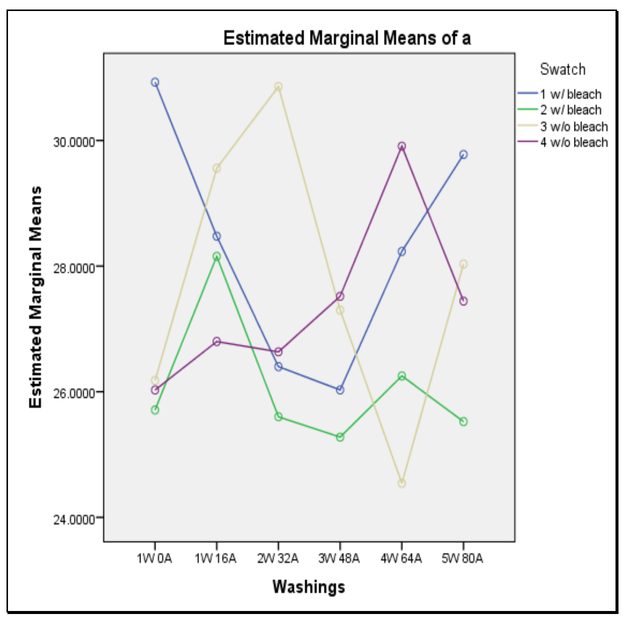
8. Swatch * Washings: RMP

Dependent Variable: a

Swatch		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	1W 0A	30.928[a]	.908	29.145	32.711
	1W 16A	28.476[a]	.642	27.215	29.737
	2W 32A	26.400[a]	.642	25.139	27.661
	3W 48A	26.028[a]	.642	24.768	27.289
	4W 64A	28.234[a]	.642	26.973	29.495
	5W 80A	29.778[a]	.642	28.517	31.039
2 w/ bleach	1W 0A	25.710[a]	.908	23.927	27.493
	1W 16A	28.156[a]	.642	26.895	29.416
	2W 32A	25.602[a]	.642	24.341	26.862
	3W 48A	25.277[a]	.642	24.016	26.538
	4W 64A	26.252[a]	.642	24.991	27.513
	5W 80A	25.524[a]	.642	24.263	26.785
3 w/o bleach	1W 0A	26.180[a]	.908	24.397	27.963
	1W 16A	29.559[a]	.642	28.298	30.820
	2W 32A	30.858[a]	.642	29.598	32.119
	3W 48A	27.299[a]	.642	26.038	28.560
	4W 64A	24.543[a]	.642	23.282	25.803
	5W 80A	28.034[a]	.642	26.773	29.294
4 w/o bleach	1W 0A	26.028[a]	.908	24.245	27.811
	1W 16A	26.800[a]	.642	25.539	28.060
	2W 32A	26.635[a]	.642	25.374	27.896
	3W 48A	27.519[a]	.642	26.259	28.780
	4W 64A	29.909[a]	.642	28.648	31.170
	5W 80A	27.443[a]	.642	26.182	28.704

a. Based on modified population marginal mean.





It is clear that the patterns for these two reference samples PMP (l), RMP (r) are not consistent.

In both samples, the patterns of each swatch deviate through the progression of the cycles.

Variable 'b'

Tests of Between-Subjects Effects: PMP

Dependent Variable: b

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2434.4[a]	43	56.614	8.042	.000
Intercept	63800	1	63800	9062.2	0.000
SampleArea	3.905	1	3.905	.555	.457
Swatch	123.60	2	61.804	8.779	.000
Bleached	0.000	0			
Washings	498.64	5	99.728	14.166	.000
SampleArea * Swatch	7.230	2	3.615	.513	.599
SampleArea * Bleached	0.000	0			
SampleArea * Washings	314.55	4	78.637	11.170	.000
Swatch * Bleached	0.000	0			
Swatch * Washings	597.81	8	74.726	10.614	.000
Bleached * Washings	0.000	0			
SampleArea * Swatch * Bleached	0.000	0			
SampleArea * Swatch * Washings	449.98	8	56.248	7.990	.000
SampleArea * Bleached * Washings	0.000	0			
Swatch * Bleached * Washings	0.000	0			
SampleArea * Swatch * Bleached * Washings	0.000	0			
Error	5885.5	836	7.040		
Total	75326	880			
Corrected Total	8320.0	879			

a. R Squared = .293 (Adjusted R Squared = .256)

b. Computed using alpha = .05

Tests of Between-Subjects Effects: RMP

Dependent Variable: b

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3074.21[a]	43	71.493	6.198	.000
Intercept	203556	1	203556	17648	0.000
SampleArea	17.281	1	17.281	1.498	.221
Swatch	106.82	2	53.409	4.631	.010
Bleached	0.000	0			
Washings	128.04	5	25.607	2.220	.050
SampleArea * Swatch	271.89	2	135.944	11.786	.000
SampleArea * Bleached	0.000	0			
SampleArea * Washings	435.65	4	108.913	9.443	.000
Swatch * Bleached	0.000	0			
Swatch * Washings	495.07	8	61.883	5.365	.000
Bleached * Washings	0.000	0			
SampleArea * Swatch * Bleached	0.000	0			
SampleArea * Swatch * Washings	471.37	8	58.922	5.108	.000
SampleArea * Bleached * Washings	0.000	0			
Swatch * Bleached * Washings	0.000	0			
SampleArea * Swatch * Bleached * Washings	0.000	0			
Error	9642.5	836	11.534		
Total	230906	880			
Corrected Total	12717	879			

a. R Squared = .242 (Adjusted R Squared = .203)

b. Computed using alpha = .05

The main effects of sample area were observed as insignificant between both the reference samples. The main effect for washing was also observed insignificant for sample RMP. In addition, Sample Area* Swatch interaction was also observed to be insignificant at sample PMP.

2. Swatch Estimates: RMP

Dependent Variable: b

Swatch	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1 w/ bleach	15.993[a]	.229	15.544	16.443
2 w/ bleach	14.658[a]	.229	14.208	15.107
3 w/o bleach	16.208[a]	.229	15.759	16.658
4 w/o bleach	16.125[a]	.229	15.676	16.575

a. Based on modified population marginal mean.

Pairwise Comparisons: RMP

Dependent Variable: b

(I) Swatch		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach	1.335[*,b,c]	.324	.000	.700	1.971
	3 w/o bleach	-.215[b,c]	.324	.507	-.851	.420
	4 w/o bleach	-.132[b,c]	.324	.684	-.767	.504
2 w/ bleach	1 w/ bleach	-1.335[*,b,c]	.324	.000	-1.971	-.700
	3 w/o bleach	-1.551[*,b,c]	.324	.000	-2.186	-.915
	4 w/o bleach	-1.467[*,b,c]	.324	.000	-2.103	-.832
3 w/o bleach	1 w/ bleach	.215[b,c]	.324	.507	-.420	.851
	2 w/ bleach	1.551[*,b,c]	.324	.000	.915	2.186
	4 w/o bleach	.083[b,c]	.324	.797	-.552	.719
4 w/o bleach	1 w/ bleach	.132[b,c]	.324	.684	-.504	.767
	2 w/ bleach	1.467[*,b,c]	.324	.000	.832	2.103
	3 w/o bleach	-.083[b,c]	.324	.797	-.719	.552

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

A significant main effect of swatch was only observed at sample RMP. Only at swatch 2 was significant values observed; at all other levels of interactions, no significant mean difference was observed.

4. Washing Estimates: PMP

Dependent Variable: b

Washings	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1W 0A	-9.522[a]	.297	-10.105	-8.940
1W 16A	-8.504[a]	.210	-8.916	-8.092
2W 32A	-8.371[a]	.210	-8.783	-7.959
3W 48A	-9.556[a]	.210	-9.967	-9.144
4W 64A	-9.317[a]	.210	-9.729	-8.906
5W 80A	-7.484[a]	.210	-7.896	-7.072

a. Based on modified population marginal mean.

Pairwise Comparisons: PMP

Dependent Variable: b

(I) Washings		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
1W 0A	1W 16A	-1.018[*,b,c]	.363	.005	-1.731	-.305
	2W 32A	-1.151[*,b,c]	.363	.002	-1.865	-.438
	3W 48A	.033[b,c]	.363	.927	-.680	.747
	4W 64A	-.205[b,c]	.363	.573	-.918	.508
	5W 80A	-2.038[*,b,c]	.363	.000	-2.751	-1.325
1W 16A	1W 0A	1.018[*,b,c]	.363	.005	.305	1.731
	2W 32A	-.133[b,c]	.297	.654	-.715	.449
	3W 48A	1.052[*,b,c]	.297	.000	.469	1.634
	4W 64A	.813[*,b,c]	.297	.006	.231	1.396
	5W 80A	-1.020[*,b,c]	.297	.001	-1.602	-.438
2W 32A	1W 0A	1.151[*,b,c]	.363	.002	.438	1.865
	1W 16A	.133[b,c]	.297	.654	-.449	.715
	3W 48A	1.185[*,b,c]	.297	.000	.603	1.767
	4W 64A	.946[*,b,c]	.297	.001	.364	1.529
	5W 80A	-.887[*,b,c]	.297	.003	-1.469	-.304
3W 48A	1W 0A	-.033[b,c]	.363	.927	-.747	.680
	1W 16A	-1.052[*,b,c]	.297	.000	-1.634	-.469
	2W 32A	-1.185[*,b,c]	.297	.000	-1.767	-.603
	4W 64A	-.238[b,c]	.297	.422	-.821	.344
	5W 80A	-2.071[*,b,c]	.297	.000	-2.654	-1.489
4W 64A	1W 0A	.205[b,c]	.363	.573	-.508	.918
	1W 16A	-.813[*,b,c]	.297	.006	-1.396	-.231
	2W 32A	-.946[*,b,c]	.297	.001	-1.529	-.364
	3W 48A	.238[b,c]	.297	.422	-.344	.821
	5W 80A	-1.833[*,b,c]	.297	.000	-2.415	-1.251
5W 80A	1W 0A	2.038[*,b,c]	.363	.000	1.325	2.751
	1W 16A	1.020[*,b,c]	.297	.001	.438	1.602
	2W 32A	.887[*,b,c]	.297	.003	.304	1.469
	3W 48A	2.071[*,b,c]	.297	.000	1.489	2.654
	4W 64A	1.833[*,b,c]	.297	.000	1.251	2.415

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

4. Washing Estimates: RMP

Dependent Variable: b

Washings	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1W 0A	16.132[a]	.380	15.387	16.878
1W 16A	16.218[a]	.268	15.691	16.745
2W 32A	15.737[a]	.268	15.210	16.264
3W 48A	15.093[a]	.268	14.566	15.620
4W 64A	15.466[a]	.268	14.939	15.993
5W 80A	16.023[a]	.268	15.496	16.550

a. Based on modified population marginal mean.

Pairwise Comparisons: RMP

Dependent Variable: b

(I) Washings		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
1W 0A	1W 16A	-.086[a,b]	.465	.854	-.999	.827
	2W 32A	.395[a,b]	.465	.396	-.518	1.308
	3W 48A	1.040[a,b,*]	.465	.026	.127	1.952
	4W 64A	.666[a,b]	.465	.153	-.247	1.579
	5W 80A	.110[a,b]	.465	.814	-.803	1.023
1W 16A	1W 0A	.086[a,b]	.465	.854	-.827	.999
	2W 32A	.481[a,b]	.380	.206	-.264	1.226
	3W 48A	1.125[a,b,*]	.380	.003	.380	1.871
	4W 64A	.752[a,b,*]	.380	.048	.007	1.497
	5W 80A	.196[a,b]	.380	.607	-.550	.941
2W 32A	1W 0A	-.395[a,b]	.465	.396	-1.308	.518
	1W 16A	-.481[a,b]	.380	.206	-1.226	.264
	3W 48A	.645[a,b]	.380	.090	-.101	1.390
	4W 64A	.271[a,b]	.380	.476	-.474	1.016
	5W 80A	-.285[a,b]	.380	.453	-1.031	.460
3W 48A	1W 0A	-1.040[a,b,*]	.465	.026	-1.952	-.127
	1W 16A	-1.125[a,b,*]	.380	.003	-1.871	-.380
	2W 32A	-.645[a,b]	.380	.090	-1.390	.101
	4W 64A	-.374[a,b]	.380	.325	-1.119	.372
	5W 80A	-.930[a,b,*]	.380	.015	-1.675	-.185
4W 64A	1W 0A	-.666[a,b]	.465	.153	-1.579	.247
	1W 16A	-.752[a,b,*]	.380	.048	-1.497	-.007
	2W 32A	-.271[a,b]	.380	.476	-1.016	.474
	3W 48A	.374[a,b]	.380	.325	-.372	1.119
	5W 80A	-.556[a,b]	.380	.143	-1.302	.189
5W 80A	1W 0A	-.110[a,b]	.465	.814	-1.023	.803
	1W 16A	-.196[a,b]	.380	.607	-.941	.550
	2W 32A	.285[a,b]	.380	.453	-.460	1.031
	3W 48A	.930[a,b,*]	.380	.015	.185	1.675
	4W 64A	.556[a,b]	.380	.143	-.189	1.302

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

A greater amount of marked significant differences was observed in sample PMP, whereas only a few significant values were observed for sample RMP. In fact, for sample PMP, all the groups observed significant results but not at all pair-wise groups. In contrast, no significant mean differences were observed at 2W 32A for sample RMP.

7. Bleached * Washings: PMP

Dependent Variable: b

Bleached		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
w/ bleach	1W 0A	-8.696[a]	.420	-9.519	-7.872
	1W 16A	-8.451[a]	.297	-9.033	-7.869
	2W 32A	-8.533[a]	.297	-9.116	-7.951
	3W 48A	-9.371[a]	.297	-9.953	-8.788
	4W 64A	-9.098[a]	.297	-9.680	-8.515
	5W 80A	-7.463[a]	.297	-8.045	-6.880
w/o bleach	1W 0A	-10.349[a]	.420	-11.172	-9.525
	1W 16A	-8.557[a]	.297	-9.139	-7.975
	2W 32A	-8.208[a]	.297	-8.791	-7.626
	3W 48A	-9.741[a]	.297	-10.323	-9.158
	4W 64A	-9.537[a]	.297	-10.119	-8.955
	5W 80A	-7.506[a]	.297	-8.088	-6.923

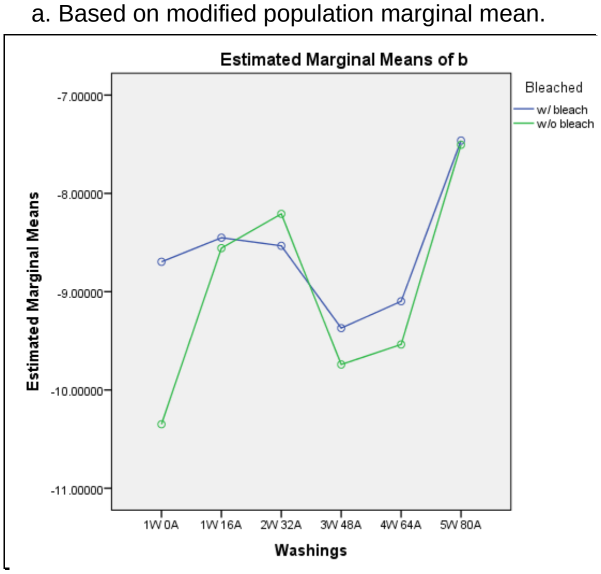
a. Based on modified population marginal mean.

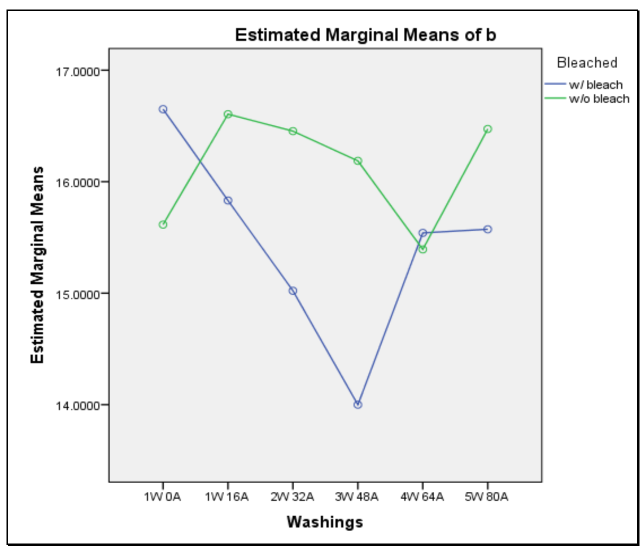
7. Bleached * Washings: RMP

Dependent Variable: b

Bleached		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
w/ bleach	1W 0A	16.650[a]	.537	15.596	17.704
	1W 16A	15.831[a]	.380	15.086	16.576
	2W 32A	15.022[a]	.380	14.276	15.767
	3W 48A	13.999[a]	.380	13.254	14.745
	4W 64A	15.541[a]	.380	14.796	16.286
	5W 80A	15.573[a]	.380	14.828	16.318
w/o bleach	1W 0A	15.615[a]	.537	14.561	16.669
	1W 16A	16.605[a]	.380	15.860	17.351
	2W 32A	16.453[a]	.380	15.708	17.198
	3W 48A	16.186[a]	.380	15.441	16.932
	4W 64A	15.392[a]	.380	14.647	16.137
	5W 80A	16.473[a]	.380	15.727	17.218

a. Based on modified population marginal mean.





The plots above represent PMP and RMP from left to right, respectively. Overall, this interaction diagram shows a similar pattern for reference sample PMP. Apart from the untreated sample at 1W 0A, the remaining pattern between the bleached and unbleached samples was consistent. It can also be observed that at 5W 80A, the mean values increases for both samples.

Based on the swatch * washing interaction below, swatches 3 and 4 observed similar patterns between both reference samples.

8. Swatch * Washings: PMP

Dependent Variable: b

Swatch		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
1 w/ bleach	1W 0A	-7.110[a]	.593	-8.274	-5.945
	1W 16A	-8.476[a]	.420	-9.300	-7.653
	2W 32A	-10.544[a]	.420	-11.367	-9.720
	3W 48A	-8.939[a]	.420	-9.762	-8.115
	4W 64A	-7.589[a]	.420	-8.412	-6.765
	5W 80A	-6.987[a]	.420	-7.811	-6.164
2 w/ bleach	1W 0A	-10.282[a]	.593	-11.447	-9.118
	1W 16A	-8.425[a]	.420	-9.249	-7.602
	2W 32A	-6.523[a]	.420	-7.346	-5.699
	3W 48A	-9.802[a]	.420	-10.626	-8.979
	4W 64A	-10.606[a]	.420	-11.430	-9.783
	5W 80A	-7.938[a]	.420	-8.762	-7.115
3 w/o bleach	1W 0A	-11.383[a]	.593	-12.548	-10.219
	1W 16A	-7.906[a]	.420	-8.729	-7.082
	2W 32A	-7.283[a]	.420	-8.106	-6.459
	3W 48A	-9.730[a]	.420	-10.554	-8.907
	4W 64A	-9.357[a]	.420	-10.181	-8.534
	5W 80A	-6.519[a]	.420	-7.343	-5.696
4 w/o bleach	1W 0A	-9.314[a]	.593	-10.478	-8.149
	1W 16A	-9.208[a]	.420	-10.031	-8.384
	2W 32A	-9.134[a]	.420	-9.958	-8.311
	3W 48A	-9.751[a]	.420	-10.575	-8.928
	4W 64A	-9.717[a]	.420	-10.540	-8.893
	5W 80A	-8.492[a]	.420	-9.315	-7.668

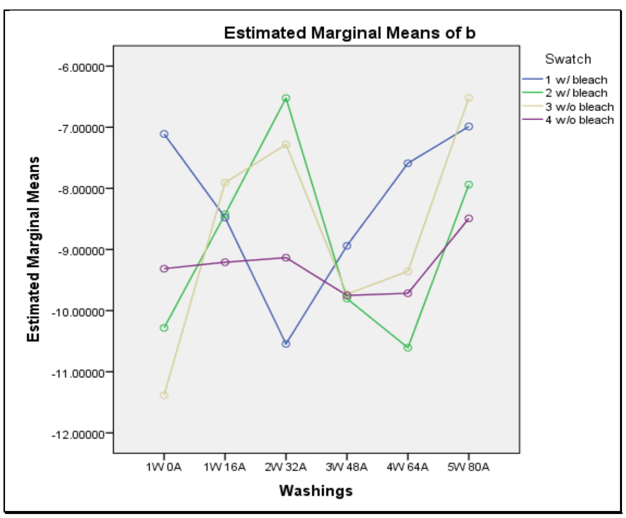
a. Based on modified population marginal mean.

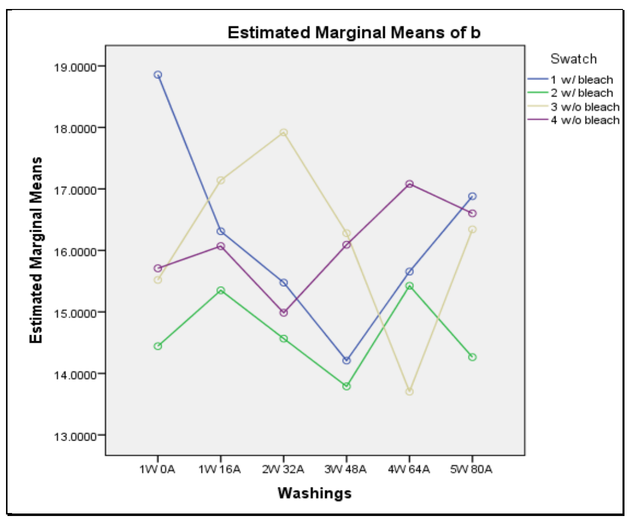
8. Swatch * Washings: RMP

Dependent Variable: b

Swatch		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	1W 0A	18.857[a]	.759	17.367	20.348
	1W 16A	16.311[a]	.537	15.257	17.365
	2W 32A	15.477[a]	.537	14.423	16.531
	3W 48A	14.209[a]	.537	13.155	15.263
	4W 64A	15.656[a]	.537	14.602	16.710
	5W 80A	16.882[a]	.537	15.828	17.936
2 w/ bleach	1W 0A	14.443[a]	.759	12.952	15.933
	1W 16A	15.351[a]	.537	14.297	16.405
	2W 32A	14.566[a]	.537	13.512	15.620
	3W 48A	13.790[a]	.537	12.736	14.844
	4W 64A	15.426[a]	.537	14.372	16.480
	5W 80A	14.264[a]	.537	13.210	15.318
3 w/o bleach	1W 0A	15.521[a]	.759	14.030	17.011
	1W 16A	17.141[a]	.537	16.087	18.195
	2W 32A	17.920[a]	.537	16.866	18.974
	3W 48A	16.280[a]	.537	15.226	17.334
	4W 64A	13.703[a]	.537	12.649	14.757
	5W 80A	16.342[a]	.537	15.288	17.396
4 w/o bleach	1W 0A	15.709[a]	.759	14.219	17.200
	1W 16A	16.070[a]	.537	15.016	17.124
	2W 32A	14.987[a]	.537	13.933	16.041
	3W 48A	16.093[a]	.537	15.039	17.147
	4W 64A	17.081[a]	.537	16.027	18.135
	5W 80A	16.603[a]	.537	15.549	17.657

a. Based on modified population marginal mean.





VII. Comparison of colors

To discriminate between colors, color was chosen as an independent factor. The results of this multifactorial analysis will be discussed by dependent variables. For the interaction effects, only the interactions involving color as a factor were examined below. The Between-Subject Factors table is located in **section** of the appendix.

Variable- L

Tests of Between-Subjects Effects: all colors

Dependent Variable: L

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	175509.408[a]	307	571.692	45.541	.000
Intercept	46512345	1	46512345.399	3705160.713	.000
Swatch	92.3	2	46.138	3.675	.025
SampleArea	43.9	1	43.935	3.500	.061
Bleached	0.0	0	.	.	.
Washing	1046.0	5	209.196	16.664	.000
Color	129614.6	6	21602.425	1720.843	.000
Swatch * SampleArea	8.8	2	4.410	.351	.704
Swatch * Bleached	0.0	0	.	.	.
Swatch * Washing	519.4	8	64.919	5.171	.000
Swatch * Color	1124.9	12	93.742	7.467	.000
SampleArea * Bleached	0.0	0	.	.	.
SampleArea * Washing	182.9	4	45.735	3.643	.006
SampleArea * Color	328.6	6	54.774	4.363	.000
Bleached * Washing	0.0	0	.	.	.
Bleached * Color	0.0	0	.	.	.
Washing * Color	8562.2	30	285.407	22.735	.000
Swatch * SampleArea * Bleached	0.0	0	.	.	.
Swatch * SampleArea * Washing	1296.8	8	162.098	12.913	.000
Swatch * SampleArea * Color	1564.9	12	130.407	10.388	.000
Swatch * Bleached * Washing	0.0	0	.	.	.
Swatch * Bleached * Color	0.0	0	.	.	.
Swatch * Washing * Color	4761.0	48	99.188	7.901	.000
SampleArea * Bleached * Washing	0.0	0	.	.	.
SampleArea * Bleached * Color	0.0	0	.	.	.
SampleArea * Washing * Color	1848.4	24	77.018	6.135	.000
Bleached * Washing * Color	0.0	0	.	.	.
Swatch * SampleArea * Bleached * Washing	0.0	0	.	.	.
Swatch * SampleArea * Bleached * Color	0.0	0	.	.	.
Swatch * SampleArea * Washing * Color	5605.1	48	116.772	9.302	.000
Swatch * Bleached * Washing * Color	0.0	0	.	.	.
SampleArea * Bleached * Washing * Color	0.0	0	.	.	.
Swatch * SampleArea * Bleached * Washing * Color	0.0	0	.	.	.
Error	73462.5	5852	12.553		
Total	49933424.0	6160			
Corrected Total	248971.9	6159			

a. R Squared = .705 (Adjusted R Squared = .689)

Based on the results, the main effects of sample area and the interaction effects of Swatch * Sample Area was not significant.

1. Sample Area Estimates: all colors

Dependent Variable: L

Sample Area	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	89.817[a]	.064	89.692	89.942
B	89.801[a]	.064	89.676	89.926

a. Based on modified population marginal mean.

Pairwise Comparisons: all colors

Dependent Variable: L

(I) Sample Area	(J) Sample Area	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
A	B	.016[a],b	.090	.859	-.161	.193
B	A	-.016[a],b	.090	.859	-.193	.161

Based on estimated marginal means
a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Based on the calculated p-values, the effects on the outcome was not dependent upon changes in the levels of the group.

2. Swatch Estimates: all colors

Dependent Variable: L

Swatch	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	90.172[a]	.090	89.995	90.349
2 w/ bleach	89.761[a]	.090	89.584	89.938
3 w/o bleach	89.855[a]	.090	89.678	90.032
4 w/o bleach	89.449[a]	.090	89.272	89.626

a. Based on modified population marginal mean.

Pairwise Comparisons: all colors

Dependent Variable: L

(I) Swatch	(J) Swatch	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
1 w/ bleach	2 w/ bleach	.411*,a,b	.128	.001	.161	.661
	3 w/o bleach	.317*,a,b	.128	.013	.066	.567
	4 w/o bleach	.723*,a,b	.128	.000	.473	.973
2 w/ bleach	1 w/ bleach	-.411*,a,b	.128	.001	-.661	-.161
	3 w/o bleach	-.094[a],b	.128	.460	-.345	.156
	4 w/o bleach	.312*,a,b	.128	.014	.062	.563
3 w/o bleach	1 w/ bleach	-.317*,a,b	.128	.013	-.567	-.066
	2 w/ bleach	.094[a],b	.128	.460	-.156	.345
	4 w/o bleach	.407*,a,b	.128	.001	.156	.657
4 w/o bleach	1 w/ bleach	-.723*,a,b	.128	.000	-.973	-.473
	2 w/ bleach	-.312*,a,b	.128	.014	-.563	-.062
	3 w/o bleach	-.407*,a,b	.128	.001	-.657	-.156

Based on estimated marginal means

*. The mean difference is significant at the .05 level.
a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Between the swatches significant values was observed for all pair-wise group except for swatch 2 and 3. This result is unpredicted as both swatches were washed using different detergents.

3. Bleach Estimates: all colors

Dependent Variable: L

Bleached	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
bleached	89.966[a]	.064	89.841	90.091
w/o bleached	89.652[a]	.064	89.527	89.777

a. Based on modified population marginal mean.

Pairwise Comparisons: all colors

Dependent Variable: L

(I) Bleached	(J) Bleached	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
bleached	w/o bleached	.314*,a,b	.090	.001	.137	.491
w/o bleached	bleached	-.314*,a,b	.090	.001	-.491	-.137

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The calculated p- values significant; the effect of the outcome of the ‘bleach’ level is dependent upon the effect of the ‘unbleached’ level.

For the main effect of washing below, significant values were observed for at least three pair-wise groups for each level of factors.

4. Washing Estimates: all color

Dependent Variable: L

Washing	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1W 0A	88.771[a]	.150	88.478	89.065
1W 16A	90.286[a]	.106	90.079	90.494
2W 32A	90.067[a]	.106	89.860	90.275
3W 48A	89.568[a]	.106	89.361	89.776
4W 64A	89.571[a]	.106	89.363	89.778
5W 80A	90.071[a]	.106	89.863	90.278

a. Based on modified population marginal mean.

Pairwise Comparisons: all colors

Dependent Variable: L

(I) Washing	(J) Washing	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	Upper Bound
1W 0A	1W 16A	-1.515*,a,b	.183	.000	-1.874	-1.155
	2W 32A	-1.296*,a,b	.183	.000	-1.655	-.937
	3W 48A	-.797*,a,b	.183	.000	-1.156	-.437
	4W 64A	-.799*,a,b	.183	.000	-1.159	-.440
	5W 80A	-1.299*,a,b	.183	.000	-1.659	-.940
1W 16A	1W 0A	1.515*,a,b	.183	.000	1.155	1.874
	2W 32A	.219a,b	.150	.144	-.075	.512
	3W 48A	.718*,a,b	.150	.000	.424	1.011
	4W 64A	.716*,a,b	.150	.000	.422	1.009
	5W 80A	.216a,b	.150	.150	-.078	.509
2W 32A	1W 0A	1.296*,a,b	.183	.000	.937	1.655
	1W 16A	-.219a,b	.150	.144	-.512	.075
	3W 48A	.499*,a,b	.150	.001	.206	.793
	4W 64A	.497*,a,b	.150	.001	.203	.790
	5W 80A	-.003a,b	.150	.982	-.297	.290
3W 48A	1W 0A	.797*,a,b	.183	.000	.437	1.156
	1W 16A	-.718*,a,b	.150	.000	-1.011	-.424
	2W 32A	-.499*,a,b	.150	.001	-.793	-.206
	4W 64A	-.002a,b	.150	.988	-.296	.291
	5W 80A	-.502*,a,b	.150	.001	-.796	-.209
4W 64A	1W 0A	.799*,a,b	.183	.000	.440	1.159
	1W 16A	-.716*,a,b	.150	.000	-1.009	-.422
	2W 32A	-.497*,a,b	.150	.001	-.790	-.203
	3W 48A	.002a,b	.150	.988	-.291	.296
	5W 80A	-.500*,a,b	.150	.001	-.794	-.207
5W 80A	1W 0A	1.299*,a,b	.183	.000	.940	1.659
	1W 16A	-.216a,b	.150	.150	-.509	.078
	2W 32A	.003a,b	.150	.982	-.290	.297
	3W 48A	.502*,a,b	.150	.001	.209	.796
	4W 64A	.500*,a,b	.150	.001	.207	.794

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

5. Color Estimates: all colors

Dependent Variable: L

Color	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Dk pink	85.586[a]	.119	85.352	85.821
Green	94.339[a]	.119	94.105	94.573
Orange	91.323[a]	.119	91.088	91.557
pink-C	94.716[a]	.119	94.482	94.950
Pink-J	94.675[a]	.119	94.441	94.909
Purple	83.724[a]	.119	83.490	83.958
Red	84.301[a]	.119	84.066	84.535

a. Based on modified population marginal mean.

Pairwise Comparisons: all colors

Dependent Variable: L

(I) Color	(J) Color	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	Upper Bound
Dk pink	Green	-8.752*,a,b	.169	.000	-9.084	-8.421
	Orange	-5.736*,a,b	.169	.000	-6.067	-5.405
	pink-C	-9.129*,a,b	.169	.000	-9.460	-8.798
	Pink-J	-9.089*,a,b	.169	.000	-9.420	-8.757
	Purple	1.863*,a,b	.169	.000	1.531	2.194
	Red	1.286*,a,b	.169	.000	.955	1.617
Green	dk pink	8.752*,a,b	.169	.000	8.421	9.084
	Orange	3.016*,a,b	.169	.000	2.685	3.347
	pink-C	-.377*,a,b	.169	.026	-.708	-.046
	Pink-J	-.336*,a,b	.169	.047	-.667	-.005
	Purple	10.615*,a,b	.169	.000	10.284	10.946
	Red	10.038*,a,b	.169	.000	9.707	10.369
Orange	dk pink	5.736*,a,b	.169	.000	5.405	6.067
	Green	-3.016*,a,b	.169	.000	-3.347	-2.685
	pink-C	-3.393*,a,b	.169	.000	-3.724	-3.062
	Pink-J	-3.352*,a,b	.169	.000	-3.684	-3.021
	Purple	7.599*,a,b	.169	.000	7.267	7.930
	Red	7.022*,a,b	.169	.000	6.691	7.353
pink-C	dk pink	9.129*,a,b	.169	.000	8.798	9.460
	Green	.377*,a,b	.169	.026	.046	.708
	Orange	3.393*,a,b	.169	.000	3.062	3.724
	Pink-J	.041a,b	.169	.810	-.290	.372
	Purple	10.992*,a,b	.169	.000	10.661	11.323
	Red	10.415*,a,b	.169	.000	10.084	10.746
Pink-J	dk pink	9.089*,a,b	.169	.000	8.757	9.420
	Green	.336*,a,b	.169	.047	.005	.667
	Orange	3.352*,a,b	.169	.000	3.021	3.684
	pink-C	-.041a,b	.169	.810	-.372	.290
	Purple	10.951*,a,b	.169	.000	10.620	11.282
	Red	10.374*,a,b	.169	.000	10.043	10.706
Purple	dk pink	-1.863*,a,b	.169	.000	-2.194	-1.531
	Green	-10.615*,a,b	.169	.000	-10.946	-10.284
	Orange	-7.599*,a,b	.169	.000	-7.930	-7.267
	pink-C	-10.992*,a,b	.169	.000	-11.323	-10.661
	Pink-J	-10.951*,a,b	.169	.000	-11.282	-10.620
	Red	-.577*,a,b	.169	.001	-.908	-.246
Red	dk pink	-1.286*,a,b	.169	.000	-1.617	-.955
	Green	-10.038*,a,b	.169	.000	-10.369	-9.707
	Orange	-7.022*,a,b	.169	.000	-7.353	-6.691
	pink-C	-10.415*,a,b	.169	.000	-10.746	-10.084
	Pink-J	-10.374*,a,b	.169	.000	-10.706	-10.043
	Purple	.577*,a,b	.169	.001	.246	.908

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

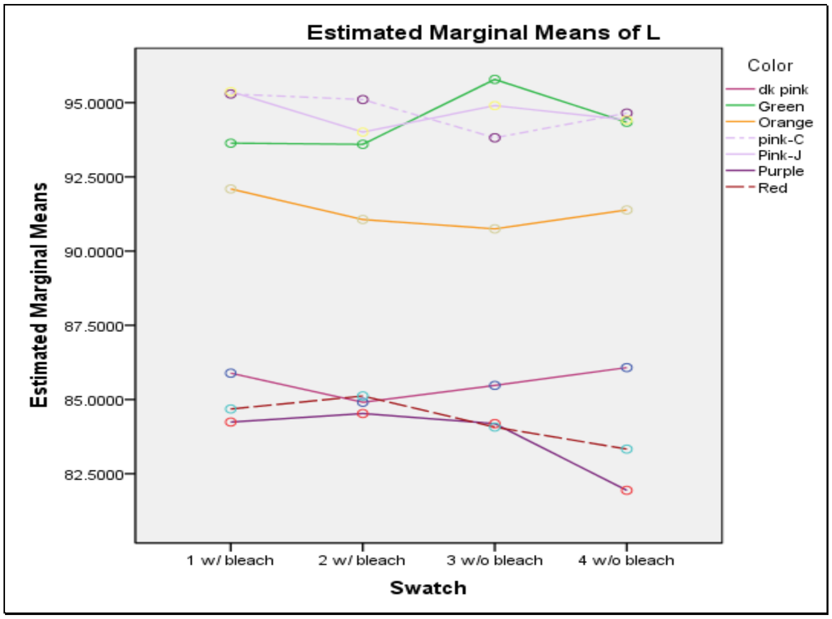
Dk pink, pink-C and pink- J refers to samples DPMP, PMCL and PMJX, respectively. Significant values were observed for all the colors except for one particular pair-wise comparing group, pink-C and pink-J or samples PMCL and PMJX. The actual mean values are relatively similar such that at this variable, these samples cannot be differentiated. The mean differences between each pair-wise group for the remaining samples are substantial. Purple observes the lowest mean value and GMP observes the highest mean value at variable 'L'.

6. Swatch * Color

Dependent Variable: L

Swatch	Color	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	dk pink	85.887[a]	.239	85.419	86.355
	Green	93.636[a]	.239	93.168	94.104
	Orange	92.093[a]	.239	91.625	92.562
	pink-C	95.292[a]	.239	94.824	95.760
	Pink-J	95.372[a]	.239	94.904	95.840
	Purple	84.240[a]	.239	83.771	84.708
	Red	84.681[a]	.239	84.213	85.150
2 w/ bleach	dk pink	84.908[a]	.239	84.440	85.376
	Green	93.596[a]	.239	93.128	94.065
	Orange	91.062[a]	.239	90.594	91.530
	pink-C	95.105[a]	.239	94.637	95.573
	Pink-J	94.008[a]	.239	93.540	94.476
	Purple	84.527[a]	.239	84.059	84.996
	Red	85.119[a]	.239	84.651	85.587
3 w/o bleach	dk pink	85.475[a]	.239	85.007	85.943
	Green	95.784[a]	.239	95.316	96.252
	Orange	90.749[a]	.239	90.281	91.217
	pink-C	93.817[a]	.239	93.349	94.285
	Pink-J	94.901[a]	.239	94.433	95.369
	Purple	84.188[a]	.239	83.720	84.656
	Red	84.071[a]	.239	83.603	84.540
4 w/o bleach	dk pink	86.076[a]	.239	85.607	86.544
	Green	94.339[a]	.239	93.871	94.808
	Orange	91.386[a]	.239	90.917	91.854
	pink-C	94.649[a]	.239	94.180	95.117
	Pink-J	94.419[a]	.239	93.951	94.888
	Purple	81.941[a]	.239	81.472	82.409
	Red	83.331[a]	.239	82.862	83.799

a. Based on modified population marginal mean.



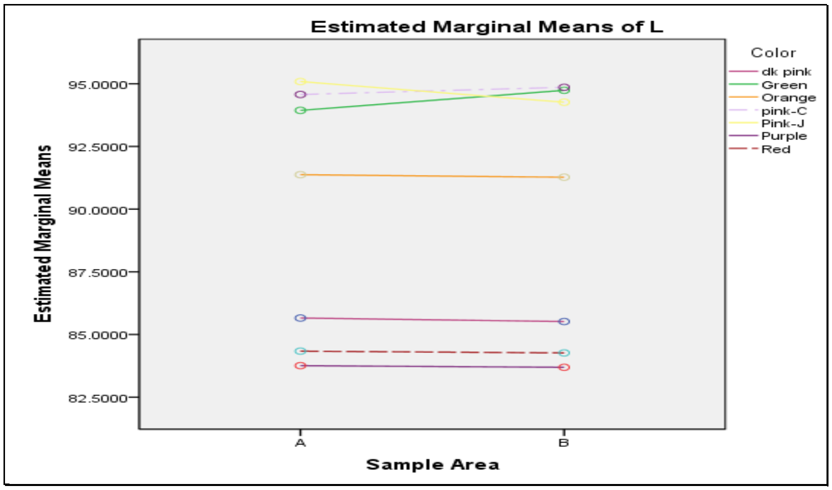
Based on the chart, DPMP, PMP and RMP are associated in one group; PMCL, PMJX and GMP are in the second group; with OSDP closely trailing the second group. Dark pink, purple and red are relatively close in hue and luminance so it is understandable that these colors would be grouped together. Although colors pink and green are on opposite ends of the CIELab space, since both are relatively light, they were also grouped together.

7. Sample Area * Color

Dependent Variable: L

Sample Area	Color	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	dk pink	85.656[a]	.169	85.325	85.987
	Green	93.939[a]	.169	93.608	94.270
	Orange	91.373[a]	.169	91.042	91.704
	pink-C	94.572[a]	.169	94.241	94.903
	Pink-J	95.087[a]	.169	94.756	95.418
	Purple	83.757[a]	.169	83.426	84.088
	Red	84.336[a]	.169	84.005	84.667
B	dk pink	85.517[a]	.169	85.186	85.848
	Green	94.739[a]	.169	94.408	95.070
	Orange	91.272[a]	.169	90.941	91.603
	pink-C	94.860[a]	.169	94.529	95.191
	Pink-J	94.263[a]	.169	93.932	94.594
	Purple	83.691[a]	.169	83.360	84.022
	Red	84.265[a]	.169	83.934	84.597

a. Based on modified population marginal mean.



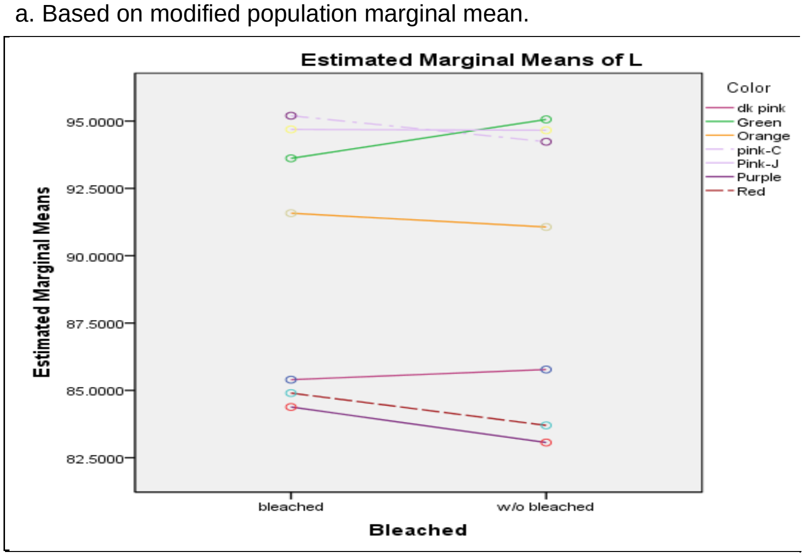
At a p- value at .704, this interaction is concluded as insignificant.

8. Bleached * Color

Dependent Variable: L

Bleached	Color	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
bleached	dk pink	85.398[a]	.169	85.066	85.729
	Green	93.616[a]	.169	93.285	93.947
	Orange	91.578[a]	.169	91.247	91.909
	pink-C	95.198[a]	.169	94.867	95.530
	Pink-J	94.690[a]	.169	94.359	95.021
	Purple	84.384[a]	.169	84.052	84.715
	Red	84.900[a]	.169	84.569	85.231
w/o bleached	dk pink	85.775[a]	.169	85.444	86.106
	Green	95.062[a]	.169	94.731	95.393
	Orange	91.067[a]	.169	90.736	91.398
	pink-C	94.233[a]	.169	93.902	94.564
	Pink-J	94.660[a]	.169	94.329	94.991
	Purple	83.064[a]	.169	82.733	83.395
	Red	83.701[a]	.169	83.370	84.032

a. Based on modified population marginal mean.



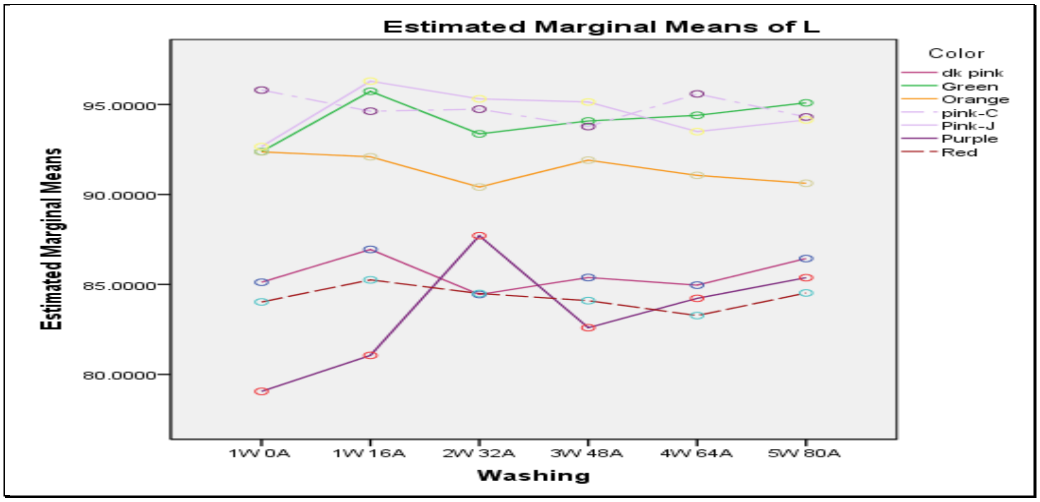
Five of the seven colors observed a decrease in mean value between the bleached and unbleached samples. A decrease in 'L' means that the samples were darker as they were washed without bleach than with bleach. This change in lightness was not evident macroscopically.

15. Washing * Color

Dependent Variable: L

Washing	Color	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1W 0A	dk pink	85.119[a]	.396	84.342	85.896
	Green	92.379[a]	.396	91.602	93.155
	Orange	92.366[a]	.396	91.589	93.142
	pink-C	95.802[a]	.396	95.025	96.579
	Pink-J	92.656[a]	.396	91.880	93.433
	Purple	79.053[a]	.396	78.276	79.829
	Red	84.026[a]	.396	83.249	84.803
1W 16A	dk pink	86.946[a]	.280	86.397	87.495
	Green	95.734[a]	.280	95.185	96.283
	Orange	92.093[a]	.280	91.544	92.642
	pink-C	94.625[a]	.280	94.076	95.174
	Pink-J	96.299[a]	.280	95.750	96.848
	Purple	81.055[a]	.280	80.506	81.604
	Red	85.253[a]	.280	84.704	85.802
2W 32A	dk pink	84.440[a]	.280	83.891	84.989
	Green	93.366[a]	.280	92.817	93.915
	Orange	90.411[a]	.280	89.862	90.960
	pink-C	94.739[a]	.280	94.190	95.288
	Pink-J	95.313[a]	.280	94.764	95.862
	Purple	87.708[a]	.280	87.159	88.257
	Red	84.496[a]	.280	83.947	85.045
3W 48A	dk pink	85.383[a]	.280	84.834	85.932
	Green	94.085[a]	.280	93.535	94.634
	Orange	91.907[a]	.280	91.358	92.456
	pink-C	93.773[a]	.280	93.224	94.323
	Pink-J	95.140[a]	.280	94.591	95.689
	Purple	82.592[a]	.280	82.043	83.141
	Red	84.099[a]	.280	83.550	84.648
4W 64A	dk pink	84.958[a]	.280	84.409	85.508
	Green	94.398[a]	.280	93.849	94.947
	Orange	91.060[a]	.280	90.511	91.609
	pink-C	95.591[a]	.280	95.042	96.140
	Pink-J	93.493[a]	.280	92.943	94.042
	Purple	84.226[a]	.280	83.677	84.775
	Red	83.269[a]	.280	82.720	83.818
5W 80A	dk pink	86.439[a]	.280	85.890	86.988
	Green	95.092[a]	.280	94.543	95.641
	Orange	90.621[a]	.280	90.072	91.170
	pink-C	94.307[a]	.280	93.758	94.856
	Pink-J	94.140[a]	.280	93.591	94.689
	Purple	85.374[a]	.280	84.825	85.923
	Red	84.524[a]	.280	83.975	85.073

a. Based on modified population marginal mean.



Colors red, dark pink, pink-C, orange, and green observe a similar pattern.

Variable 'a'

Tests of Between-Subjects Effects: all colors

Dependent Variable: a

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	659240[a]	307	2147.4	430.78	.000
Intercept	663104	1	663104	133026	.000
Swatch	133.42	2	66.708	13.382	.000
SampleArea	10.436	1	10.436	2.094	.148
Bleached	.000	0	.	.	.
Washing	106.72	5	21.345	4.282	.001
Color	605821	6	100970	20256	.000
Swatch * SampleArea	6.413	2	3.206	.643	.526
Swatch * Bleached	.000	0	.	.	.
Swatch * Washing	359.89	8	44.987	9.025	.000
Swatch * Color	544.73	12	45.394	9.107	.000
SampleArea * Bleached	.000	0	.	.	.
SampleArea * Washing	279.31	4	69.827	14.008	.000
SampleArea * Color	96.262	6	16.044	3.219	.004
Bleached * Washing	.000	0	.	.	.
Bleached * Color	.000	0	.	.	.
Washing * Color	771.44	30	25.715	5.159	.000
Swatch * SampleArea * Bleached	.000	0	.	.	.
Swatch * SampleArea * Washing	173.41	8	21.676	4.348	.000
Swatch * SampleArea * Color	698.10	12	58.175	11.671	.000
Swatch * Bleached * Washing	.000	0	.	.	.
Swatch * Bleached * Color	.000	0	.	.	.
Swatch * Washing * Color	2010.957	48	41.895	8.405	.000
SampleArea * Bleached * Washing	.000	0	.	.	.
SampleArea * Bleached * Color	.000	0	.	.	.
SampleArea * Washing * Color	1468.468	24	61.186	12.275	.000
Bleached * Washing * Color	.000	0	.	.	.
Swatch * SampleArea * Bleached * Washing	.000	0	.	.	.
Swatch * SampleArea * Bleached * Color	.000	0	.	.	.
Swatch * SampleArea * Washing * Color	1930.483	48	40.218	8.068	.000
Swatch * Bleached * Washing * Color	.000	0	.	.	.
SampleArea * Bleached * Washing * Color	.000	0	.	.	.
Swatch * SampleArea * Bleached * Washing * Color	.000	0	.	.	.
Error	29170.889	5852	4.985		
Total	1396541.012	6160			
Corrected Total	688410.481	6159			

a. R Squared = .958 (Adjusted R Squared = .955)

The main effects of the sample area and the interaction effects of Sample Area* Swatch were both deemed insignificant.

1. Sample Area Estimates: all colors

Dependent Variable: a

Sample Area	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A	10.787[a]	.040	10.708	10.866
B	10.656[a]	.040	10.578	10.735

a. Based on modified population marginal mean.

Pairwise Comparisons: all colors

Dependent Variable: a

(I) Sample Area	(J) Sample Area	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
A	B	.131*,a,b	.057	.022	.019	.242
B	A	-.131*,a,b	.057	.022	-.242	-.019

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The interactions between these two sample areas are significant. This means that the effect of the outcome on the change for either level depends on the effect of the change on the opposing level.

2. Swatch Estimates: all color

Dependent Variable: a

Swatch	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1 w/ bleach	10.948[a]	.057	10.836	11.059
2 w/ bleach	10.483[a]	.057	10.371	10.594
3 w/o bleach	10.747[a]	.057	10.635	10.858
4 w/o bleach	10.710[a]	.057	10.598	10.821

a. Based on modified population marginal mean.

Pairwise Comparisons: all color

Dependent Variable: a

(I) Swatch	(J) Swatch	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach	.465*, a,b	.080	.000	.307	.623
	3 w/o bleach	.201*, a,b	.080	.012	.043	.359
	4 w/o bleach	.238*, a,b	.080	.003	.080	.396
2 w/ bleach	1 w/ bleach	-.465*, a,b	.080	.000	-.623	-.307
	3 w/o bleach	-.264*, a,b	.080	.001	-.421	-.106
	4 w/o bleach	-.227*, a,b	.080	.005	-.385	-.069
3 w/o bleach	1 w/ bleach	-.201*, a,b	.080	.012	-.359	-.043
	2 w/ bleach	.264*, a,b	.080	.001	.106	.421
	4 w/o bleach	.037a, b	.080	.648	-.121	.195
4 w/o bleach	1 w/ bleach	-.238*, a,b	.080	.003	-.396	-.080
	2 w/ bleach	.227*, a,b	.080	.005	.069	.385
	3 w/o bleach	-.037a, b	.080	.648	-.195	.121

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Significant values were observed for the bleached samples. Swatch 1 and 2 was significant at all their pair-wise comparing groups. The pair-wise group for swatch 3 and 4 was not significant.

3. Bleach Estimates: all colors

Dependent Variable: a

Bleached	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
bleached	10.715[a]	.040	10.636	10.794
w/o bleached	10.728[a]	.040	10.649	10.807

a. Based on modified population marginal mean.

Pairwise Comparisons: all colors

Dependent Variable: a

(I) Bleached	(J) Bleached	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
bleached	w/o bleached	-.013[a],b	.057	.820	-.124	.099
w/o bleached	bleached	.013[a],b	.057	.820	-.099	.124

Based on estimated marginal means
a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The effects of the change in the bleached sample on the outcome do not depend on the change in the unbleached sample. This can also be interrupted inversely. In other words, while the effect of one of the factors changes, the other factor is fixed.

For the main effect of washing below, only at the treatment cycle of 1W 16A was significant values observed.

4. Washing Estimates: all color

Dependent Variable: a

Washing	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1W 0A	10.684[a]	.094	10.499	10.869
1W 16A	10.984[a]	.067	10.854	11.115
2W 32A	10.635[a]	.067	10.504	10.766
3W 48A	10.732[a]	.067	10.601	10.862
4W 64A	10.602[a]	.067	10.471	10.733
5W 80A	10.675[a]	.067	10.544	10.806

a. Based on modified population marginal mean.

Pairwise Comparisons: all color

Dependent Variable: a

(I) Washing	(J) Washing	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	Upper Bound
1W 0A	1W 16A	-.301*,a,b	.116	.009	-.527	-.074
	2W 32A	.049a,b	.116	.673	-.178	.275
	3W 48A	-.048a,b	.116	.677	-.275	.178
	4W 64A	.082a,b	.116	.480	-.145	.308
	5W 80A	.008a,b	.116	.942	-.218	.235
1W 16A	1W 0A	.301*,a,b	.116	.009	.074	.527
	2W 32A	.350*,a,b	.094	.000	.165	.535
	3W 48A	.253*,a,b	.094	.007	.068	.438
	4W 64A	.382*,a,b	.094	.000	.197	.567
	5W 80A	.309*,a,b	.094	.001	.124	.494
2W 32A	1W 0A	-.049a,b	.116	.673	-.275	.178
	1W 16A	-.350*,a,b	.094	.000	-.535	-.165
	3W 48A	-.097a,b	.094	.304	-.282	.088
	4W 64A	.033a,b	.094	.728	-.152	.218
	5W 80A	-.040a,b	.094	.669	-.225	.145
3W 48A	1W 0A	.048a,b	.116	.677	-.178	.275
	1W 16A	-.253*,a,b	.094	.007	-.438	-.068
	2W 32A	.097a,b	.094	.304	-.088	.282
	4W 64A	.130a,b	.094	.169	-.055	.315
	5W 80A	.057a,b	.094	.549	-.128	.242
4W 64A	1W 0A	-.082a,b	.116	.480	-.308	.145
	1W 16A	-.382*,a,b	.094	.000	-.567	-.197
	2W 32A	-.033a,b	.094	.728	-.218	.152
	3W 48A	-.130a,b	.094	.169	-.315	.055
	5W 80A	-.073a,b	.094	.438	-.258	.112
5W 80A	1W 0A	-.008a,b	.116	.942	-.235	.218
	1W 16A	-.309*,a,b	.094	.001	-.494	-.124
	2W 32A	.040a,b	.094	.669	-.145	.225
	3W 48A	-.057a,b	.094	.549	-.242	.128
	4W 64A	.073a,b	.094	.438	-.112	.258

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

5. Color Estimates: all colors

Dependent Variable: a

Color	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
dk pink	25.254[a]	.075	25.106	25.401
Green	.802[a]	.075	.655	.950
Orange	9.786[a]	.075	9.639	9.934
pink-C	2.771[a]	.075	2.623	2.919
Pink-J	2.653[a]	.075	2.505	2.801
Purple	6.389[a]	.075	6.241	6.536
Red	27.398[a]	.075	27.250	27.545

a. Based on modified population marginal mean.

Pairwise Comparisons: all colors

Dependent Variable: a

(I) Color	(J) Color	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
dk pink	Green	24.452*,a,b	.106	.000	24.243	24.660
	Orange	15.467*,a,b	.106	.000	15.259	15.676
	pink-C	22.483*,a,b	.106	.000	22.274	22.691
	Pink-J	22.601*,a,b	.106	.000	22.392	22.809
	Purple	18.865*,a,b	.106	.000	18.656	19.074
	Red	-2.144*,a,b	.106	.000	-2.353	-1.935
Green	dk pink	-24.452*,a,b	.106	.000	-24.660	-24.243
	Orange	-8.984*,a,b	.106	.000	-9.193	-8.775
	pink-C	-1.969*,a,b	.106	.000	-2.178	-1.760
	Pink-J	-1.851*,a,b	.106	.000	-2.060	-1.642
	Purple	-5.587*,a,b	.106	.000	-5.795	-5.378
	Red	-26.595*,a,b	.106	.000	-26.804	-26.387
Orange	dk pink	-15.467*,a,b	.106	.000	-15.676	-15.259
	Green	8.984*,a,b	.106	.000	8.775	9.193
	pink-C	7.015*,a,b	.106	.000	6.807	7.224
	Pink-J	7.133*,a,b	.106	.000	6.925	7.342
	Purple	3.397*,a,b	.106	.000	3.189	3.606
	Red	-17.611*,a,b	.106	.000	-17.820	-17.403
pink-C	dk pink	-22.483*,a,b	.106	.000	-22.691	-22.274
	Green	1.969*,a,b	.106	.000	1.760	2.178
	Orange	-7.015*,a,b	.106	.000	-7.224	-6.807
	Pink-J	.118[a],b	.106	.268	-.091	.327
	Purple	-3.618*,a,b	.106	.000	-3.826	-3.409
	Red	-24.627*,a,b	.106	.000	-24.835	-24.418
Pink-J	dk pink	-22.601*,a,b	.106	.000	-22.809	-22.392
	Green	1.851*,a,b	.106	.000	1.642	2.060
	Orange	-7.133*,a,b	.106	.000	-7.342	-6.925
	pink-C	-.118[a],b	.106	.268	-.327	.091
	Purple	-3.736*,a,b	.106	.000	-3.944	-3.527
	Red	-24.745*,a,b	.106	.000	-24.953	-24.536
Purple	dk pink	-18.865*,a,b	.106	.000	-19.074	-18.656
	Green	5.587*,a,b	.106	.000	5.378	5.795
	Orange	-3.397*,a,b	.106	.000	-3.606	-3.189
	pink-C	3.618*,a,b	.106	.000	3.409	3.826
	Pink-J	3.736*,a,b	.106	.000	3.527	3.944
	Red	-21.009*,a,b	.106	.000	-21.218	-20.800
Red	dk pink	2.144*,a,b	.106	.000	1.935	2.353
	Green	26.595*,a,b	.106	.000	26.387	26.804
	Orange	17.611*,a,b	.106	.000	17.403	17.820
	pink-C	24.627*,a,b	.106	.000	24.418	24.835
	Pink-J	24.745*,a,b	.106	.000	24.536	24.953
	Purple	21.009*,a,b	.106	.000	20.800	21.218

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Similar to variable 'L', sample PMCL and PMJX did not produce significant results. The values between the groups are approximately equal. In this red to green region, these two samples cannot be differentiated which suggests that their 'a' values are similar. Significant mean differences were observed for the remaining colors.

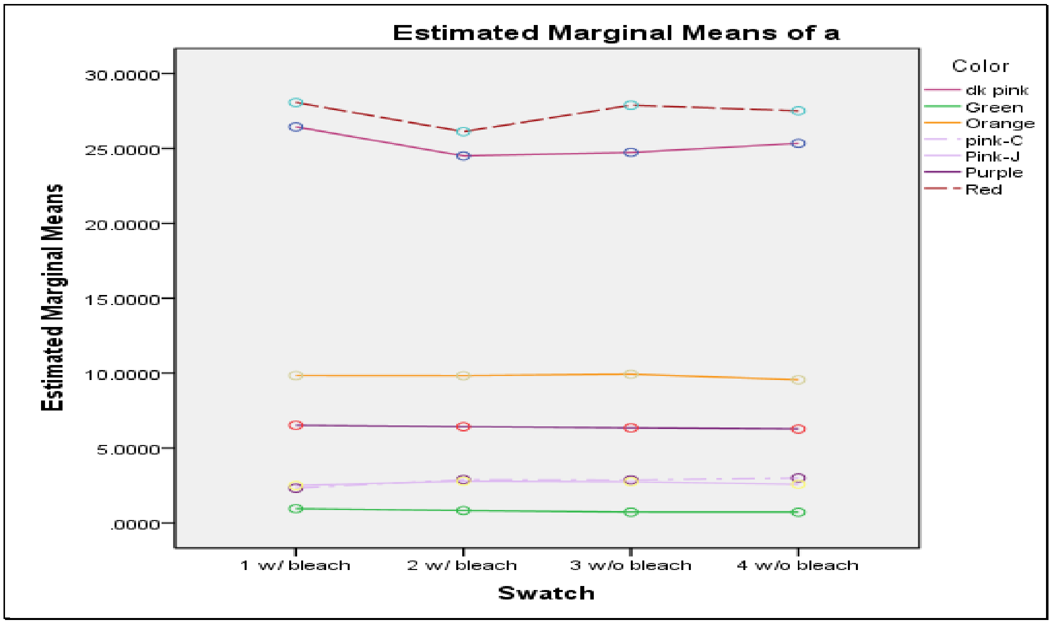
6. Swatch * Color: all colors

Dependent Variable: a

Swatch	Color	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1 w/ bleach	dk pink	26.438[a]	.151	26.143	26.733
	Green	.950[a]	.151	.654	1.245
	Orange	9.835[a]	.151	9.540	10.130
	pink-C	2.323[a]	.151	2.028	2.618
	Pink-J	2.500[a]	.151	2.205	2.795
	Purple	6.519[a]	.151	6.224	6.814
	Red	28.069[a]	.151	27.774	28.364
2 w/ bleach	dk pink	24.504[a]	.151	24.209	24.799
	Green	.826[a]	.151	.531	1.121
	Orange	9.827[a]	.151	9.531	10.122
	pink-C	2.892[a]	.151	2.597	3.187
	Pink-J	2.787[a]	.151	2.492	3.082
	Purple	6.424[a]	.151	6.129	6.719
	Red	26.121[a]	.151	25.826	26.416
3 w/o bleach	dk pink	24.733[a]	.151	24.438	25.028
	Green	.719[a]	.151	.424	1.014
	Orange	9.926[a]	.151	9.631	10.221
	pink-C	2.867[a]	.151	2.572	3.162
	Pink-J	2.749[a]	.151	2.454	3.044
	Purple	6.345[a]	.151	6.050	6.640
	Red	27.888[a]	.151	27.593	28.183
4 w/o bleach	dk pink	25.339[a]	.151	25.044	25.634
	Green	.714[a]	.151	.419	1.009
	Orange	9.557[a]	.151	9.262	9.852
	pink-C	3.002[a]	.151	2.707	3.297
	Pink-J	2.577[a]	.151	2.282	2.872
	Purple	6.267[a]	.151	5.972	6.563
	Red	27.513[a]	.151	27.217	27.808

a. Based on modified population marginal mean.

Based on the graph below, the mean values can be separated into two groups. The first group contains red and dark pink colors, and the second group contains the remaining colors. It can be observed that red and dark pink observes a consistent pattern and that between the bleached and unbleached samples, the 'a' values are affected. For the remaining colors, the mean values remain consistent among the swatches. At this level of interaction, samples PMJX and PMCL are indistinguishable. It can be concluded that the significant mean differences are observed between the two groups.

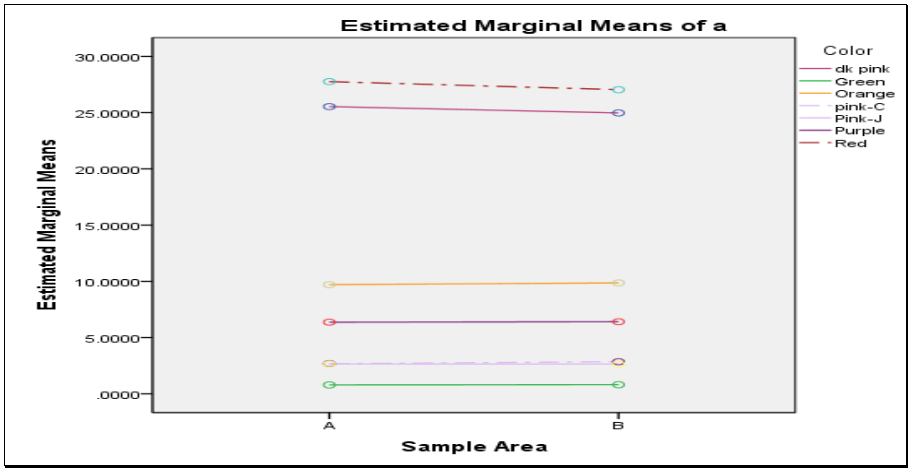


7. Sample Area * Color: all colors

Dependent Variable: a

Sample Area	Color	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	dk pink	25.538[a]	.106	25.330	25.747
	Green	.791[a]	.106	.583	1.000
	Orange	9.710[a]	.106	9.501	9.919
	pink-C	2.686[a]	.106	2.477	2.894
	Pink-J	2.656[a]	.106	2.448	2.865
	Purple	6.368[a]	.106	6.160	6.577
	Red	27.760[a]	.106	27.551	27.969
B	dk pink	24.969[a]	.106	24.760	25.178
	Green	.813[a]	.106	.604	1.022
	Orange	9.862[a]	.106	9.654	10.071
	pink-C	2.856[a]	.106	2.648	3.065
	Pink-J	2.650[a]	.106	2.441	2.859
	Purple	6.409[a]	.106	6.200	6.618
	Red	27.035[a]	.106	26.826	27.244

a. Based on modified population marginal mean.



The mean values observed to be consistent between the sample areas. It can then be concluded that the significant difference observed is due to the difference in mean values between the red and dark pink samples to the remaining samples.

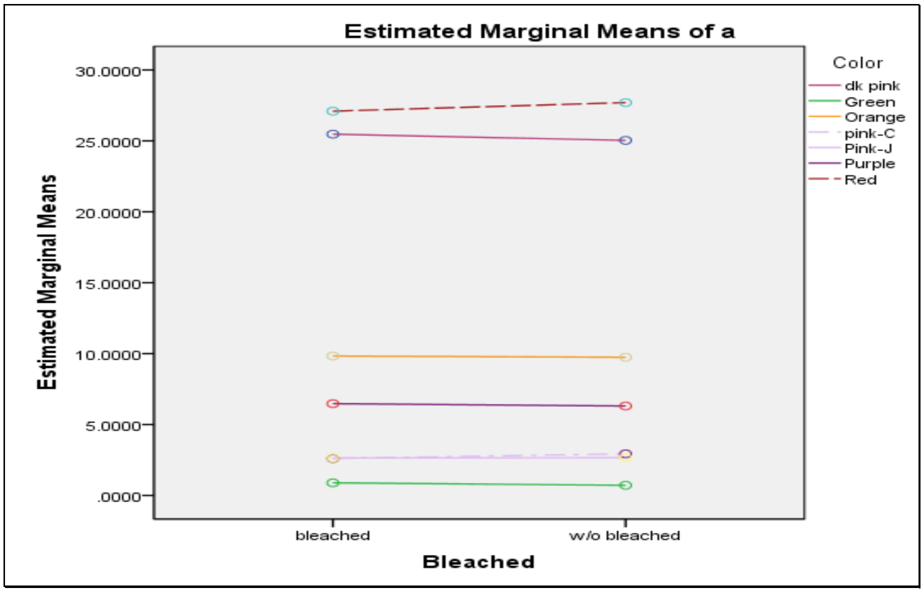
8. Bleached * Color: all colors

Dependent Variable: a

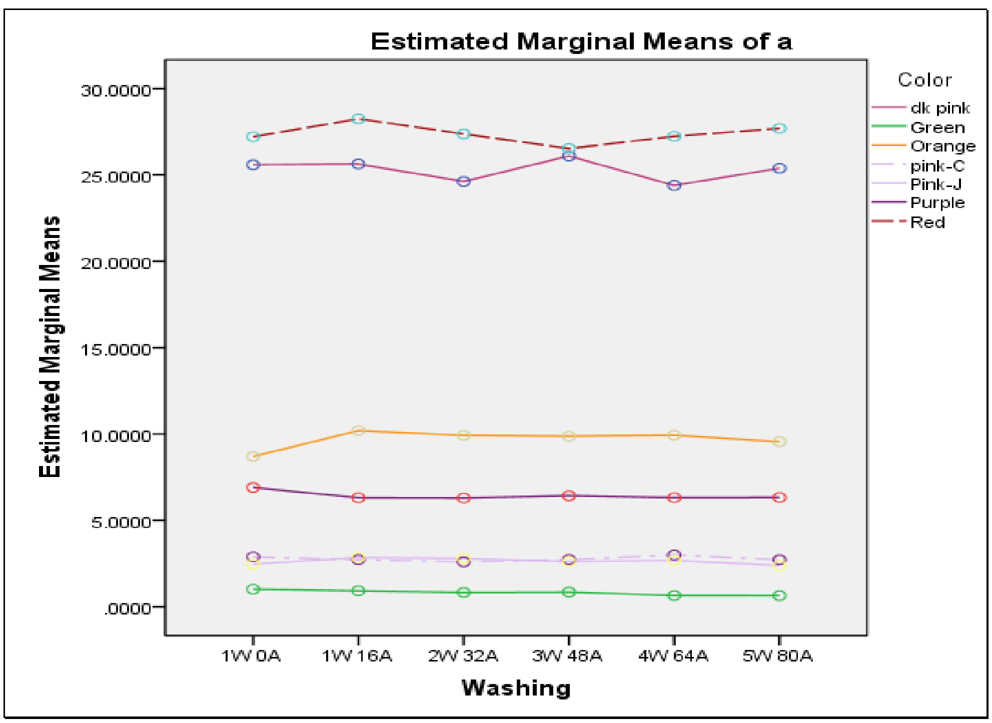
Bleached	Color	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
bleached	dk pink	25.471[a]	.106	25.263	25.680
	Green	.888[a]	.106	.679	1.097
	Orange	9.831[a]	.106	9.622	10.040
	pink-C	2.608[a]	.106	2.399	2.816
	Pink-J	2.643[a]	.106	2.435	2.852
	Purple	6.471[a]	.106	6.263	6.680
	Red	27.095[a]	.106	26.886	27.304
w/o bleached	dk pink	25.036[a]	.106	24.828	25.245
	Green	.716[a]	.106	.508	.925
	Orange	9.741[a]	.106	9.533	9.950
	pink-C	2.934[a]	.106	2.726	3.143
	Pink-J	2.663[a]	.106	2.454	2.872
	Purple	6.306[a]	.106	6.098	6.515
	Red	27.700[a]	.106	27.492	27.909

a. Based on modified population marginal mean.

The mean values observed to be consistent between the bleached and unbleached. It can then be equally concluded that the significant difference observed is due to the difference in mean values between the red and dark pink samples to the remaining samples.



Lastly, for the interaction effects washing * color, again, it can then be equally concluded that the significant difference observed is due to the difference in mean values between the red and dark pink samples to the remaining samples. Note the corresponding table below.



9. Washing * Color: all color

Dependent Variable: a

Washing	Color	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1W 0A	dk pink	25.582[a]	.250	25.093	26.072
	Green	1.018[a]	.250	.529	1.508
	Orange	8.697[a]	.250	8.208	9.186
	pink-C	2.896[a]	.250	2.407	3.385
	Pink-J	2.471[a]	.250	1.982	2.961
	Purple	6.909[a]	.250	6.419	7.398
	Red	27.211[a]	.250	26.722	27.701
1W 16A	dk pink	25.625[a]	.177	25.279	25.971
	Green	.925[a]	.177	.579	1.271
	Orange	10.198[a]	.177	9.852	10.544
	pink-C	2.727[a]	.177	2.381	3.073
	Pink-J	2.857[a]	.177	2.511	3.203
	Purple	6.311[a]	.177	5.965	6.657
	Red	28.248[a]	.177	27.902	28.594
2W 32A	dk pink	24.617[a]	.177	24.271	24.963
	Green	.828[a]	.177	.482	1.174
	Orange	9.922[a]	.177	9.576	10.268
	pink-C	2.606[a]	.177	2.260	2.952
	Pink-J	2.800[a]	.177	2.454	3.146
	Purple	6.297[a]	.177	5.951	6.643
	Red	27.374[a]	.177	27.028	27.720
3W 48A	dk pink	26.090[a]	.177	25.744	26.436
	Green	.846[a]	.177	.500	1.192
	Orange	9.872[a]	.177	9.526	10.218
	pink-C	2.731[a]	.177	2.385	3.077
	Pink-J	2.618[a]	.177	2.272	2.964
	Purple	6.433[a]	.177	6.087	6.779
	Red	26.531[a]	.177	26.185	26.877
4W 64A	dk pink	24.392[a]	.177	24.046	24.738
	Green	.656[a]	.177	.310	1.002
	Orange	9.929[a]	.177	9.583	10.275
	pink-C	3.003[a]	.177	2.657	3.349
	Pink-J	2.683[a]	.177	2.337	3.029
	Purple	6.316[a]	.177	5.970	6.662
	Red	27.234[a]	.177	26.888	27.580
5W 80A	dk pink	25.380[a]	.177	25.034	25.726
	Green	.647[a]	.177	.301	.993
	Orange	9.554[a]	.177	9.208	9.900
	pink-C	2.725[a]	.177	2.379	3.071
	Pink-J	2.398[a]	.177	2.052	2.744
	Purple	6.327[a]	.177	5.981	6.673
	Red	27.695[a]	.177	27.349	28.041

a. Based on modified population marginal mean.

Variable 'b'

The main effects of sample area and swatch, and the interaction effects of Sample Area* Swatch was determined as insignificant.

Tests of Between-Subjects Effects: all color

Dependent Variable: b

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	764478[a]	307	2490.2	379.62	.000
Intercept	492066	1	492066	75014	.000
Swatch	36.638	2	18.319	2.793	.061
SampleArea	17.385	1	17.385	2.650	.104
Bleached	.000	0	.	.	.
Washing	141.53	5	28.305	4.315	.001
Color	711389	6	118565	18075	.000
Swatch * SampleArea	22.873	2	11.436	1.743	.175
Swatch * Bleached	.000	0	.	.	.
Swatch * Washing	481.43	8	60.178	9.174	.000
Swatch * Color	377.65	12	31.471	4.798	.000
SampleArea * Bleached	.000	0	.	.	.
SampleArea * Washing	288.96	4	72.239	11.013	.000
SampleArea * Color	151.07	6	25.179	3.838	.001
Bleached * Washing	.000	0	.	.	.
Bleached * Color	.000	0	.	.	.
Washing * Color	1411.9	30	47.063	7.175	.000
Swatch * SampleArea * Bleached	.000	0	.	.	.
Swatch * SampleArea * Washing	143.14	8	17.893	2.728	.005
Swatch * SampleArea * Color	431.93	12	35.994	5.487	.000
Swatch * Bleached * Washing	.000	0	.	.	.
Swatch * Bleached * Color	.000	0	.	.	.
Swatch * Washing * Color	1478.6	48	30.804	4.696	.000
SampleArea * Bleached * Washing	.000	0	.	.	.
SampleArea * Bleached * Color	.000	0	.	.	.
SampleArea * Washing * Color	1586.7	24	66.112	10.079	.000
Bleached * Washing * Color	.000	0	.	.	.
Swatch * SampleArea * Bleached * Washing	.000	0	.	.	.
Swatch * SampleArea * Bleached * Color	.000	0	.	.	.
Swatch * SampleArea * Washing * Color	2458.1	48	51.211	7.807	.000
Swatch * Bleached * Washing * Color	.000	0	.	.	.
SampleArea * Bleached * Washing * Color	.000	0	.	.	.
Swatch * SampleArea * Bleached * Washing * Color	.000	0	.	.	.
Error	38387	5852	6.560		
Total	1326199	6160			
Corrected Total	802865	6159			

a. R Squared = .952 (Adjusted R Squared = .950)

1. Sample Area Estimates: all colors

Dependent Variable: b

Sample Area	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A	9.212[a]	.046	9.122	9.302
B	9.222[a]	.046	9.132	9.313

a. Based on modified population marginal mean.

Pairwise Comparisons: all colors

Dependent Variable: b

(I) Sample Area	(J) Sample Area	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
A	B	-.010[a],b	.065	.873	-.138	.118
B	A	.010[a],b	.065	.873	-.118	.138

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Between sample areas, no significant difference was observed.

2. Swatch Estimates: all colors

Dependent Variable: b

Swatch	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1 w/ bleach	9.270[a]	.065	9.143	9.398
2 w/ bleach	9.113[a]	.065	8.985	9.241
3 w/o bleach	9.392[a]	.065	9.264	9.520
4 w/o bleach	9.093[a]	.065	8.965	9.221

a. Based on modified population marginal mean.

Pairwise Comparisons: all colors

Dependent Variable: b

(I) Swatch	(J) Swatch	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach	.157[a],b	.092	.089	-.024	.338
	3 w/o bleach	-.121[a],b	.092	.189	-.302	.060
	4 w/o bleach	.177[a],b	.092	.055	-.004	.358
2 w/ bleach	1 w/ bleach	-.157[a],b	.092	.089	-.338	.024
	3 w/o bleach	-.278[a],b,*	.092	.003	-.459	-.097
	4 w/o bleach	.020[a],b	.092	.826	-.161	.201
3 w/o bleach	1 w/ bleach	.121[a],b	.092	.189	-.060	.302
	2 w/ bleach	.278[a],b,*	.092	.003	.097	.459
	4 w/o bleach	.299[a],b,*	.092	.001	.118	.480
4 w/o bleach	1 w/ bleach	-.177[a],b	.092	.055	-.358	.004
	2 w/ bleach	-.020[a],b	.092	.826	-.201	.161
	3 w/o bleach	-.299[a],b,*	.092	.001	-.480	-.118

Based on estimated marginal means
a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).
*. The mean difference is significant at the .05 level.

Significant values were observed for all groups but not all pair-wise comparing groups. The pair-wise groups for the bleached swatches were insignificant, while the unbleached swatches were significant.

3. Bleach Estimates: all colors

Dependent Variable: b

Bleached	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
bleached	9.192[a]	.046	9.101	9.282
w/o bleached	9.242[a]	.046	9.152	9.333

a. Based on modified population marginal mean.

Pairwise Comparisons: all colors

Dependent Variable: b

(I) Bleached	(J) Bleached	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
bleached	w/o bleached	-.051[a],b	.065	.439	-.178	.077
w/o bleached	bleached	.051[a],b	.065	.439	-.077	.178

Based on estimated marginal means
a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Between the bleached and unbleached samples, no significant difference was observed.

Based on the main effects of washing, marked significant differences are observed for all groups but not at all pair-wise comparing groups. No patterns were observed for this factor.

4. Washing Estimates: all colors

Dependent Variable: b

Washing	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1W 0A	9.511[a]	.108	9.299	9.724
1W 16A	9.439[a]	.077	9.289	9.589
2W 32A	9.146[a]	.077	8.996	9.296
3W 48A	9.094[a]	.077	8.944	9.244
4W 64A	9.039[a]	.077	8.889	9.189
5W 80A	9.221[a]	.077	9.071	9.371

a. Based on modified population marginal mean.

Pairwise Comparisons: all colors

Dependent Variable: b

(I) Washing	(J) Washing	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	Upper Bound
1W 0A	1W 16A	.073[a],b	.133	.583	-.187	.333
	2W 32A	.365[a],b,*	.133	.006	.106	.625
	3W 48A	.417[a],b,*	.133	.002	.157	.677
	4W 64A	.472[a],b,*	.133	.000	.212	.732
	5W 80A	.290[a],b,*	.133	.029	.030	.550
1W 16A	1W 0A	-.073[a],b	.133	.583	-.333	.187
	2W 32A	.293[a],b,*	.108	.007	.081	.505
	3W 48A	.345[a],b,*	.108	.001	.132	.557
	4W 64A	.400[a],b,*	.108	.000	.187	.612
	5W 80A	.217[a],b,*	.108	.045	.005	.430
2W 32A	1W 0A	-.365[a],b,*	.133	.006	-.625	-.106
	1W 16A	-.293[a],b,*	.108	.007	-.505	-.081
	3W 48A	.052[a],b	.108	.632	-.160	.264
	4W 64A	.107[a],b	.108	.324	-.105	.319
	5W 80A	-.075[a],b	.108	.486	-.288	.137
3W 48A	1W 0A	-.417[a],b,*	.133	.002	-.677	-.157
	1W 16A	-.345[a],b,*	.108	.001	-.557	-.132
	2W 32A	-.052[a],b	.108	.632	-.264	.160
	4W 64A	.055[a],b	.108	.611	-.157	.267
	5W 80A	-.127[a],b	.108	.240	-.339	.085
4W 64A	1W 0A	-.472[a],b,*	.133	.000	-.732	-.212
	1W 16A	-.400[a],b,*	.108	.000	-.612	-.187
	2W 32A	-.107[a],b	.108	.324	-.319	.105
	3W 48A	-.055[a],b	.108	.611	-.267	.157
	5W 80A	-.182[a],b	.108	.092	-.394	.030
5W 80A	1W 0A	-.290[a],b,*	.133	.029	-.550	-.030
	1W 16A	-.217[a],b,*	.108	.045	-.430	-.005
	2W 32A	.075[a],b	.108	.486	-.137	.288
	3W 48A	.127[a],b	.108	.240	-.085	.339
	4W 64A	.182[a],b	.108	.092	-.030	.394

Based on estimated marginal means
a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).
*. The mean difference is significant at the .05 level.

5. Color Estimates: all colors

Dependent Variable: b

Color	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
dk pink	7.317[a]	.086	7.148	7.487
Green	10.325[a]	.086	10.156	10.494
Orange	30.286[a]	.086	30.117	30.455
pink-C	4.429[a]	.086	4.259	4.598
Pink-J	5.143[a]	.086	4.974	5.312
Purple	-8.726[a]	.086	-8.895	-8.557
Red	15.746[a]	.086	15.577	15.915

a. Based on modified population marginal mean.

Pairwise Comparisons: all colors

Dependent Variable: b

(I) Color	(J) Color	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	Upper Bound
dk pink	Green	-3.008*,a,b	.122	.000	-3.247	-2.768
	Orange	-22.968*,a,b	.122	.000	-23.208	-22.729
	pink-C	2.889*,a,b	.122	.000	2.649	3.128
	Pink-J	2.174*,a,b	.122	.000	1.935	2.414
	Purple	16.043*,a,b	.122	.000	15.804	16.283
	Red	-8.429*,a,b	.122	.000	-8.668	-8.189
Green	dk pink	3.008*,a,b	.122	.000	2.768	3.247
	Orange	-19.961*,a,b	.122	.000	-20.200	-19.721
	pink-C	5.896*,a,b	.122	.000	5.657	6.136
	Pink-J	5.182*,a,b	.122	.000	4.943	5.421
	Purple	19.051*,a,b	.122	.000	18.812	19.290
	Red	-5.421*,a,b	.122	.000	-5.660	-5.182
Orange	dk pink	22.968*,a,b	.122	.000	22.729	23.208
	Green	19.961*,a,b	.122	.000	19.721	20.200
	pink-C	25.857*,a,b	.122	.000	25.618	26.097
	Pink-J	25.143*,a,b	.122	.000	24.903	25.382
	Purple	39.012*,a,b	.122	.000	38.772	39.251
	Red	14.540*,a,b	.122	.000	14.300	14.779
pink-C	dk pink	-2.889*,a,b	.122	.000	-3.128	-2.649
	Green	-5.896*,a,b	.122	.000	-6.136	-5.657
	Orange	-25.857*,a,b	.122	.000	-26.097	-25.618
	Pink-J	-.715*,a,b	.122	.000	-.954	-.475
	Purple	13.155*,a,b	.122	.000	12.915	13.394
	Red	-11.318*,a,b	.122	.000	-11.557	-11.078
Pink-J	dk pink	-2.174*,a,b	.122	.000	-2.414	-1.935
	Green	-5.182*,a,b	.122	.000	-5.421	-4.943
	Orange	-25.143*,a,b	.122	.000	-25.382	-24.903
	pink-C	.715*,a,b	.122	.000	.475	.954
	Purple	13.869*,a,b	.122	.000	13.630	14.109
	Red	-10.603*,a,b	.122	.000	-10.842	-10.364
Purple	dk pink	-16.043*,a,b	.122	.000	-16.283	-15.804
	Green	-19.051*,a,b	.122	.000	-19.290	-18.812
	Orange	-39.012*,a,b	.122	.000	-39.251	-38.772
	pink-C	-13.155*,a,b	.122	.000	-13.394	-12.915
	Pink-J	-13.869*,a,b	.122	.000	-14.109	-13.630
	Red	-24.472*,a,b	.122	.000	-24.712	-24.233
Red	dk pink	8.429*,a,b	.122	.000	8.189	8.668
	Green	5.421*,a,b	.122	.000	5.182	5.660
	Orange	-14.540*,a,b	.122	.000	-14.779	-14.300
	pink-C	11.318*,a,b	.122	.000	11.078	11.557
	Pink-J	10.603*,a,b	.122	.000	10.364	10.842
	Purple	24.472*,a,b	.122	.000	24.233	24.712

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

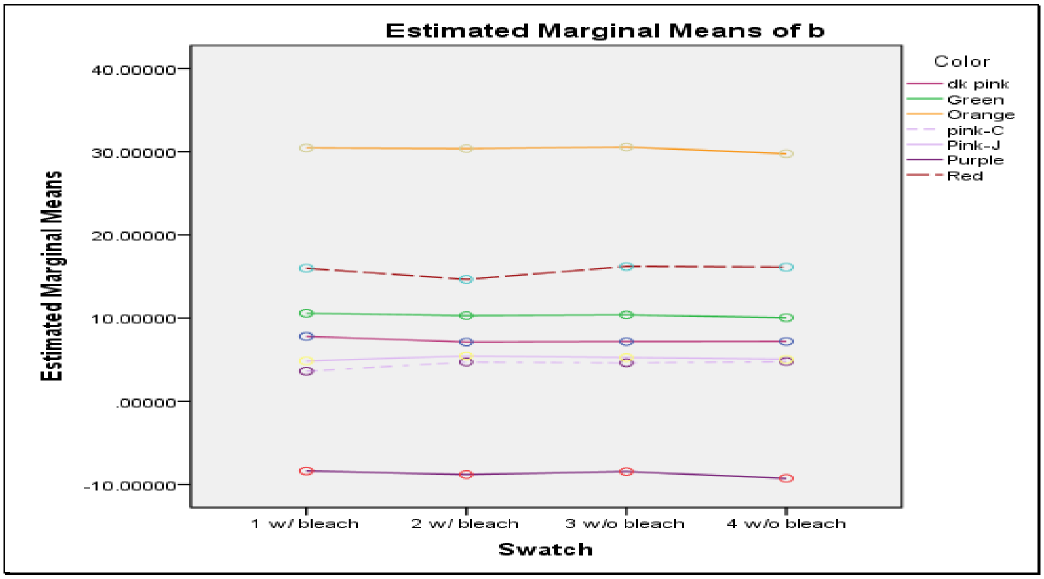
Marked significant differences were observed for all pair-wise comparison. Note that at this variable, sample PMJX and PMCL were also observed to be significantly different and thus, can be differentiated as separate colors. The values between these samples at the yellow to blue region allow discrimination between the samples.

6. Swatch * Color: all colors

Dependent Variable: b

Swatch	Color	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	dk pink	7.793[a]	.173	7.455	8.132
	Green	10.578[a]	.173	10.239	10.916
	Orange	30.449[a]	.173	30.111	30.788
	pink-C	3.618[a]	.173	3.279	3.956
	Pink-J	4.842[a]	.173	4.504	5.181
	Purple	-8.380[a]	.173	-8.718	-8.041
	Red	15.993[a]	.173	15.655	16.332
2 w/ bleach	dk pink	7.119[a]	.173	6.780	7.457
	Green	10.297[a]	.173	9.958	10.635
	Orange	30.379[a]	.173	30.041	30.718
	pink-C	4.713[a]	.173	4.374	5.051
	Pink-J	5.435[a]	.173	5.097	5.774
	Purple	-8.807[a]	.173	-9.145	-8.468
	Red	14.658[a]	.173	14.319	14.996
3 w/o bleach	dk pink	7.168[a]	.173	6.829	7.506
	Green	10.384[a]	.173	10.045	10.722
	Orange	30.557[a]	.173	30.219	30.896
	pink-C	4.618[a]	.173	4.279	4.956
	Pink-J	5.260[a]	.173	4.922	5.599
	Purple	-8.452[a]	.173	-8.791	-8.114
	Red	16.208[a]	.173	15.870	16.547
4 w/o bleach	dk pink	7.190[a]	.173	6.851	7.528
	Green	10.042[a]	.173	9.704	10.381
	Orange	29.758[a]	.173	29.419	30.096
	pink-C	4.767[a]	.173	4.428	5.105
	Pink-J	5.035[a]	.173	4.697	5.374
	Purple	-9.265[a]	.173	-9.604	-8.927
	Red	16.125[a]	.173	15.787	16.464

a. Based on modified population marginal mean.



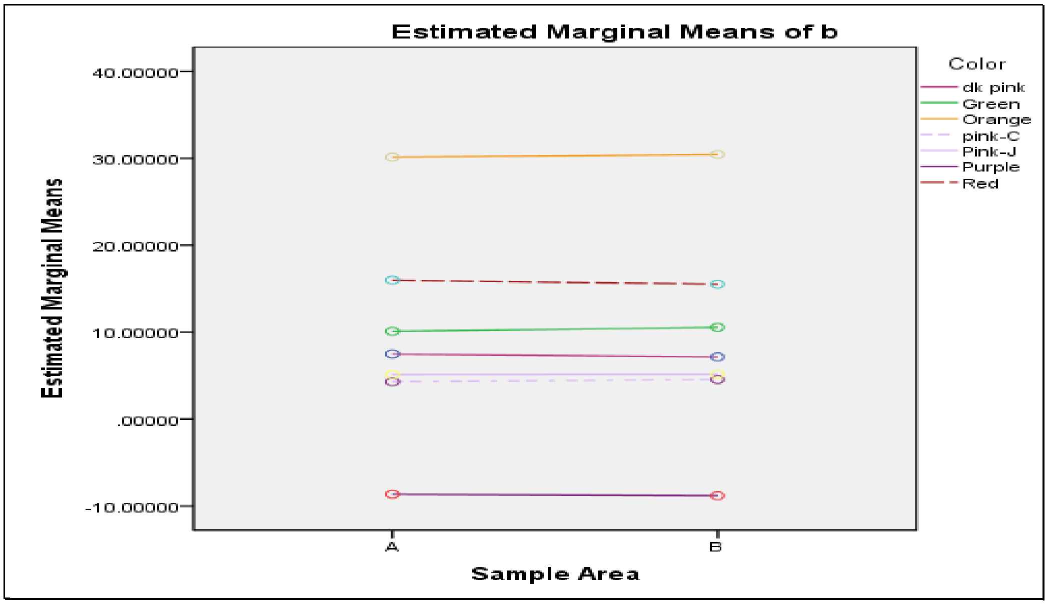
It can be observed that the bleached and unbleached swatches affect each color differently, although these differences observe to be minimal. The significant differences are more likely due to mean difference between purple and orange.

7. Sample Area * Color: all colors

Dependent Variable: b

Sample Area	Color	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	dk pink	7.488[a]	.122	7.249	7.728
	Green	10.097[a]	.122	9.858	10.337
	Orange	30.133[a]	.122	29.894	30.373
	pink-C	4.303[a]	.122	4.064	4.543
	Pink-J	5.123[a]	.122	4.884	5.362
	Purple	-8.637[a]	.122	-8.877	-8.398
	Red	15.976[a]	.122	15.736	16.215
B	dk pink	7.146[a]	.122	6.907	7.386
	Green	10.553[a]	.122	10.314	10.792
	Orange	30.438[a]	.122	30.199	30.678
	pink-C	4.554[a]	.122	4.315	4.793
	Pink-J	5.163[a]	.122	4.924	5.403
	Purple	-8.815[a]	.122	-9.054	-8.575
	Red	15.517[a]	.122	15.277	15.756

a. Based on modified population marginal mean.



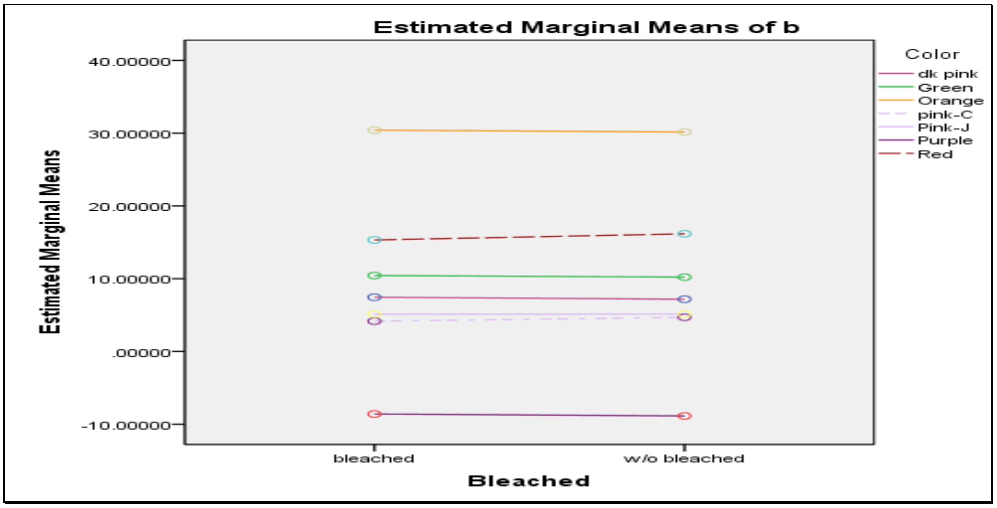
The mean values between the sample areas are minimal. However, the significant values are more likely contributed by the difference between the purple and orange values as these two samples vary the greatest in means.

8. Bleached * Color: all colors

Dependent Variable: b

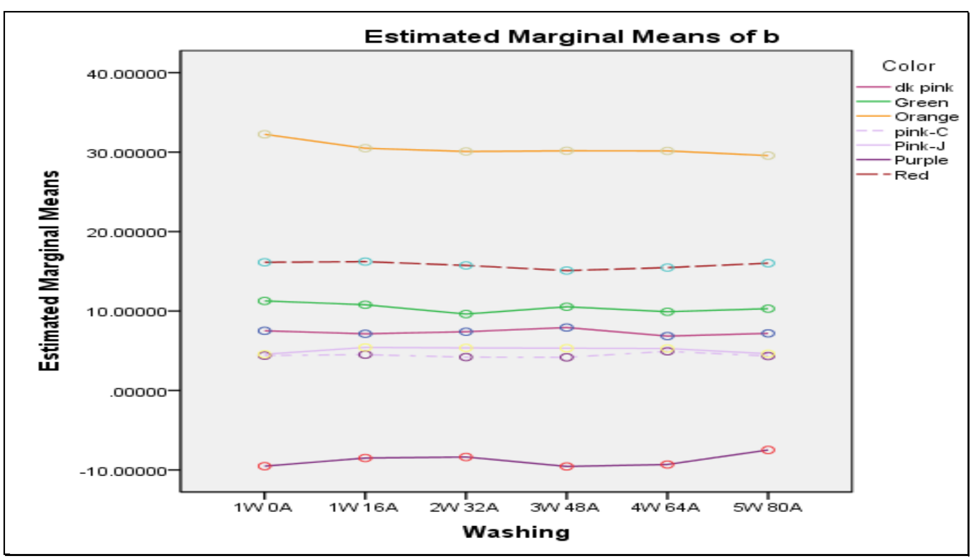
Bleached	Color	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
bleached	dk pink	7.456[a]	.122	7.217	7.695
	Green	10.437[a]	.122	10.198	10.677
	Orange	30.414[a]	.122	30.175	30.653
	pink-C	4.165[a]	.122	3.926	4.404
	Pink-J	5.139[a]	.122	4.899	5.378
	Purple	-8.593[a]	.122	-8.833	-8.354
	Red	15.326[a]	.122	15.086	15.565
w/o bleached	dk pink	7.179[a]	.122	6.939	7.418
	Green	10.213[a]	.122	9.974	10.452
	Orange	30.158[a]	.122	29.918	30.397
	pink-C	4.692[a]	.122	4.453	4.932
	Pink-J	5.148[a]	.122	4.908	5.387
	Purple	-8.859[a]	.122	-9.098	-8.619
	Red	16.167[a]	.122	15.927	16.406

a. Based on modified population marginal mean.



The mean values between the bleached ad unbleached samples are minimal. Similarly, the significant values are more likely contributed by the difference between the purple and orange values as these two samples vary the greatest in means.

Lastly, below is the interaction of washing * color. The differences between mean values are better observed at this variable. It is only at variable ‘b’, that samples PMJX and PMCL, and samples RMP (red) and DPMP (dk pink) can be differentiated suggesting that the saturation of the color was affected in the yellow/blue region.



15. Washing * Color: all color

Dependent Variable: b

Washing	Color	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1W 0A	dk pink	7.509[a]	.286	6.947	8.070
	Green	11.265[a]	.286	10.704	11.826
	Orange	32.242[a]	.286	31.681	32.803
	pink-C	4.397[a]	.286	3.835	4.958
	Pink-J	4.557[a]	.286	3.996	5.119
	Purple	-9.522[a]	.286	-10.084	-8.961
	Red	16.132[a]	.286	15.571	16.694
1W 16A	dk pink	7.136[a]	.202	6.739	7.533
	Green	10.794[a]	.202	10.397	11.191
	Orange	30.489[a]	.202	30.092	30.886
	pink-C	4.518[a]	.202	4.121	4.915
	Pink-J	5.419[a]	.202	5.022	5.816
	Purple	-8.504[a]	.202	-8.901	-8.107
	Red	16.218[a]	.202	15.821	16.615
2W 32A	dk pink	7.394[a]	.202	6.997	7.791
	Green	9.621[a]	.202	9.224	10.018
	Orange	30.081[a]	.202	29.684	30.478
	pink-C	4.199[a]	.202	3.802	4.596
	Pink-J	5.359[a]	.202	4.962	5.756
	Purple	-8.371[a]	.202	-8.768	-7.974
	Red	15.737[a]	.202	15.340	16.134
3W 48A	dk pink	7.921[a]	.202	7.524	8.318
	Green	10.539[a]	.202	10.142	10.936
	Orange	30.167[a]	.202	29.770	30.563
	pink-C	4.176[a]	.202	3.779	4.573
	Pink-J	5.319[a]	.202	4.922	5.716
	Purple	-9.556[a]	.202	-9.953	-9.159
	Red	15.093[a]	.202	14.696	15.490
4W 64A	dk pink	6.850[a]	.202	6.453	7.247
	Green	9.909[a]	.202	9.512	10.306
	Orange	30.150[a]	.202	29.753	30.547
	pink-C	4.933[a]	.202	4.536	5.330
	Pink-J	5.283[a]	.202	4.886	5.680
	Purple	-9.317[a]	.202	-9.714	-8.920
	Red	15.466[a]	.202	15.070	15.863
5W 80A	dk pink	7.191[a]	.202	6.794	7.587
	Green	10.293[a]	.202	9.896	10.690
	Orange	29.564[a]	.202	29.168	29.961
	pink-C	4.333[a]	.202	3.936	4.730
	Pink-J	4.629[a]	.202	4.232	5.026
	Purple	-7.484[a]	.202	-7.881	-7.087
	Red	16.023[a]	.202	15.626	16.420

a. Based on modified population marginal mean.

6.6 Summary of Washed-Aged Results

Intra-variability was not extensively studied through the washed-aged treatment as it was understood that intra-variability occurs within fibers and that this variation can influence analytical results. Since the sub-population being analyzed was not as intrinsic, this particular level of investigating intra-variability was not taken into consideration.

Sample Area and Swatch

In summary of the pair-wise comparisons for sample area, marked significances were observed for each color sample. Fibers extracted from relatively close distances produces mean differences, but once this distance increases, the variation becomes more significant. Sample areas and swatches both examine fiber inter-variability; sample area is a smaller subset whereas swatch is much larger. As analyses increases from sample area to swatch, the variation observes among the fibers also increases until the differences observed to be, significant. Where more samples produce insignificant results at the sample area level, they produced more significant results at the swatch level. For the two samples areas investigated, except for sample OSDP which produced insignificant values, the remaining samples observed mean significant differences. It can be concluded that the area on the swatch is being for sample OSDP is irrelevant. Between both areas, insignificant values were obtained at all three dependent variables suggest that these variables were not affected by the location of which the fiber is being analyzed. The opposite is true for sample GMP which observed significant values at all three dependent variables. The location where the fiber is analyzed plays an important role in affecting the outcome of the results. Although the sample area was performed for inter-variability purposes, at this level of analysis, caution must still be taken to ensure precise and accurate results.

The pair-wise comparisons for swatch observed to be significantly different for all the samples. Two swatches were analyzed per detergent for inter-variability purposes. At this magnified level of sampling, greater amounts of variation between the fibers are expected. The swatches were washed using different detergents did not play a prominent factor with the results. Inconsistencies were observed between the swatches washed under the same parameters. It can be concluded that at this level of inter-variability between the swatches have increased the variations among them thereby affecting the results to a greater extent.

Washing-Aging

The pair-wise comparisons for bleach produced significant values for the reference samples but the results being samples varied. Sample PMJX was the only sample that produced insignificant results for bleaching at all three variables. This means that the effect between the bleached and unbleached samples was indifferent with the outcome of the results. The difference in the detergent used proved to be unimportant. Samples PMCL and RMP produced significant results at all three variables. Surprisingly, samples PMJX and PMCL differ in this level of analysis. Although both samples are not easily differentiated macroscopically, they reacted very differently to the detergent treatment. The remaining samples presented several results. Based on this treatment, it can be concluded that each sample will react differently to the type of detergent used and no one consistent pattern can be observed with the dependent variables. It is therefore possible to differentiate between garments of similar color after the aging and laundering process as this was applicable to these samples.

The pair-wise comparison for washing produced significant effects for the reference samples, although not all the pair-wise differences on levels of washing for each sample were significant. In summary of these results, the washing treatment did affect dependent variables, thereby affecting the gloss of the sample and the color saturation.

The interaction of most concern is the Swatch* Washing. It is impervious to note how much the washing and the bleached and unbleached swatches affected the variables. For all reference samples, significances were observed. It is clear that some changes in both factors must have had an effect of the outcome, rather than this outcome due to random chance. Similar detergents used for washing did not produce similar interaction effects; at times similar patterns were observed between different treated swatches.

7. Conclusion

Fibers are one of the most commonly encountered yet complex types of trace evidence. One of its most discriminatory attribute, color, aids in the analysis and comparison between fibers. Spectrophotometric analysis was able to measure the minor to significant differences in textiles and fiber colors that were influenced by environmental factors. Statistical analysis was able to determine the identifying characteristics of color that changed as a result of environmental parameters.

The variability of the quantitative measurements of color was temperately observed during the validation part of the research. Due to the nature of the fiber, its process during manufacturing such as the coloring mechanism, intra- and inter-variability is observed in and between fibers of the same source. At the same time, variation that occurs for each sample is specific for each coordinate. Blue fibers are expected to vary most in the b-axis which is the blue to yellow region, green and red at the a-axis which corresponds to the red to green region. And these variations should be taken into account as the results are interpreted.

Through the treatment process of artificially exposing the fibers to UV light, the greatest amount of changes were observed for variable ‘a’, followed by ‘b’, then closely behind was ‘L’. This was determined by the summation of the marked significant differences taken from G-H test observed for all reference samples. This concludes that both the red/green and yellow/blue regions were affected during the process of this treatment. It has been previously been reported that the use of UV light to accelerate discoloration have been reported to only affect the gloss of the samples (41). However, by using statistical methods such as ANOVA with the addition of applying post hoc comparison tests, the changes that took place for the variables could be determined.

Through the treatment process of washing and artificially aging the fibers, the greatest amount of changes were observed for variables ‘L’, then ‘a’, then ‘b’, which closely followed behind. These results indicate that with the combination of both these environmental factors, the gloss of the sample and the saturations of the color in the fibers were affected overtime.

Color changes are affected by environmental conditions. Through periodical washing and artificially aging, color degradation in fibers was observed. The amount of exposure to washing and aging, and the type of detergent used will play an important role in altering the gloss of the sample and the saturation of the color. The changes in color caused by the treatments were imperceptible to the observer. Overall, in the processes that were applied, color changes in the fibers were affected microscopically.

8. Recommendations and Future Applications

It is recommended that once the goal of a study is developed, that a statistician should be contacted to assist in the method of collection, analysis and interpretation. This will limit unsuccessful results, time wasting and resources if the study does not go as planned.

Another recommendation that would produce additional results for gratifying results and interpretation is to perform two separate analyses when the process of washing and aging was combined. Instead of analyzing the sample after each washed-aged cycle, observe and analyze each treatment separately. By doing so, after washing, the calculation of how washing affects the color change in fiber can be accurately determined. Likewise, the calculation of how washing and aging combined affects the color changed can also be determined separately.

A future application to this study would be to continue analyzing the remaining blue, yellow and gray colors and the cotton textiles that were brought at the beginning of the experiment to observe if similarities would exist between the colors of different types of textiles.

9. Glossary

COX method- COX is not an acronym but rather a development of a new diagnostic single wash test protocol to identify colored cotton fabrics susceptible to oxygen bleach fading through repeated washing with domestic detergents.

Degree of freedom- is the number of population averages being compared.

Mechanical adhesion- is the process where pigments or water-insoluble dyes are made to adhere through resin binders or

Median- is the 50^{th} percentile which conveys information about what a typical value is.

Percentiles- are the division of the total observations into 100 equal parts. The p percentile corresponds to a value for which p% of the observation lies at or below it and (100-p)% of the observations lie at or above it.

Quantiles- are the division of the total observation into *n* equal parts and is a fraction of the observations at or below it.

Quartiles-are the cutpoints when a set of ordered observations is divided into four equal size sets. There are three quartiles: Q1, Q2, and Q3, corresponds to the 25^{th}, 50^{th}, 75^{th} percentile or 0.25, 0.50 and 0.75 quantiles,

Skewness- measure how non-symmetric a distribution is.

Statistically significant- is when the group means are too different to have been that way by chance alone.

Variance- is a measure of dispersion; how much does each measurement (of one group) vary around the mean.

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11. Appendix

1. Validation Results

Table 1.1: Validation Result of Blue Fibers

Date	Duplicate	blue: L	blue: a	blue: b	green: L	green: a	green: b	red: L	red: a	red: b
2/7/2011	1	85.836	-6.436	-13.313	90.518	-1.740	5.021	77.969	33.685	15.532
	2	80.934	-5.467	-10.635	90.515	-1.739	5.011	77.941	33.699	15.515
	3	81.687	-5.521	-10.210	90.839	-1.631	5.298	77.836	33.771	15.494
	4	81.485	-5.729	-11.533	90.770	-1.637	5.197	77.843	33.792	15.488
	5	81.448	-5.722	-11.484	90.770	-1.637	5.197	77.827	33.770	15.451
2/8/2011	1	88.001	-9.215	-16.067	89.068	-4.786	5.120	73.100	28.955	12.868
	2	88.413	-9.531	-17.001	91.541	-5.593	3.852	73.098	28.946	12.831
	3	88.443	-9.530	-16.977	91.550	-5.561	3.864	72.895	28.840	12.797
	4	88.435	-9.555	-17.035	91.539	-5.532	3.878	72.747	28.740	12.763
	5	88.435	-9.555	-17.035	91.563	-5.519	3.880	72.808	28.748	12.749
2/9/2011	1	90.112	-4.074	-9.994	87.574	-2.625	4.666	82.219	28.091	7.577
	2	90.114	-4.059	-9.964	87.593	-2.613	4.683	82.219	28.084	7.584
	3	90.089	-4.069	-9.988	87.604	-2.593	4.686	82.222	28.096	7.613
	4	90.045	-4.084	-10.004	87.619	-2.583	4.706	82.219	28.071	7.569
	5	90.005	-4.098	-10.013	87.650	-2.576	4.724	82.168	28.008	7.496
2/10/2011	1	89.687	-4.486	-9.186	88.873	-2.059	5.607	77.355	28.481	11.539
	2	89.843	-4.517	-9.248	88.869	-2.064	5.581	77.476	28.571	11.557
	3	89.960	-4.541	-9.288	88.877	-2.065	5.560	75.711	26.894	10.774
	4	90.093	-4.550	-9.291	88.876	-2.067	5.544	75.713	26.902	10.773
	5	90.056	-4.556	-9.297	88.888	-2.066	5.545	75.730	26.903	10.788
2/11/2011	1	87.993	-2.618	-7.104	87.373	-1.905	6.180	79.306	32.279	15.753
	2	88.052	-2.612	-7.085	87.362	-1.863	6.201	79.309	32.250	15.719
	3	88.070	-2.609	-7.070	87.360	-1.878	6.176	79.283	32.241	15.697
	4	88.127	-2.592	-7.036	87.346	-1.872	6.187	79.283	32.257	15.715
	5	88.148	-2.579	-7.030	87.349	-1.863	6.187	79.278	32.275	15.695
2/14/2011	1	84.762	-6.560	-15.153	86.769	-2.565	4.615	87.953	27.752	12.453
	2	84.785	-6.567	-15.154	86.694	-2.547	4.630	87.978	27.758	12.425
	3	84.813	-6.579	-15.142	86.704	-2.548	4.617	88.019	27.784	12.389
	4	84.824	-6.591	-15.141	86.661	-2.527	4.635	88.040	27.794	12.347
	5	84.797	-6.586	-15.126	86.681	-2.539	4.621	88.063	27.808	12.319
2/15/2011	1	89.733	-3.468	-8.133	89.708	-1.987	5.314	81.796	27.344	10.150
	2	89.724	-3.456	-8.121	89.726	-1.983	5.312	81.802	27.325	10.118
	3	89.717	-3.449	-8.112	89.741	-1.977	5.316	81.764	27.288	10.083
	4	89.703	-3.448	-8.104	89.733	-1.976	5.309	81.890	27.318	10.062
	5	89.729	-3.441	-8.102	89.746	-1.976	5.302	82.008	27.344	10.055
2/16/2011	1	90.476	-8.482	-7.911	93.007	-4.782	6.863	83.206	22.699	12.957
	2	90.472	-8.414	-7.766	93.029	-4.768	6.868	83.257	22.695	12.958
	3	90.433	-8.394	-7.729	93.055	-4.764	6.874	83.274	22.685	12.924
	4	90.438	-8.353	-7.643	93.056	-4.760	6.864	83.304	22.684	12.917
	5	90.402	-8.340	-7.625	93.068	-4.758	6.874	83.328	22.677	12.900
2/17/2011	1	90.230	-14.036	-3.436	93.037	-12.295	9.651	76.304	16.330	12.618
	2	90.211	-14.042	-3.455	93.034	-12.286	9.622	76.299	16.335	12.613
	3	90.217	-14.048	-3.453	93.043	-12.279	9.607	76.329	16.354	12.633
	4	90.206	-14.053	-3.467	93.052	-12.279	9.586	76.316	16.355	12.608

	5	90.194	-14.064	-3.492	93.066	-12.284	9.570	76.318	16.337	12.615
2/18/2011	1	84.942	-5.273	-11.492	88.260	-2.206	4.914	83.768	23.003	8.921
	2	84.881	-5.256	-11.486	88.267	-2.198	4.897	83.793	22.996	8.890
	3	84.833	-5.251	-11.499	88.259	-2.189	4.873	83.850	22.995	8.878
	4	84.561	-5.222	-11.460	88.245	-2.198	4.871	83.912	23.000	8.897
	5	84.522	-5.217	-11.458	88.238	-2.188	4.873	84.039	23.019	8.937

2. Descriptive Statistics from One-Way ANOVA for Aged Samples- by 'Hours'

Table 2.1 Descriptive Statistics for reference samples grouped by 'Hours'

DPMP	Hours	N	Means	Std. Dev	Std. Err.	95% Confidence Interval for Means		Minimum	Maximum
						Lower Bound	Upper bound		
L	0	45	84.484	3.922	0.585	83.306	85.663	77.915	89.022
	16	60	86.446	3.638	0.470	85.506	87.386	82.267	94.640
	32	60	83.659	2.694	0.348	82.963	84.355	77.552	86.551
	48	60	83.798	3.064	0.396	83.006	84.589	78.376	88.713
	64	60	86.303	3.465	0.447	85.408	87.198	81.939	94.845
	80	60	83.305	3.815	0.493	82.319	84.290	76.581	90.204
	All Grps	**345**	**84.674**	**3.647**	**0.196**	**84.288**	**85.060**	**76.581**	**94.845**
a	0	45	26.830	2.344	0.349	26.126	27.534	23.068	30.920
	16	60	26.928	2.826	0.365	26.198	27.658	21.818	31.669
	32	60	25.791	4.281	0.553	24.685	26.897	19.549	35.793
	48	60	25.035	3.333	0.430	24.174	25.896	21.321	33.077
	64	60	26.935	3.556	0.459	26.016	27.853	21.023	32.374
	80	60	25.384	2.577	0.333	24.719	26.050	20.792	30.484
	All Grps	**345**	**26.121**	**3.323**	**0.179**	**25.769**	**26.473**	**19.549**	**35.793**
b	0	45	7.307	2.610	0.389	6.523	8.091	0.762	9.900
	16	60	8.467	1.692	0.218	8.030	8.904	5.518	11.350
	32	60	7.599	1.656	0.214	7.172	8.027	4.866	10.948
	48	60	7.161	1.827	0.236	6.689	7.633	4.716	10.067
	64	60	8.070	2.132	0.275	7.519	8.620	4.561	11.151
	80	60	7.652	1.471	0.190	7.271	8.032	5.234	9.894
	All Grps	**345**	**7.727**	**1.938**	**0.104**	**7.522**	**7.932**	**0.762**	**11.350**

GMP	Hours	N	Means	Std. Dev	Std. Err.	95% Confidence Interval for Means		Minimum	Maximum
						Lower Bound	Upper bound		
L	0	45	95.794	4.521	0.674	94.436	97.152	89.960	103.495
	16	60	94.040	2.459	0.317	93.405	94.676	89.593	97.852
	32	60	92.996	5.132	0.662	91.671	94.322	83.374	100.173
	48	60	93.103	6.201	0.801	91.501	94.705	83.389	105.309
	64	60	95.857	3.756	0.485	94.886	96.827	88.712	101.836
	80	60	95.056	4.035	0.521	94.014	96.098	86.814	100.836
	All Grps	**345**	**94.417**	**4.619**	**0.249**	**93.928**	**94.906**	**83.374**	**105.309**
a	0	45	0.961	1.994	0.297	0.362	1.560	-0.692	6.522
	16	60	0.954	0.421	0.054	0.845	1.063	0.169	1.846
	32	60	1.143	0.623	0.080	0.982	1.303	0.058	2.486
	48	60	0.830	0.542	0.070	0.690	0.970	0.045	1.897
	64	60	1.263	0.624	0.081	1.102	1.424	0.130	2.298
	80	60	0.711	0.628	0.081	0.549	0.874	-0.337	2.351
	All Grps	**345**	**0.978**	**0.908**	**0.049**	**0.881**	**1.074**	**-0.692**	**6.522**
b	0	45	11.059	1.584	0.236	10.583	11.535	8.570	13.942
	16	60	10.594	1.982	0.256	10.082	11.106	6.737	14.042
	32	60	11.062	2.198	0.284	10.494	11.630	7.959	15.879
	48	60	10.164	1.846	0.238	9.687	10.641	7.201	13.085
	64	60	10.181	3.175	0.410	9.361	11.002	2.443	15.455
	80	60	10.041	1.902	0.246	9.549	10.532	7.953	14.108
	All Grps	**345**	**10.493**	**2.220**	**0.120**	**10.258**	**10.728**	**2.443**	**15.879**

OSDP	Hours	N	Means	Std. Dev	Std. Err.	95% Confidence Interval for Means		Minimum	Maximum
						Lower Bound	Upper bound		
L	0	45	92.486	2.607	0.389	91.703	93.270	88.425	96.390
	16	60	92.344	4.559	0.589	91.166	93.522	84.527	98.217
	32	60	92.681	3.938	0.508	91.664	93.699	85.111	100.498
	48	60	93.599	2.797	0.361	92.877	94.322	88.053	98.626
	64	60	91.604	6.352	0.820	89.963	93.245	79.250	103.549
	80	60	90.558	4.359	0.563	89.432	91.684	84.837	98.307
	All Grps	**345**	**92.200**	**4.421**	**0.238**	**91.732**	**92.668**	**79.250**	**103.549**
a	0	45	8.994	0.655	0.098	8.798	9.191	7.914	10.016
	16	60	9.769	1.217	0.157	9.455	10.084	7.232	11.365
	32	60	9.780	2.279	0.294	9.192	10.369	4.048	12.144
	48	60	10.462	1.841	0.238	9.987	10.938	5.454	13.428
	64	60	9.917	1.822	0.235	9.446	10.387	6.008	12.405
	80	60	9.549	1.277	0.165	9.219	9.879	7.067	11.516
	All Grps	**345**	**9.778**	**1.675**	**0.090**	**9.601**	**9.955**	**4.048**	**13.428**
b	0	45	36.540	1.743	0.260	36.017	37.064	32.915	38.851
	16	60	32.009	4.207	0.543	30.922	33.096	23.392	37.995
	32	60	31.507	6.424	0.829	29.848	33.167	15.639	38.601
	48	60	34.053	4.761	0.615	32.824	35.283	22.190	42.614
	64	60	32.584	6.129	0.791	31.000	34.167	19.993	41.309
	80	60	30.883	3.600	0.465	29.953	31.813	24.022	36.703
	All Grps	**345**	**32.773**	**5.119**	**0.276**	**32.230**	**33.315**	**15.639**	**42.614**

PMCL	Hours	N	Means	Std. Dev	Std. Err.	95% Confidence Interval for Means: Lower Bound	95% Confidence Interval for Means: Upper bound	Minimum	Maximum
L	0	45	97.980	5.550	0.827	96.312	99.647	87.129	106.534
	16	60	94.309	5.876	0.759	92.791	95.828	83.570	105.758
	32	60	94.213	4.330	0.559	93.094	95.331	86.034	100.437
	48	60	93.656	4.182	0.540	92.576	94.736	87.407	102.545
	64	60	94.532	3.596	0.464	93.603	95.461	84.559	98.994
	80	60	95.265	3.939	0.509	94.247	96.282	88.073	101.165
	All Grps	**345**	**94.862**	**4.760**	**0.256**	**94.358**	**95.367**	**83.570**	**106.534**
a	0	45	3.450	0.765	0.114	3.220	3.680	2.107	4.272
	16	60	2.888	0.622	0.080	2.727	3.049	1.717	3.920
	32	60	3.009	0.511	0.066	2.877	3.141	2.037	3.676
	48	60	3.015	0.965	0.125	2.765	3.264	1.601	5.016
	64	60	2.868	0.770	0.099	2.669	3.067	1.542	3.920
	80	60	2.944	0.635	0.082	2.780	3.108	1.481	4.211
	All Grps	**345**	**3.011**	**0.741**	**0.040**	**2.932**	**3.089**	**1.481**	**5.016**
b	0	45	5.436	1.202	0.179	5.074	5.797	2.676	6.678
	16	60	4.310	0.897	0.116	4.078	4.542	2.595	5.819
	32	60	4.899	0.755	0.097	4.704	5.094	3.137	5.883
	48	60	4.713	1.570	0.203	4.307	5.119	2.472	7.086
	64	60	4.729	1.190	0.154	4.421	5.036	2.650	6.581
	80	60	4.716	1.511	0.195	4.326	5.106	1.230	6.727
	All Grps	**345**	**4.773**	**1.256**	**0.068**	**4.640**	**4.906**	**1.230**	**7.086**

PMJX	Hours	N	Means	Std. Dev	Std. Err.	95% Confidence Interval for Means: Lower Bound	95% Confidence Interval for Means: Upper bound	Minimum	Maximum
L	0	45	95.837	5.916	0.882	94.059	97.614	85.790	102.507
	16	60	95.223	3.809	0.492	94.239	96.207	86.899	103.330
	32	60	95.596	4.679	0.604	94.388	96.805	89.704	107.488
	48	60	94.815	3.949	0.510	93.795	95.835	88.771	102.092
	64	60	96.427	3.803	0.491	95.445	97.410	91.096	104.538
	80	60	95.554	3.185	0.411	94.731	96.377	90.469	101.088
	All Grps	**345**	**95.564**	**4.228**	**0.228**	**95.116**	**96.012**	**85.790**	**107.488**
a	0	45	2.947	0.842	0.125	2.694	3.200	1.621	3.933
	16	60	2.953	0.545	0.070	2.812	3.094	1.937	3.716
	32	60	2.696	0.682	0.088	2.519	2.872	1.826	4.112
	48	60	2.412	0.361	0.047	2.319	2.505	1.627	2.937
	64	60	3.096	0.835	0.108	2.881	3.312	1.471	4.547
	80	60	3.123	0.493	0.064	2.996	3.250	2.042	3.727
	All Grps	**345**	**2.868**	**0.685**	**0.037**	**2.795**	**2.940**	**1.471**	**4.547**
b	0	45	6.056	1.620	0.241	5.570	6.543	3.794	9.142
	16	60	5.474	1.021	0.132	5.211	5.738	3.643	7.348
	32	60	4.800	1.361	0.176	4.448	5.151	2.763	7.469
	48	60	4.639	0.733	0.095	4.450	4.828	3.269	6.127
	64	60	6.050	1.542	0.199	5.652	6.448	3.076	7.638
	80	60	6.306	0.899	0.116	6.074	6.538	4.376	8.181
	All Grps	**345**	**5.532**	**1.375**	**0.074**	**5.387**	**5.678**	**2.763**	**9.142**

PMP	Hours	N	Means	Std. Dev	Std. Err.	95% Confidence Interval for Means		Minimum	Maximum
						Lower Bound	Upper bound		
L	0	45	83.718	4.444	0.662	82.383	85.053	78.487	90.977
	16	60	80.827	5.272	0.681	79.465	82.189	73.407	87.850
	32	60	79.436	2.717	0.351	78.734	80.138	73.864	83.806
	48	60	79.123	4.784	0.618	77.887	80.359	68.977	85.757
	64	60	81.714	2.465	0.318	81.077	82.351	78.375	86.384
	80	60	82.035	5.427	0.701	80.633	83.437	72.717	89.539
	All Grps	**345**	**81.030**	**4.568**	**0.246**	**80.547**	**81.514**	**68.977**	**90.977**
a	0	45	6.660	0.741	0.110	6.437	6.883	5.748	8.304
	16	60	7.164	1.345	0.174	6.816	7.511	5.461	9.778
	32	60	6.909	1.729	0.223	6.463	7.356	4.592	9.950
	48	60	6.213	1.719	0.222	5.769	6.657	2.791	9.016
	64	60	6.582	1.322	0.171	6.241	6.924	4.535	8.989
	80	60	5.858	1.384	0.179	5.500	6.215	3.311	7.980
	All Grps	**345**	**6.560**	**1.491**	**0.080**	**6.402**	**6.718**	**2.791**	**9.950**
b	0	45	-8.771	2.735	0.408	-9.593	-7.950	-12.908	-3.225
	16	60	-10.024	2.935	0.379	-10.783	-9.266	-15.423	-5.169
	32	60	-9.887	2.985	0.385	-10.658	-9.116	-16.424	-5.809
	48	60	-8.914	2.916	0.376	-9.667	-8.161	-14.641	-5.039
	64	60	-10.913	3.512	0.453	-11.821	-10.006	-16.933	-6.347
	80	60	-11.226	3.315	0.428	-12.082	-10.370	-16.938	-5.530
	All Grps	**345**	**-10.008**	**3.199**	**0.172**	**-10.346**	**-9.669**	**-16.938**	**-3.225**
RMP	Hours	N	Means	Std. Dev	Std. Err.	95% Confidence Interval for Means		Minimum	Maximum
						Lower Bound	Upper bound		
L	0	45	80.848	3.737	0.557	79.725	81.970	74.676	87.810
	16	60	81.810	2.698	0.348	81.113	82.507	77.150	87.337
	32	60	82.524	3.774	0.487	81.549	83.499	75.446	90.277
	48	60	82.084	4.313	0.557	80.970	83.199	74.870	90.094
	64	60	83.530	4.799	0.620	82.291	84.770	71.828	93.720
	80	60	80.481	3.946	0.509	79.462	81.501	71.912	87.660
	All Grps	**345**	**81.924**	**4.040**	**0.218**	**81.497**	**82.352**	**71.828**	**93.720**
a	0	45	27.059	2.828	0.422	26.209	27.908	23.994	32.211
	16	60	29.230	1.601	0.207	28.816	29.644	24.829	30.838
	32	60	26.394	5.583	0.721	24.952	27.836	18.633	36.543
	48	60	27.997	3.647	0.471	27.055	28.940	21.941	32.965
	64	60	27.755	6.587	0.850	26.054	29.457	17.510	40.633
	80	60	28.729	4.656	0.601	27.527	29.932	22.776	37.050
	All Grps	**345**	**27.896**	**4.601**	**0.248**	**27.408**	**28.383**	**17.510**	**40.633**
b	0	45	16.106	1.766	0.263	15.576	16.637	12.965	18.434
	16	60	16.733	1.251	0.161	16.410	17.056	14.857	18.924
	32	60	14.624	4.647	0.600	13.424	15.825	7.441	23.956
	48	60	15.564	2.624	0.339	14.886	16.242	11.389	20.563
	64	60	16.640	4.604	0.594	15.451	17.829	8.056	25.316
	80	60	17.503	3.982	0.514	16.475	18.532	12.870	25.067
	All Grps	**345**	**16.199**	**3.576**	**0.193**	**15.820**	**16.578**	**7.441**	**25.316**

3. Test of Homogeneity of Variance- by ‘Hours’

Table 3.1 Levene’s test for samples grouped by ‘Hours’

Variable	Levene Test of Homogeneity of Variances (DPMP spreadsheet) Marked effects are significant at p < .05000							
	SS Effect	df Effect	MS Effect	SS Error	df Error	MS Error	F	p
L	47.62	5	9.523	1270.0	339	3.746	2.542	0.028
a	95.01	5	19.003	1185.9	339	3.498	5.432	0.000
b	23.54	5	4.708	428.5	339	1.264	3.725	0.003

Variable	Levene Test of Homogeneity of Variances (GMP spreadsheet) Marked effects are significant at p < .05000							
	SS Effect	df Effect	MS Effect	SS Error	df Error	MS Error	F	p
L	279.86	5	55.97	2288.1	339	6.750	8.293	0.000
a	36.61	5	7.32	124.9	339	0.369	19.869	0.000
b	44.84	5	8.97	532.5	339	1.571	5.710	0.000

Variable	Levene Test of Homogeneity of Variances (OSDP spreadsheet) Marked effects are significant at p < .05000							
	SS Effect	df Effect	MS Effect	SS Error	df Error	MS Error	F	p
L	294.79	5	58.957	2154.4	339	6.355	9.277	0.000
a	47.04	5	9.408	351.4	339	1.037	9.077	0.000
b	483.02	5	96.604	2915.6	339	8.600	11.232	0.000

Variable	Levene Test of Homogeneity of Variances (PMCL spreadsheet) Marked effects are significant at p < .05000							
	SS Effect	df Effect	MS Effect	SS Error	df Error	MS Error	F	p
L	209.52	5	41.905	2204.51	339	6.503	6.444	0.000
a	5.9578	5	1.192	59.300	339	0.175	6.812	0.000
b	23.9071	5	4.781	158.514	339	0.468	10.226	0.000

Variable	Levene Test of Homogeneity of Variances (PMJX spreadsheet) Marked effects are significant at p < .05000							
	SS Effect	df Effect	MS Effect	SS Error	df Error	MS Error	F	p
L	174.76	5	34.953	2187.87	339	6.454	5.416	0.000
a	7.08	5	1.416	37.85	339	0.112	12.686	0.000
b	37.18	5	7.436	161.83	339	0.477	15.577	0.000

4. ANOVA Output for Aged Results- by 'Hours'

Table 4.1: ANOVA Results for reference samples

GMP		Sum of Squares	df	Mean Square	F	Sig.
L	Between Groups	467.35	5	93.471	4.611	.000
	Within Groups	6871.4	339	20.270		
	Total	7338.7	344			
a	Between Groups	12.128	5	2.426	3.025	.011
	Within Groups	271.79	339	.802		
	Total	283.92	344			
b	Between Groups	59.055	5	11.811	2.447	.034
	Within Groups	1636.5	339	4.827		
	Total	1695.6	344			

OSDP		Sum of Squares	df	Mean Square	F	Sig.
L	Between Groups	319.4	5	63.878	3.381	.005
	Within Groups	6404.0	339	18.891		
	Total	6723.4	344			
a	Between Groups	60.046	5	12.009	4.500	.001
	Within Groups	904.6	339	2.669		
	Total	964.7	344			
b	Between Groups	1084.6	5	216.92	9.272	.000
	Within Groups	7931.0	339	23.395		
	Total	9015.6	344			

PMCL		Sum of Squares	df	Mean Square	F	Sig.
	Between Groups	584.50	5	116.90	5.497	.000
L	Within Groups	7208.9	339	21.27		
	Total	7793.4	344			
	Between Groups	11.060	5	2.212	4.220	.001
a	Within Groups	177.70	339	.524		
	Total	188.76	344			
	Between Groups	34.090	5	6.818	4.545	.001
b	Within Groups	508.53	339	1.500		
	Total	542.62	344			

PMJX		Sum of Squares	df	Mean Square	F	Sig.
L	Between Groups	88.771	5	17.754	.993	.422
	Within Groups	6060.0	339	17.876		
	Total	6148.8	344			
a	Between Groups	22.007	5	4.401	10.708	.000
	Within Groups	139.34	339	.411		
	Total	161.34	344			
b	Between Groups	144.62	5	28.923	19.387	.000
	Within Groups	505.76	339	1.492		
	Total	650.37	344			

PMP		Sum of Squares	df	Mean Square	F	Sig.
L	Between Groups	786.90	5	157.380	8.348	.000
	Within Groups	6390.8	339	18.852		
	Total	7177.7	344			
a	Between Groups	66.479	5	13.296	6.459	.000
	Within Groups	697.80	339	2.058		
	Total	764.28	344			
b	Between Groups	279.74	5	55.949	5.852	.000
	Within Groups	3240.8	339	9.560		
	Total	3520.6	344			

RMP		Sum of Squares	df	Mean Square	F	Sig.
L	Between Groups	357.07	5	71.414	4.604	.000
	Within Groups	5258.0	339	15.510		
	Total	5615.1	344			
a	Between Groups	316.70	5	63.340	3.082	.010
	Within Groups	6967.0	339	20.552		
	Total	7283.7	344			
b	Between Groups	308.54	5	61.708	5.108	.000
	Within Groups	4095.7	339	12.082		
	Total	4404.2	344			

5. Mean Plots for Aged Results-by ‘Hours’

Figure 5.1: Mean Plot for sample GMP

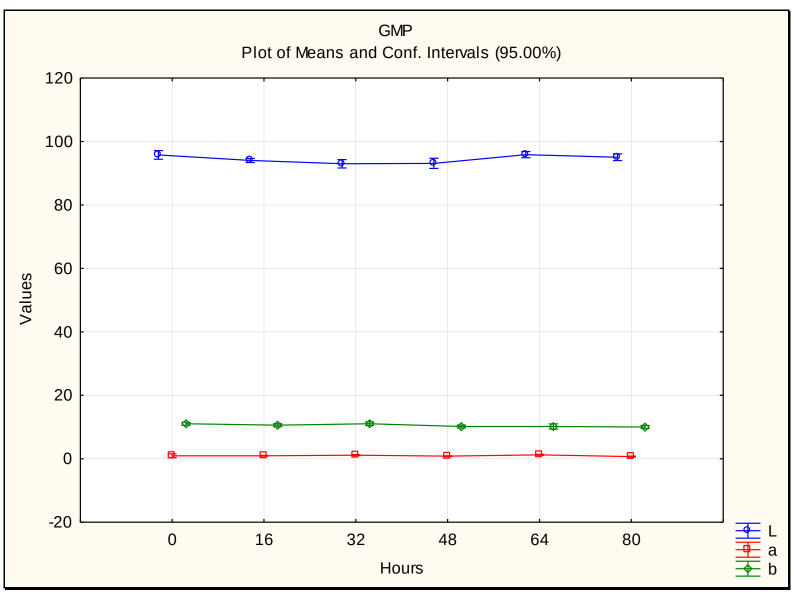


Figure 5.2: Mean Plot for sample OSDP

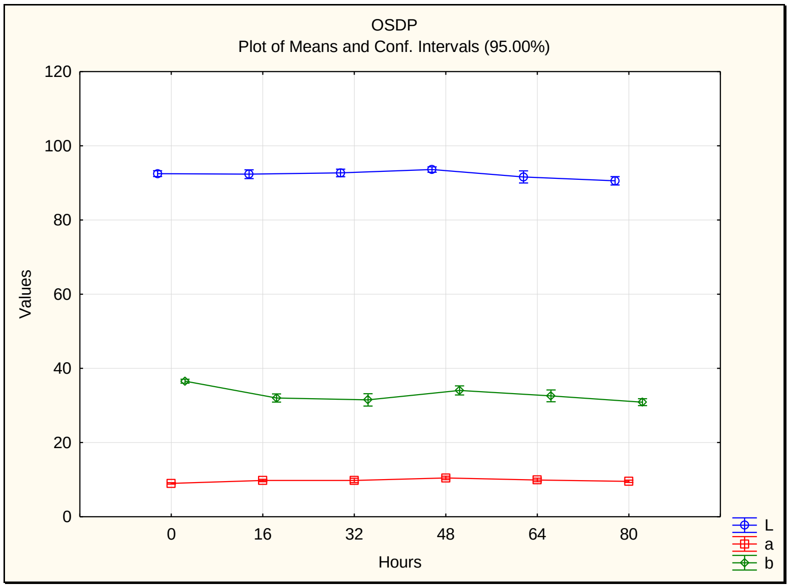


Figure 5.3: Mean Plot for sample PMCL

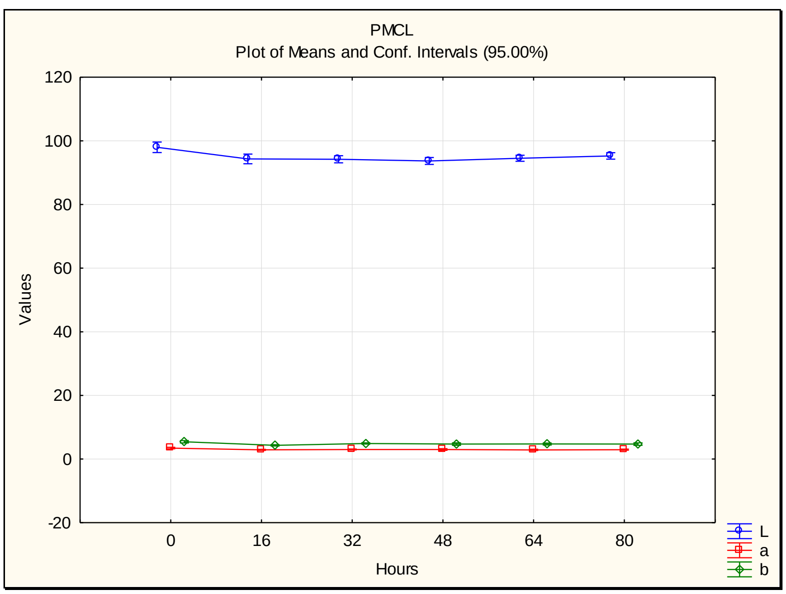


Figure 5.4: Mean Plot for sample PMJX

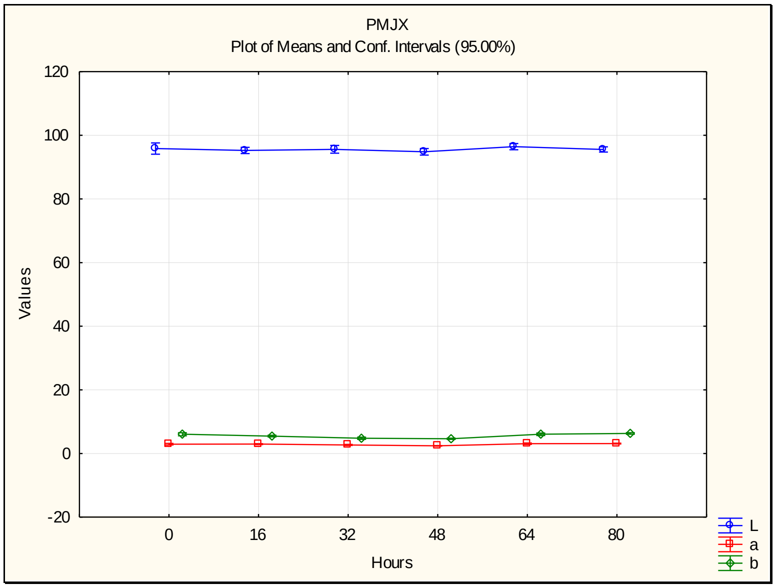


Figure 5.5: Mean Plot for sample PMP

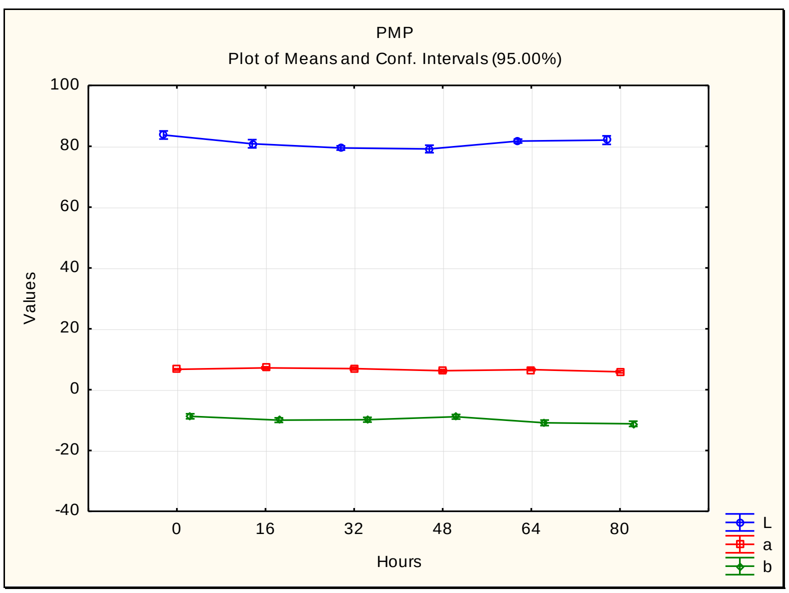
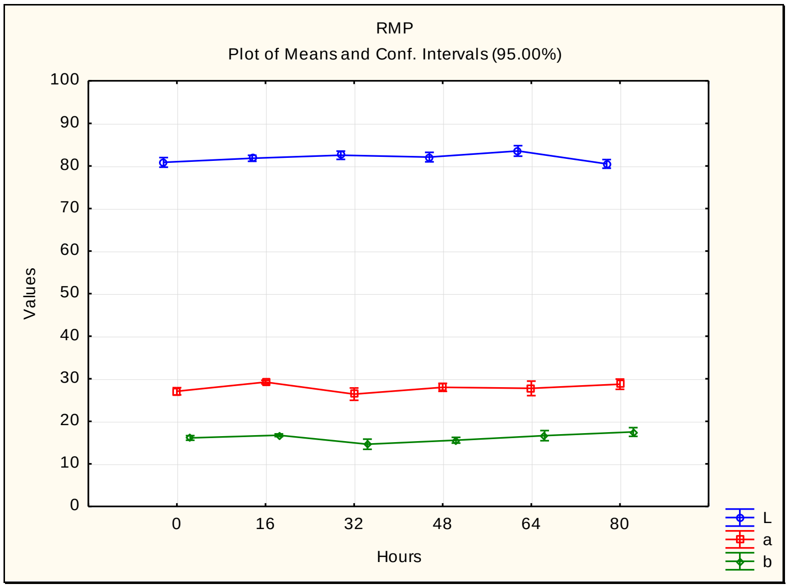


Figure 5.6: Mean Plot for sample RMP



6. Descriptive Statistics from One-Way ANOVA for Aged Samples- by 'Sample Area'

Table 6.1 Descriptive Statistics for reference samples grouped by 'Sample Area'

DPMP		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
L	1	115	84.9185	3.7743	0.3520	84.2212	85.6157	76.5814	94.8448
	2	115	85.0170	3.3014	0.3079	84.4072	85.6269	77.5515	89.3081
	3	115	84.0858	3.8040	0.3547	83.3831	84.7885	77.9147	94.6404
	Total	345	84.6738	3.6474	0.1964	84.2875	85.0600	76.5814	94.8448
a	1	115	27.1768	3.5604	0.3320	26.5190	27.8345	21.9270	35.7931
	2	115	25.5389	3.2736	0.3053	24.9342	26.1436	19.5486	31.6690
	3	115	25.6470	2.8704	0.2677	25.1167	26.1772	20.2630	30.3595
	Total	345	26.1209	3.3232	0.1789	25.7690	26.4728	19.5486	35.7931
b	1	115	8.2214	1.9797	0.1846	7.8557	8.5871	4.5609	11.3502
	2	115	7.3517	2.1648	0.2019	6.9518	7.7516	0.7615	10.6772
	3	115	7.6074	1.5231	0.1420	7.3261	7.8888	4.7164	10.2632
	Total	345	7.7269	1.9376	0.1043	7.5217	7.9320	0.7615	11.3502

GMP		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
L	A	115	93.531	4.357	0.406	92.726	94.336	83.389	100.836
	B	115	96.187	4.296	0.401	95.393	96.981	87.721	103.495
	C	115	93.533	4.711	0.439	92.663	94.403	83.374	105.309
	Total	345	94.417	4.619	0.249	93.928	94.906	83.374	105.309
a	A	115	0.8495	0.8521	0.0795	0.6921	1.0069	-.6918	2.4857
	B	115	1.2105	1.2380	0.1154	0.9818	1.4392	.0455	6.5215
	C	115	0.8727	0.3866	0.0361	0.8013	0.9441	-.1966	1.5735
	Total	345	0.9776	0.9085	0.0489	0.8814	1.0738	-.6918	6.5215
b	A	115	10.714	2.791	0.260	10.198	11.229	2.443	15.879
	B	115	10.252	1.992	0.186	9.884	10.620	6.737	13.942
	C	115	10.514	1.734	0.162	10.194	10.834	7.953	13.876
	Total	345	10.493	2.220	0.120	10.258	10.728	2.443	15.879

OSDP		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
L	A	115	93.663	4.070	0.3796	92.9113	94.4151	88.053	103.549
	B	115	90.811	4.527	0.4222	89.9743	91.6469	83.408	98.626
	C	115	92.127	4.219	0.3934	91.3477	92.9066	79.250	100.498
	Total	345	92.200	4.421	0.2380	91.7322	92.6685	79.250	103.549
a	A	115	9.645	1.824	.170101	9.30848	9.98242	4.048	12.405
	B	115	9.876	1.808	.168636	9.54190	10.21003	5.454	13.428
	C	115	9.813	1.355	.126345	9.56241	10.06298	6.008	12.144
	Total	345	9.778	1.675	.090158	9.60071	9.95537	4.048	13.428
b	A	115	32.635	5.765	0.5376	31.5701	33.7001	15.639	41.309
	B	115	32.637	5.366	0.5004	31.6460	33.6287	22.190	42.614
	C	115	33.045	4.115	0.3837	32.2851	33.8055	19.993	38.851
	Total	345	32.773	5.119	0.2756	32.2305	33.3147	15.639	42.614

PMCL		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
L	A	115	94.8100	4.3578	0.4064	94.0050	95.6151	87.129	104.558
	B	115	95.5182	4.8770	0.4548	94.6173	96.4191	83.570	106.534
	C	115	94.2592	4.9783	0.4642	93.3396	95.1788	84.559	105.758
	Total	345	94.8625	4.7597	0.2563	94.3585	95.3665	83.570	106.534
a	A	115	3.0273	0.8274	0.0772	2.8745	3.1802	1.4808	4.2719
	B	115	3.1584	0.7720	0.0720	3.0158	3.3010	1.5424	5.0161
	C	115	2.8461	0.5706	0.0532	2.7407	2.9515	1.8094	3.7672
	Total	345	3.0106	0.7408	0.0399	2.9322	3.0890	1.4808	5.0161
b	A	115	4.8037	1.4591	0.1361	4.5342	5.0733	1.2300	6.6783
	B	115	5.1611	1.1794	0.1100	4.9433	5.3790	2.6503	7.0857
	C	115	4.3534	0.9535	0.0889	4.1773	4.5296	2.5008	6.1958
	Total	345	4.7728	1.2559	0.0676	4.6398	4.9058	1.2300	7.0857

PMJX		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
L	A	115	95.4629	4.1315	0.3853	94.6997	96.2261	85.7904	103.3300
	B	115	95.0209	4.3154	0.4024	94.2237	95.8181	86.0544	107.4880
	C	115	96.2080	4.1855	0.3903	95.4348	96.9812	86.8987	104.5380
	Total	345	95.5639	4.2278	0.2276	95.1162	96.0116	85.7904	107.4880
a	A	115	2.9480	0.6188	0.0577	2.8337	3.0623	1.82606	3.89497
	B	115	2.7231	0.7261	0.0677	2.5890	2.8573	1.47121	4.54655
	C	115	2.9324	0.6880	0.0642	2.8053	3.0595	1.64672	4.11162
	Total	345	2.8678	0.6848	0.0369	2.7953	2.9403	1.47121	4.54655
b	A	115	5.4555	1.4026	0.1308	5.1964	5.7146	2.76309	8.18116
	B	115	5.3474	1.3437	0.1253	5.0992	5.5957	3.07614	9.14167
	C	115	5.7937	1.3501	0.1259	5.5443	6.0431	3.74439	7.55470
	Total	345	5.5322	1.3750	0.0740	5.3866	5.6778	2.76309	9.14167

PMP		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
L	A	115	81.5562	4.1629	0.3882	80.7872	82.3252	73.4104	90.4446
	B	115	80.8133	4.7655	0.4444	79.9330	81.6936	73.7668	90.9770
	C	115	80.7216	4.7434	0.4423	79.8454	81.5979	68.9771	87.7592
	Total	345	81.0304	4.5679	0.2459	80.5467	81.5141	68.9771	90.9770
a	A	115	6.5953	1.3627	0.1271	6.3435	6.8470	3.9195	9.7779
	B	115	6.4532	1.4846	0.1384	6.1790	6.7274	3.3110	9.5653
	C	115	6.6324	1.6203	0.1511	6.3331	6.9317	2.7908	9.9504
	Total	345	6.5603	1.4906	0.0802	6.4024	6.7181	2.7908	9.9504
b	A	115	-9.2101	2.8362	0.2645	-9.7341	-8.6862	-15.7421	-3.2247
	B	115	-9.9362	3.8814	0.3619	-10.6532	-9.2192	-16.9378	-5.1692
	C	115	-10.8765	2.5228	0.2353	-11.3426	-10.4105	-16.4240	-6.0859
	Total	345	-10.0076	3.1991	0.1722	-10.3464	-9.6689	-16.9378	-3.2247

RMP		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
L	A	115	81.5578	3.62749	.33826	80.8877	82.2279	71.91	88.12
	B	115	81.9557	3.98003	.37114	81.2205	82.6910	71.83	90.28
	C	115	82.2636	4.47252	.41706	81.4374	83.0898	74.68	93.72
	Total	345	81.9257	4.04017	.21752	81.4979	82.3535	71.83	93.72
a	A	115	27.8357	4.4981	0.4195	27.0048	28.6667	18.6332	36.5426
	B	115	29.3360	4.9071	0.4576	28.4296	30.2425	19.1991	40.6327
	C	115	26.5309	3.9502	0.3684	25.8012	27.2606	17.5098	32.2106
	Total	345	27.9009	4.6015	0.2477	27.4136	28.3882	17.5098	40.6327
b	A	115	16.4875	3.6896	0.3441	15.8059	17.1691	8.5244	23.9559
	B	115	17.2641	3.9769	0.3708	16.5295	17.9988	7.4415	25.3159
	C	115	14.8851	2.4971	0.2329	14.4238	15.3464	8.0565	18.6720
	Total	345	16.2122	3.5781	0.1926	15.8333	16.5911	7.4415	25.3159

7. Test of Homogeneity of Variance-by ‘Sample Area’

Table 7.1 *Levene’s test for reference samples grouped by ‘Sample Area’*

DPMP	Levene Statistic	df1	df2	Sig.
L	.001	2	342	.999
a	1.998	2	342	.137
b	6.028	2	342	.003
GMP	**Levene Statistic**	**df1**	**df2**	**Sig.**
L	.860	2	342	.424
a	17.590	2	342	.000
b	4.924	2	342	.008
OSDP	**Levene Statistic**	**df1**	**df2**	**Sig.**
L	4.676	2	342	.010
a	4.312	2	342	.014
b	9.167	2	342	.000
PMCL	**Levene Statistic**	**df1**	**df2**	**Sig.**
L	.770	2	342	.464
a	9.031	2	342	.000
b	15.748	2	342	.000
PMJX	**Levene Statistic**	**df1**	**df2**	**Sig.**
L	.126	2	342	.882
a	2.219	2	342	.110
b	3.653	2	342	.027
PMP	**Levene Statistic**	**df1**	**df2**	**Sig.**
L	.780	2	342	.459
a	.626	2	342	.535
b	19.396	2	342	.000
RMP	**Levene Statistic**	**df1**	**df2**	**Sig.**
L	2.522	2	342	.082
a	1.663	2	342	.191
b	6.934	2	342	.001

8. ANOVA Output for Aged Results- by 'Sample Area'

Table 8.1: ANOVA Output for sample DPMP

ANOVA: DPMP

		Sum of Squares	df	Mean Square	F	Sig.
L	Between Groups	60.191	2	30.096	2.279	.104
	Within Groups	4516.1	342	13.205		
	Total	4576.3	344			
a	Between Groups	193.0	2	96.494	9.151	.000
	Within Groups	3606.1	342	10.544		
	Total	3799.1	344			
b	Between Groups	45.949	2	22.974	6.308	.002
	Within Groups	1245.5	342	3.642		
	Total	1291.5	344			

Robust Tests of Equality of Means: DPMP

		Statistic[a]	df1	df2	Sig.
L	Welch	2.214	2	226.960	.112
a	Welch	8.258	2	226.163	.000
b	Welch	5.649	2	222.497	.004

a. Asymptotically F distributed.

Table 8.2: ANOVA Output for sample GMP

ANOVA: GMP

		Sum of Squares	df	Mean Square	F	Sig.
L	Between Groups	540.494	2	270.247	13.595	.000
	Within Groups	6798.2	342	19.878		
	Total	7338.7	344			
a	Between Groups	9.389	2	4.695	5.848	.003
	Within Groups	274.5	342	.803		
	Total	283.9	344			
b	Between Groups	12.329	2	6.165	1.253	.287
	Within Groups	1683.2	342	4.922		
	Total	1695.6	344			

Robust Tests of Equality of Means: GMP

		Statistic[a]	df1	df2	Sig.
L	Welch	14.090	2	227.646	.000
a	Welch	4.074	2	187.748	.019
b	Welch	1.154	2	221.091	.317

a. Asymptotically F distributed.

Table 8.3: ANOVA Output for sample OSDP

ANOVA: OSDP

		Sum of Squares	df	Mean Square	F	Sig.
L	Between Groups	468.82	2	234.410	12.817	.000
	Within Groups	6254.6	342	18.288		
	Total	6723.4	344			
a	Between Groups	3.263	2	1.631	.580	.560
	Within Groups	961.4	342	2.811		
	Total	964.7	344			
b	Between Groups	12.832	2	6.416	.244	.784
	Within Groups	9002.8	342	26.324		
	Total	9015.6	344			

Robust Tests of Equality of Means: OSDP

		Statistic[a]	df1	df2	Sig.
L	Welch	12.732	2	227.571	.000
a	Welch	.504	2	223.085	.605
b	Welch	.296	2	222.729	.744

a. Asymptotically F distributed.

Table 8.4: ANOVA Output for sample PMCL

ANOVA: PMCL

		Sum of Squares	df	Mean Square	F	Sig.
L	Between Groups	91.620	2	45.810	2.034	.132
	Within Groups	7701.74	342	22.520		
	Total	7793.36	344			
a	Between Groups	5.658	2	2.829	5.284	.005
	Within Groups	183.10	342	.535		
	Total	188.76	344			
b	Between Groups	37.680	2	18.840	12.760	.000
	Within Groups	504.94	342	1.476		
	Total	542.62	344			

Robust Tests of Equality of Means: PMCL

		Statistic[a]	df1	df2	Sig.
L	Welch	1.887	2	227.169	.154
a	Welch	6.391	2	221.423	.002
b	Welch	16.628	2	221.607	.000

a. Asymptotically F distributed.

Table 8.5: ANOVA Output for sample PMJX

ANOVA: PMJX

		Sum of Squares	df	Mean Square	F	Sig.
L	Between Groups	82.784	2	41.392	2.334	.098
	Within Groups	6066.0	342	17.737		
	Total	6148.8	344			
a	Between Groups	3.625	2	1.813	3.931	.021
	Within Groups	157.72	342	.461		
	Total	161.34	344			
b	Between Groups	12.468	2	6.234	3.342	.037
	Within Groups	637.90	342	1.865		
	Total	650.37	344			

Robust Tests of Equality of Means: PMJX

		Statistic[a]	df1	df2	Sig.
L	Welch	2.299	2	227.925	.103
a	Welch	3.699	2	226.956	.026
b	Welch	3.407	2	227.918	.035

a. Asymptotically F distributed.

Table 8.6: ANOVA Output for sample PMP

ANOVA: PMP

		Sum of Squares	df	Mean Square	F	Sig.
L	Between Groups	48.174	2	24.087	1.155	.316
	Within Groups	7129.48	342	20.846		
	Total	7177.65	344			
a	Between Groups	2.057	2	1.028	.461	.631
	Within Groups	762.22	342	2.229		
	Total	764.28	344			
b	Between Groups	160.551	2	80.275	8.171	.000
	Within Groups	3360.04	342	9.825		
	Total	3520.59	344			

Robust Tests of Equality of Means: PMP

		Statistic[a]	df1	df2	Sig.
L	Welch	1.257	2	227.036	.287
a	Welch	.449	2	226.876	.639
b	Welch	11.177	2	222.184	.000

a. Asymptotically F distributed.

Table 8.7: ANOVA Output for sample RMP

ANOVA: RMP

		Sum of Squares	df	Mean Square	F	Sig.
L	Between Groups	28.794	2	14.397	.881	.415
	Within Groups	5586.3	342	16.334		
	Total	5615.1	344			
a	Between Groups	453.19	2	226.595	11.345	.000
	Within Groups	6830.5	342	19.972		
	Total	7283.7	344			
b	Between Groups	338.52	2	169.259	14.238	.000
	Within Groups	4065.7	342	11.888		
	Total	4404.2	344			

Robust Tests of Equality of Means: RMP

		Statistic[a]	df1	df2	Sig.
L	Welch	.895	2	226.395	.410
a	Welch	11.447	2	226.151	.000
b	Welch	17.453	2	217.467	.000

a. Asymptotically F distributed.

9. Post Hoc Comparison test- by ‘Sample Area’

Tukey or Games-Howell tests were included based on the homogeneity of variance results. Post hoc tests were not calculated for a specific variable if the ANOVA results corresponding to samples were deemed insignificant. For this reason, only significant values obtained for variables specific for each sample was included below.

Table 9.1: Post Hoc Comparison Results for sample DPMP

Multiple Comparisons: DPMP

Dependent Variable		(I) Sample Area	(J) Sample Area	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
a	Tukey HSD	1	2	1.63785*	0.4282	.000	0.6298	2.6459
			3	1.52976*	0.4282	.001	0.5217	2.5378
		2	1	-1.638	0.4282	.000	-2.6459	-0.6298
			3	-0.1081	0.4282	.965	-1.1161	0.8999
		3	1	-1.5298	0.4282	.001	-2.5378	-0.5217
			2	0.1081	0.4282	.965	-0.8999	1.1161
	Games-Howell	1	2	1.63785*	0.4510	.001	0.5738	2.7019
			3	1.52976*	0.4265	.001	0.5234	2.5362
		2	1	-1.6378	0.4510	.001	-2.7019	-0.5738
			3	-0.1081	0.4060	.962	-1.0660	0.8498
		3	1	-1.5297	0.4265	.001	-2.5362	-0.5234
			2	0.1081	0.4060	.962	-0.8498	1.0660
b	Tukey HSD	1	2	.86966*	0.2517	.002	0.2773	1.4621
			3	.61396*	0.2517	.040	0.0215	1.2064
		2	1	-0.8697	0.2517	.002	-1.4621	-0.2773
			3	-0.2557	0.2517	.567	-0.8481	0.3367
		3	1	-0.6140	0.2517	.040	-1.2064	-0.0215
			2	0.2557	0.2517	.567	-0.3367	0.8481
	Games-Howell	1	2	.86966*	0.2736	.005	0.2243	1.5151
			3	.61396*	0.2329	.024	0.0642	1.1637
		2	1	-0.8697	0.2736	.005	-1.5151	-0.2243
			3	-0.2557	0.2468	.555	-0.8384	0.3270
		3	1	-0.6140	0.2329	.024	-1.1637	-0.0642
			2	0.2557	0.2468	.555	-0.3270	0.8384

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets: DPMP ‘a’

	Sample Area	N	Subset for alpha = 0.05	
			1	2
Tukey HSD[a]	2	115	25.539	
	3	115	25.647	
	1	115		27.177
	Sig.		.965	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 115.000.

Table 9.2: Post Hoc Comparison Results for sample GMP

Multiple Comparisons: GMP

Dependent Variable		(I) Sample Area	(J) Sample Area	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
L	Tukey HSD	A	B	-2.656	0.5880	.000	-4.0402	-1.2721
			C	-0.0019	0.5880	1.000	-1.3860	1.3821
		B	A	2.65612*	0.5880	.000	1.2721	4.0402
			C	2.65421*	0.5880	.000	1.2702	4.0383
		C	A	0.0019	0.5880	1.000	-1.3821	1.3860
			B	-2.654	0.5880	.000	-4.0383	-1.2702
	Games-Howell	A	B	-2.656	0.5706	.000	-4.0022	-1.3100
			C	-0.0019	0.5984	1.000	-1.4136	1.4098
		B	A	2.65612*	0.5706	.000	1.3100	4.0022
			C	2.65421*	0.5945	.000	1.2516	4.0569
		C	A	0.0019	0.5984	1.000	-1.4098	1.4136
			B	-2.654	0.5945	.000	-4.0569	-1.2516
a	Tukey HSD	A	B	-0.361	0.1182	.007	-0.6391	-0.0829
			C	-0.0232	0.1182	.979	-0.3013	0.2549
		B	A	.36097*	0.1182	.007	0.0829	0.6391
			C	.33777*	0.1182	.013	0.0597	0.6159
		C	A	0.0232	0.1182	.979	-0.2549	0.3013
			B	-0.338	0.1182	.013	-0.6159	-0.0597
	Games-Howell	A	B	-0.361	0.1401	.029	-0.6919	-0.0301
			C	-0.0232	0.0873	.962	-0.2296	0.1832
		B	A	.36097*	0.1401	.029	0.0301	0.6919
			C	.33777*	0.1209	.016	0.0512	0.6244
		C	A	0.0232	0.0873	.962	-0.1832	0.2296
			B	-0.338	0.1209	.016	-0.6244	-0.0512

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets: GMP 'a'

	Sample Area	N	Subset for alpha = 0.05	
			1	2
Tukey HSD[a]	A	115	0.8495	
	C	115	0.8727	
	B	115		1.2105
	Sig.		.979	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 115.000.

Table 9.3: Post Hoc Comparison Results for sample OSDP

Multiple Comparisons: OSDP

Dependent Variable		(I) Sample Area	(J) Sample Area	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
L	Tukey HSD	A	B	2.852602*	.563967	.000	1.52505	4.18016
			C	1.536090*	.563967	.019	.20853	2.86365
		B	A	-2.852602*	.563967	.000	-4.18016	-1.52505
			C	-1.316512	.563967	.052	-2.64407	.01104
		C	A	-1.536090*	.563967	.019	-2.86365	-.20853
			B	1.316512	.563967	.052	-.01104	2.64407
	Games-Howell	A	B	2.852602*	.567701	.000	1.51323	4.19198
			C	1.536090*	.546683	.015	.24639	2.82579
		B	A	-2.852602*	.567701	.000	-4.19198	-1.51323
			C	-1.316512	.577085	.060	-2.67797	.04495
		C	A	-1.536090*	.546683	.015	-2.82579	-.24639
			B	1.316512	.577085	.060	-.04495	2.67797

Table 9.4: Post Hoc Comparison Results for sample PMCL

Multiple Comparisons: PMCL

Dependent Variable		(I) Sample Area	(J) Sample Area	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
a	Tukey HSD	A	B	-0.1311	0.0965	.364	-0.3582	0.0961
			C	0.1813	0.0965	.147	-0.0459	0.4084
		B	A	0.1311	0.0965	.364	-0.0961	0.3582
			C	.31233*	0.0965	.004	0.0852	0.5395
		C	A	-0.1813	0.0965	.147	-0.4084	0.0459
			B	-0.3123	0.0965	.004	-0.5395	-0.0852
	Games-Howell	A	B	-0.1311	0.1055	.430	-0.3800	0.1179
			C	0.1813	0.0937	.132	-0.0400	0.4025
		B	A	0.1311	0.1055	.430	-0.1179	0.3800
			C	.31233*	0.0895	.002	0.1010	0.5236
		C	A	-0.1813	0.0937	.132	-0.4025	0.0400
			B	-0.3123	0.0895	.002	-0.5236	-0.1010
b	Tukey HSD	A	B	-0.3574	0.1602	.068	-0.7346	0.0198
			C	.45031*	0.1602	.014	0.0731	0.8275
		B	A	0.3574	0.1602	.068	-0.0198	0.7346
			C	.80772*	0.1602	.000	0.4305	1.1849
		C	A	-0.4503	0.1602	.014	-0.8275	-0.0731
			B	-0.8077	0.1602	.000	-1.1849	-0.4305
	Games-Howell	A	B	-0.3574	0.1750	.105	-0.7703	0.0554
			C	.45031*	0.1625	.017	0.0665	0.8342
		B	A	0.3574	0.1750	.105	-0.0554	0.7703
			C	.80772*	0.1414	.000	0.4740	1.1415
		C	A	-0.4503	0.1625	.017	-0.8342	-0.0665
			B	-0.8077	0.1414	.000	-1.1415	-0.4740

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets: PMCL 'a'

	Sample Area	N	Subset for alpha = 0.05	
			1	2
Tukey HSD[a]	C	115	2.8461	
	A	115	3.0273	3.0273
	B	115		3.1584
	Sig.		.147	.364

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 115.000.

Homogeneous Subsets: PMCL ‘b’

	Sample Area	N	Subset for alpha = 0.05	
			1	2
Tukey HSD[a]	C	115	4.3534	
	A	115		4.8037
	B	115		5.1611
	Sig.		1.000	.068

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 115.000.

Table 9.5: Post Hoc Comparison Results for sample PMJX

Multiple Comparisons: PMJX

Dependent Variable		(I) Sample Area	(J) Sample Area	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
a	Tukey HSD	A	B	.224837*	0.0896	.033	0.0140	0.4356
			C	0.0156	0.0896	.983	-0.1952	0.2264
		B	A	-0.2248	0.0896	.033	-0.4356	-0.0140
			C	-0.2092	0.0896	.052	-0.4200	0.0016
		C	A	-0.0156	0.0896	.983	-0.2264	0.1952
			B	0.2092	0.0896	.052	-0.0016	0.4200
	Games-Howell	A	B	.224837*	0.0890	.033	0.0149	0.4347
			C	0.0156	0.0863	.982	-0.1880	0.2192
		B	A	-0.2248	0.0890	.033	-0.4347	-0.0149
			C	-0.2092	0.0933	.066	-0.4293	0.0108
		C	A	-0.0156	0.0863	.982	-0.2192	0.1880
			B	0.2092	0.0933	.066	-0.0108	0.4293
b	Tukey HSD	A	B	0.1081	0.1801	.820	-0.3159	0.5320
			C	-0.3382	0.1801	.147	-0.7622	0.0857
		B	A	-0.1081	0.1801	.820	-0.5320	0.3159
			C	-0.4463	0.1801	.036	-0.8703	-0.0223
		C	A	0.3382	0.1801	.147	-0.0857	0.7622
			B	.446300*	0.1801	.036	0.0223	0.8703
	Games-Howell	A	B	0.1081	0.1811	.822	-0.3192	0.5354
			C	-0.3382	0.1815	.152	-0.7665	0.0901
		B	A	-0.1081	0.1811	.822	-0.5354	0.3192
			C	-0.4463	0.1776	.034	-0.8653	-0.0273
		C	A	0.3382	0.1815	.152	-0.0901	0.7665
			B	.446300*	0.1776	.034	0.0273	0.8653

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets: PMJX 'a'

	Sample Area	N	Subset for alpha = 0.05	
			1	2
Tukey HSD[a]	B	115	2.7231360	
	C	115	2.9323758	2.9323758
	A	115		2.9479730
	Sig.		.052	.983

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 115.000.

Table 9.6: Post Hoc Comparison Results for sample PMP

Multiple Comparisons: PMP

Dependent Variable		(I) Sample Area	(J) Sample Area	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
L	Tukey HSD	A	B	.74286	.60212	.434	-0.6745	2.1602
			C	.83455	.60212	.349	-0.5828	2.2519
		B	A	-.74286	.60212	.434	-2.1602	0.6745
			C	.09170	.60212	.987	-1.3257	1.5091
		C	A	-.83455	.60212	.349	-2.2519	0.5828
			B	-.09170	.60212	.987	-1.5091	1.3257
	Games-Howell	A	B	.74286	.59006	.420	-0.6493	2.1350
			C	.83455	.58852	.333	-0.5540	2.2231
		B	A	-.74286	.59006	.420	-2.1350	0.6493
			C	.09170	.62700	.988	-1.3875	1.5709
		C	A	-.83455	.58852	.333	-2.2231	0.5540
			B	-.091670	.62700	.988	-1.5709	1.3875
a	Tukey HSD	A	B	0.1420	0.1969	.751	-0.3214	0.6055
			C	-0.0371	0.1969	.981	-0.5006	0.4263
		B	A	-0.1420	0.1969	.751	-0.6055	0.3214
			C	-0.1792	0.1969	.634	-0.6426	0.2843
		C	A	0.0371	0.1969	.981	-0.4263	0.5006
			B	0.1792	0.1969	.634	-0.2843	0.6426
	Games-Howell	A	B	0.1420	0.1879	.730	-0.3013	0.5854
			C	-0.0371	0.1974	.981	-0.5030	0.4287
		B	A	-0.1420	0.1879	.730	-0.5854	0.3013
			C	-0.1792	0.2049	.657	-0.6626	0.3043
		C	A	0.0371	0.1974	.981	-0.4287	0.5030
			B	0.1792	0.2049	.657	-0.3043	0.6626
b	Tukey HSD	A	B	0.7260	0.4134	.186	-0.2470	1.6991
			C	1.6663*	0.4134	.000	0.6934	2.6394
		B	A	-0.7260	0.4134	.186	-1.6991	0.2470
			C	0.9404	0.4134	.061	-0.0327	1.9134
		C	A	-1.6663	0.4134	.000	-2.6394	-0.6934
			B	-0.9404	0.4134	.061	-1.9134	0.0327
	Games-Howell	A	B	0.7260	0.4483	.240	-0.3322	1.7842
			C	1.6663*	0.3540	.000	0.8313	2.5015
		B	A	-0.7260	0.4483	.240	-1.7842	0.3322
			C	0.9404	0.4317	.077	-0.0791	1.9599
		C	A	-1.6663	0.3540	.000	-2.5015	-0.8313
			B	-0.9404	0.4317	.077	-1.9599	0.0791

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets: DPMP ‘a’

	Sample Area	N	Subset for alpha = 0.05
			1
Tukey HSD[a]	B	115	6.4532
	A	115	6.5953
	C	115	6.6324
	Sig.		.634

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 115.000.

Table 9.7: Post Hoc Comparison Results for sample RMP

Multiple Comparisons: RMP

Dependent Variable		(I) Sample Area	(J) Sample Area	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
a	Tukey HSD	A	B	-1.5003	0.5894	.030	-2.8876	-.1130
			C	1.3048	0.5894	.070	-.0825	2.6922
		B	A	1.5003*	0.5894	.030	.1130	2.8876
			C	2.8051*	0.5894	.000	1.4178	4.1925
		C	A	-1.3048	0.5894	.070	-2.6922	.0825
			B	-2.8051	0.5894	.000	-4.1925	-1.4178
	Games-Howell	A	B	-1.5003	0.6207	.043	-2.9648	-.0358
			C	1.3048	0.5582	.053	-.0123	2.6219
		B	A	1.5003*	0.6207	.043	.0358	2.9648
			C	2.8051*	0.5874	.000	1.4189	4.1914
		C	A	-1.3048	0.5582	.053	-2.6219	.0123
			B	-2.8051	0.5874	.000	-4.1914	-1.4189
b	Tukey HSD	A	B	-0.7767	0.4547	.204	-1.8470	.2937
			C	1.6024*	0.4547	.001	.5321	2.6728
		B	A	0.7767	0.4547	.204	-.2937	1.8470
			C	2.3790*	0.4547	.000	1.3087	3.4494
		C	A	-1.6024	0.4547	.001	-2.6728	-.5321
			B	-2.3790	0.4547	.000	-3.4494	-1.3087
	Games-Howell	A	B	-0.7767	0.5059	.276	-1.9701	.4168
			C	1.6024*	0.4154	.000	.6214	2.5834
		B	A	0.7767	0.5059	.276	-.4168	1.9701
			C	2.3790*	0.4379	.000	1.3448	3.4134
		C	A	-1.6024	0.4154	.000	-2.5834	-.6214
			B	-2.3790	0.4379	.000	-3.4134	-1.3448

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets 'a'

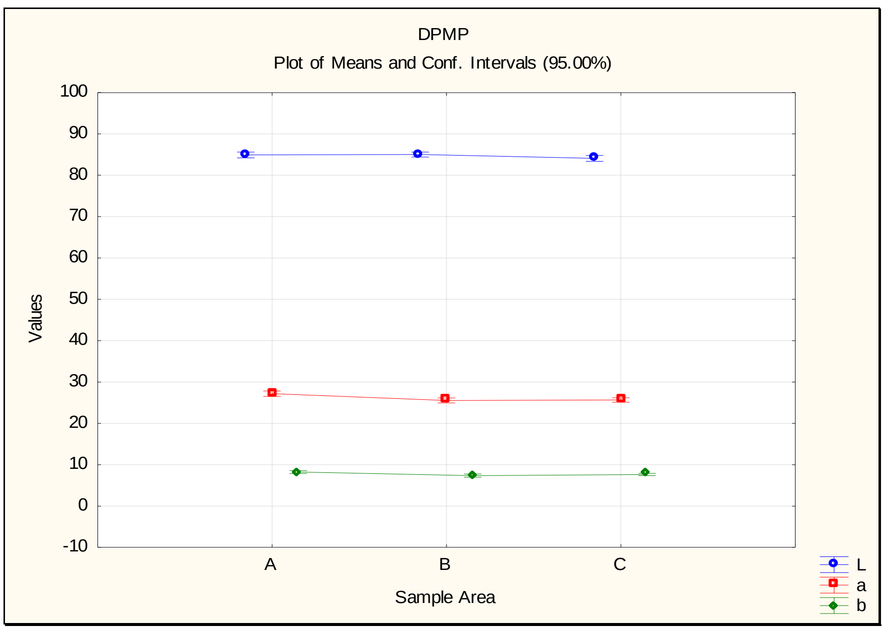
	Sample Area	N	Subset for alpha = 0.05	
			1	2
Tukey HSD[a]	C	115	26.531	
	A	115	27.836	
	B	115		29.336
	Sig.		.070	1.000

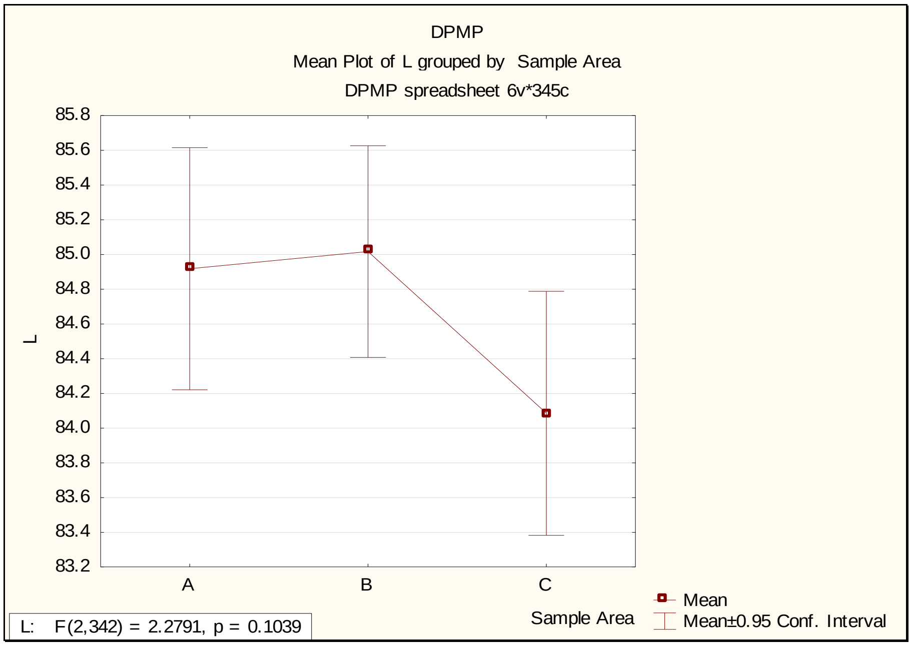
Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 115.000.

10. Mean plots for Aged Results

Figure 10.1 Mean plots for sample DPMP grouped by 'Sample Area'




DPMP
Mean Plot of L grouped by Sample Area
DPMP spreadsheet 6v*345c
85.8
85.6
85.4
85.2
85.0
84.8
84.6
84.4
84.2
84.0
83.8
83.6
83.4
83.2
L
A
B
C
Sample Area
Mean
Mean±0.95 Conf. Interval
L: F(2,342) = 2.2791, p = 0.1039

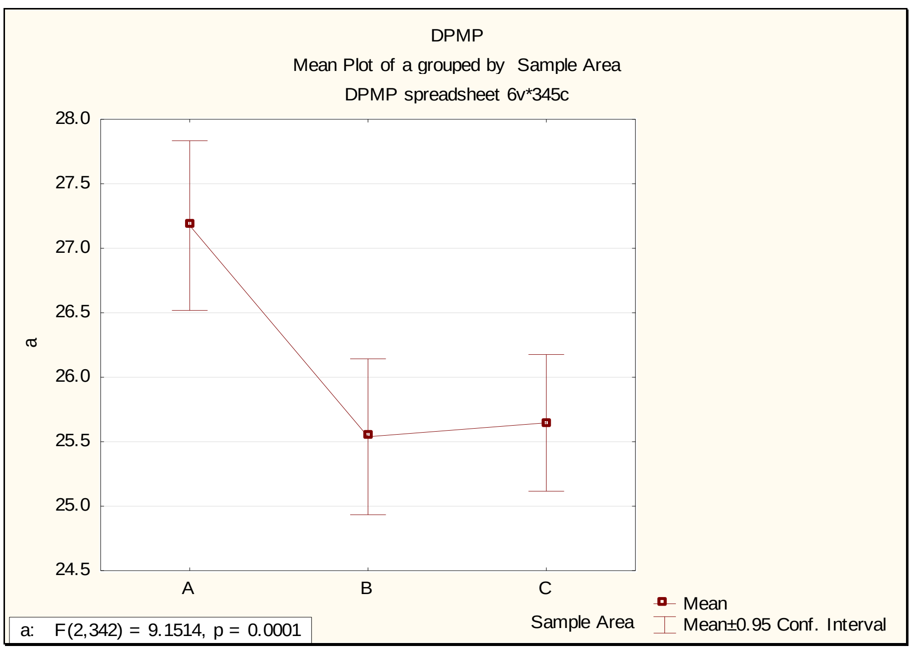
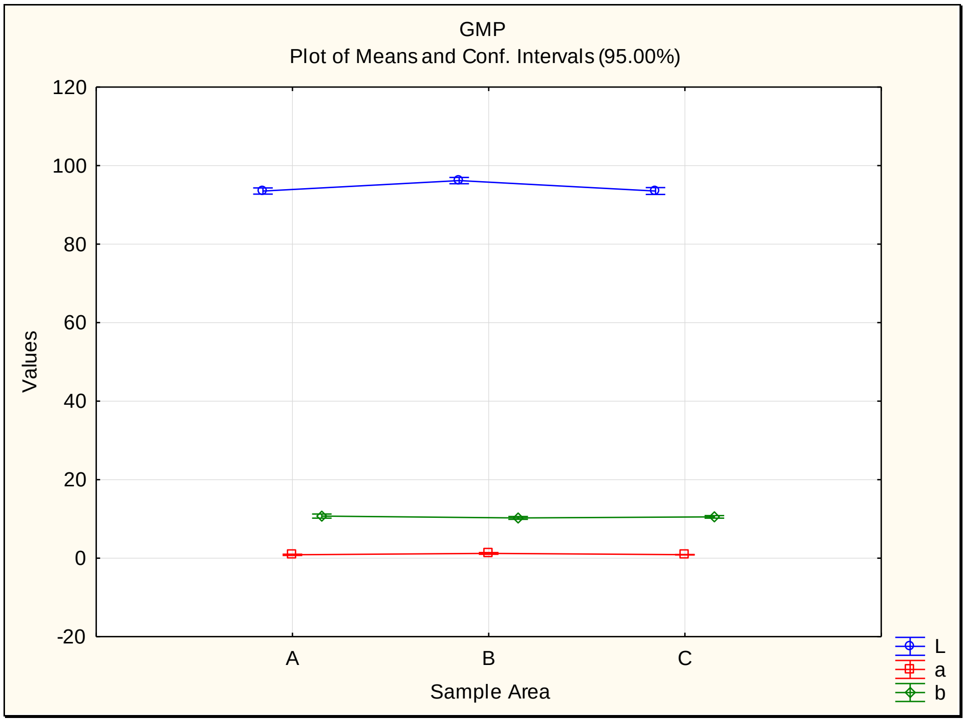
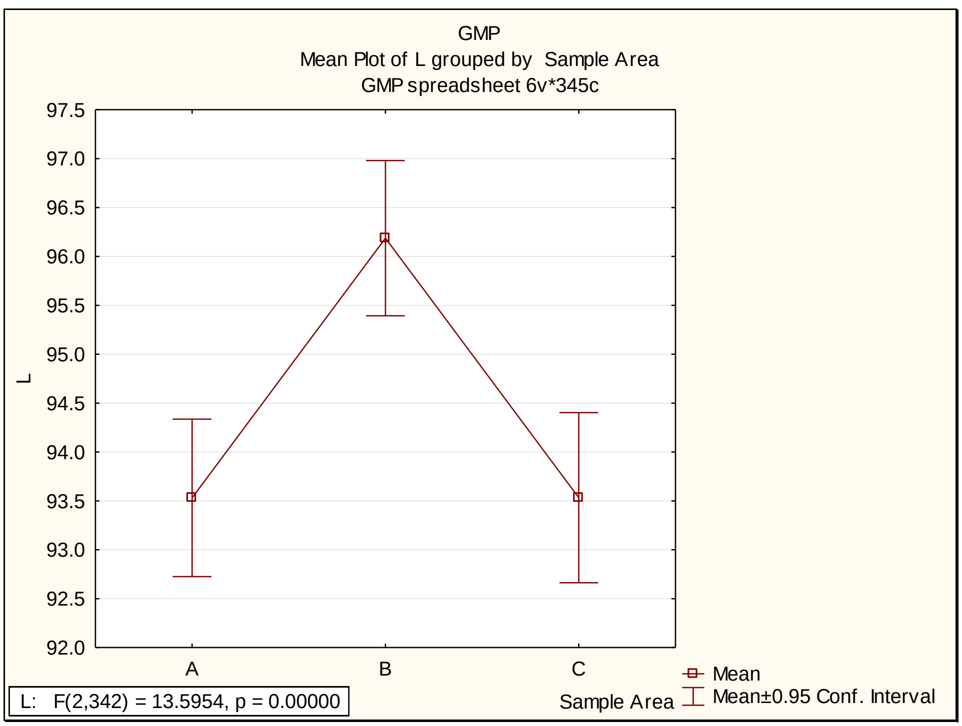
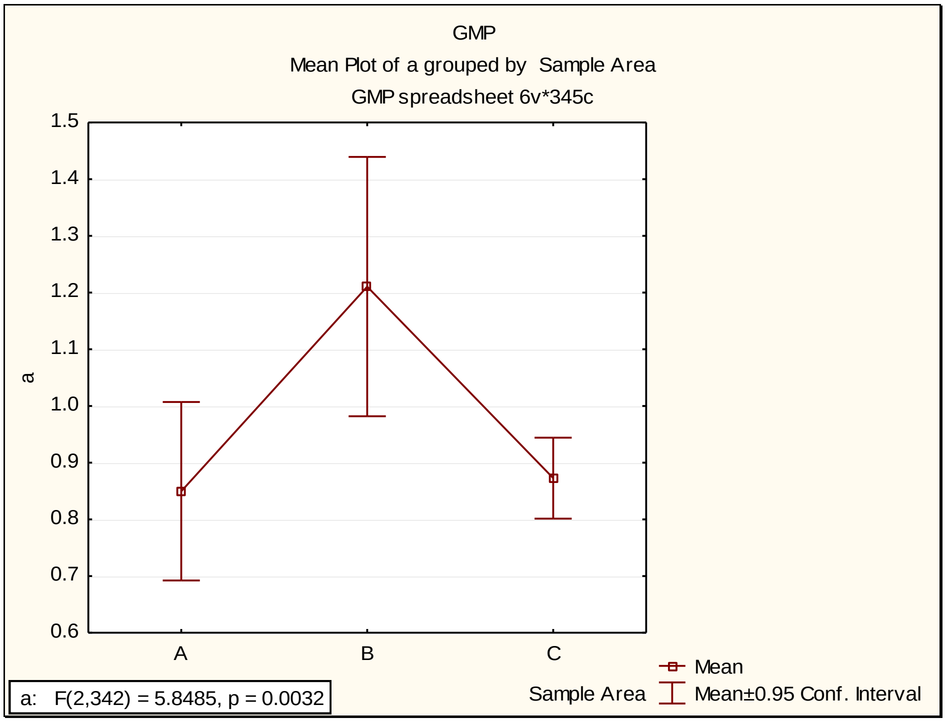

DPMP
Mean Plot of a grouped by Sample Area
DPMP spreadsheet 6v*345c
28.0
27.5
27.0
26.5
26.0
25.5
25.0
24.5
a
A
B
C
Sample Area
Mean
Mean±0.95 Conf. Interval
a: F(2,342) = 9.1514, p = 0.0001

Figure 10.2 Mean plots for sample GMP grouped by 'Sample Area'






GMP
Mean Plot of a grouped by Sample Area
GMP spreadsheet 6v*345c
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
a
A
B
C
Sample Area
Mean
Mean±0.95 Conf. Interval
a: F(2,342) = 5.8485, p = 0.0032

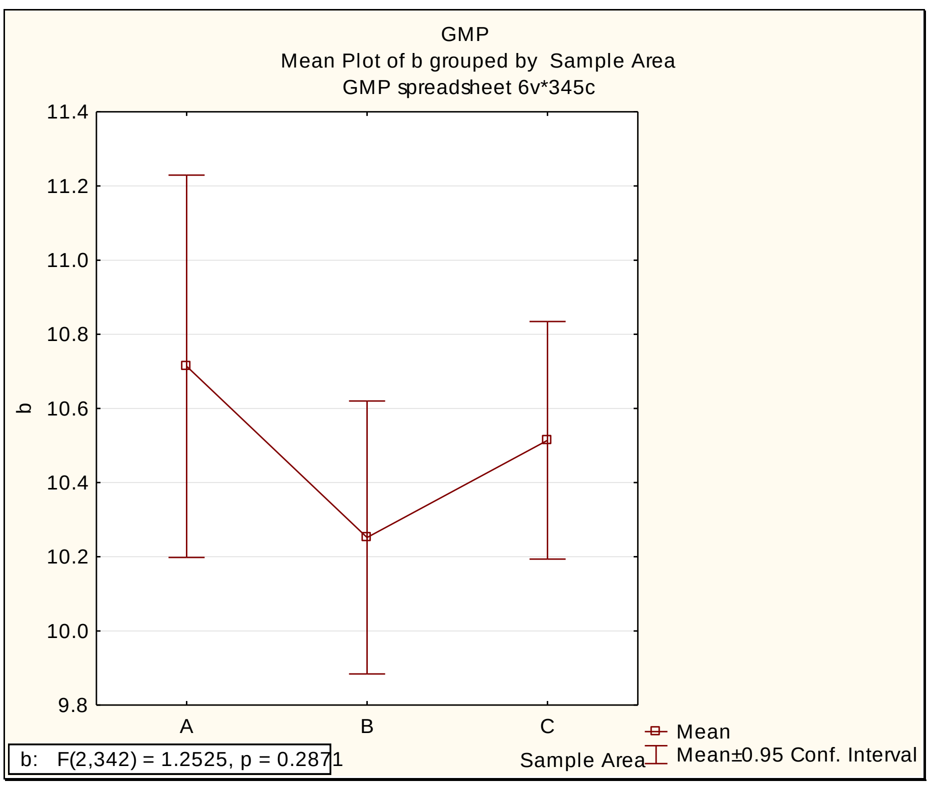
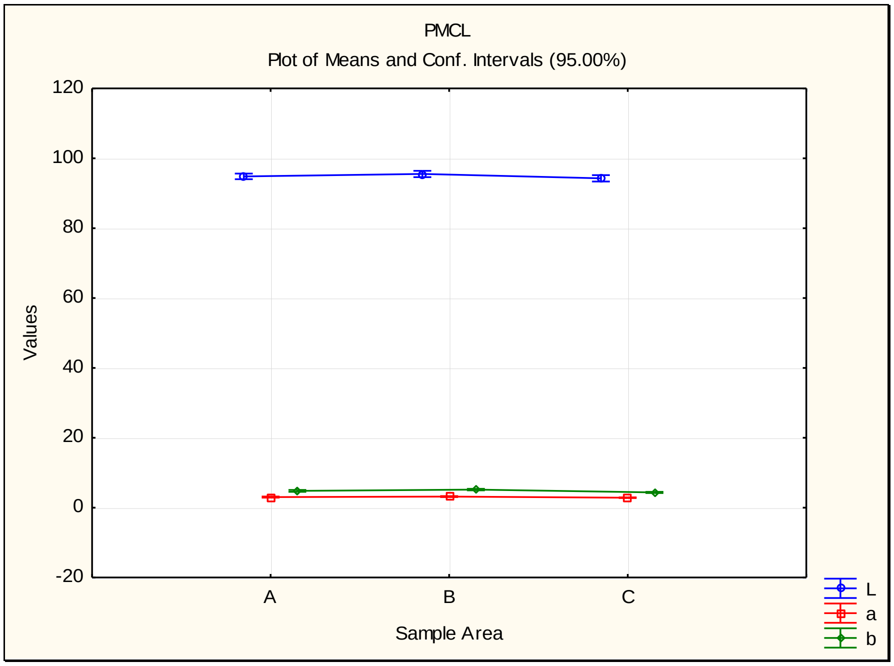
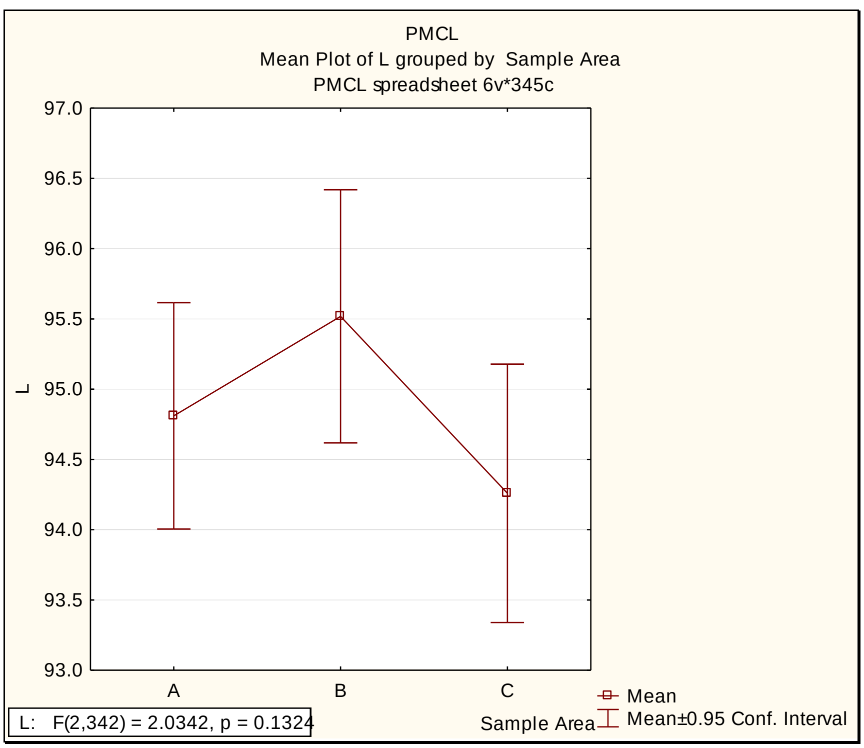
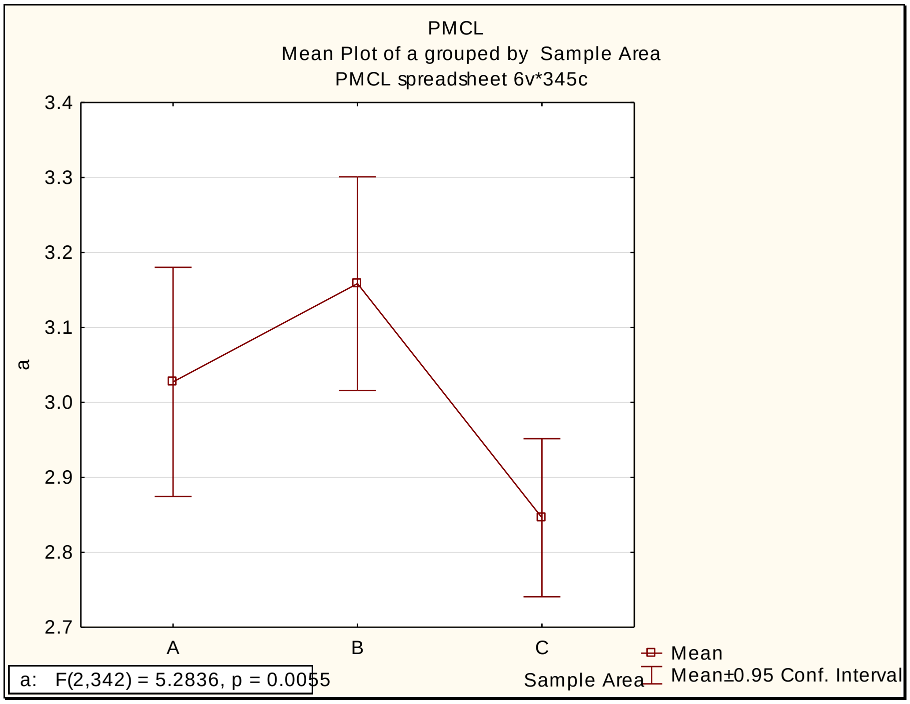

GMP
Mean Plot of b grouped by Sample Area
GMP spreadsheet 6v*345c
11.4
11.2
11.0
10.8
10.6
10.4
10.2
10.0
9.8
b
A
B
C
Sample Area
Mean
Mean±0.95 Conf. Interval
b: F(2,342) = 1.2525, p = 0.2871

Figure 10.3 Mean plots for sample PMCL grouped by 'Sample Area'






PMCL
Mean Plot of a grouped by Sample Area
PMCL spreadsheet 6v*345c
3.4
3.3
3.2
3.1
3.0
2.9
2.8
2.7
a
A
B
C
Sample Area
Mean
Mean±0.95 Conf. Interval
a: F(2,342) = 5.2836, p = 0.0055

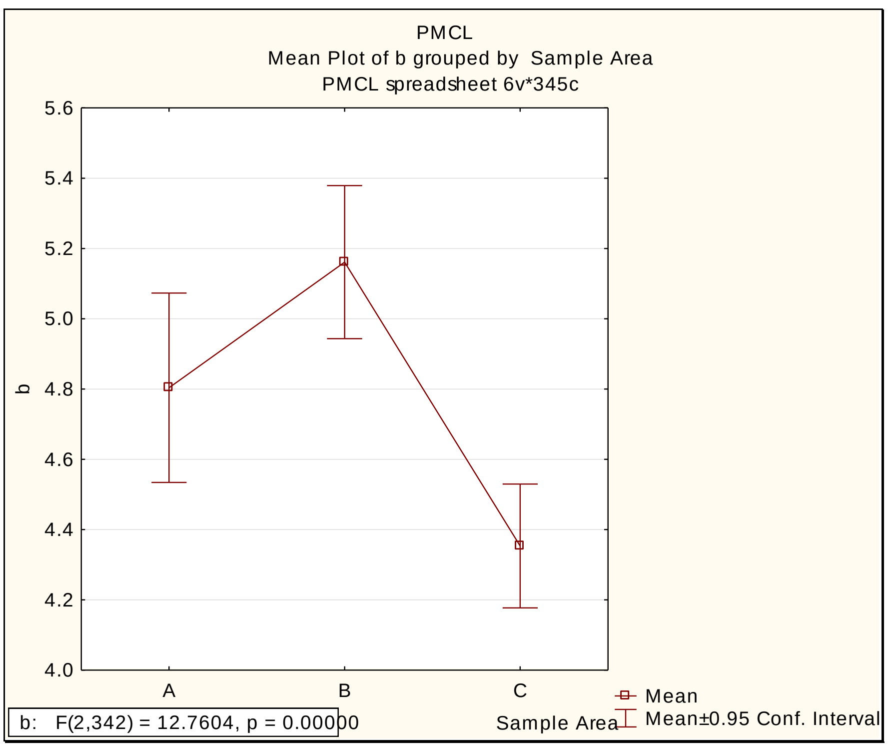
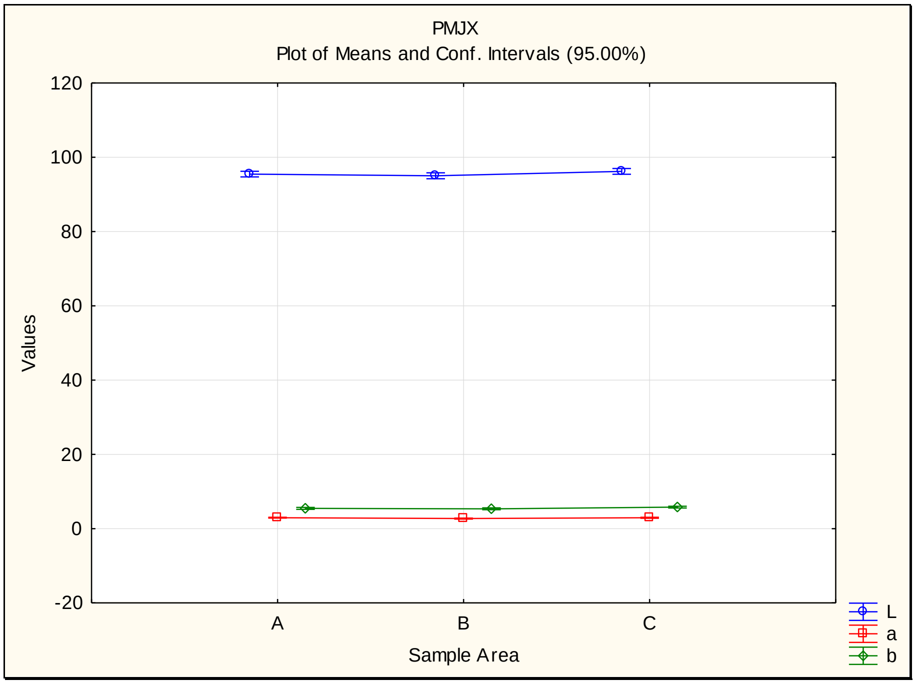
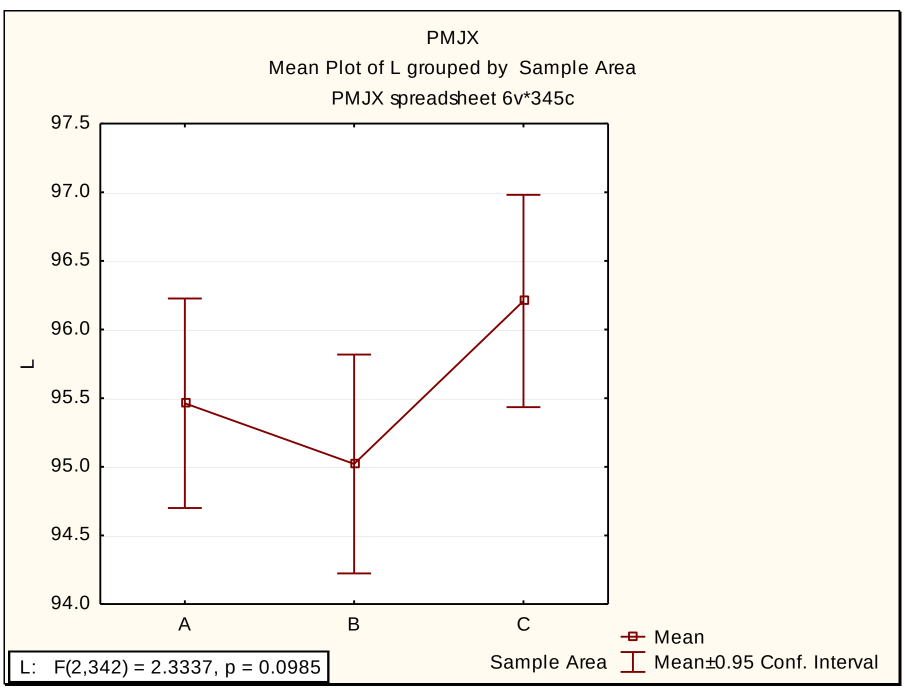

PMCL
Mean Plot of b grouped by Sample Area
PMCL spreadsheet 6v*345c
5.6
5.4
5.2
5.0
4.8
4.6
4.4
4.2
4.0
b
A
B
C
Sample Area
Mean
Mean±0.95 Conf. Interval
b: F(2,342) = 12.7604, p = 0.00000

Figure 10.4 Mean plots for sample PMJX grouped by 'Sample Area'





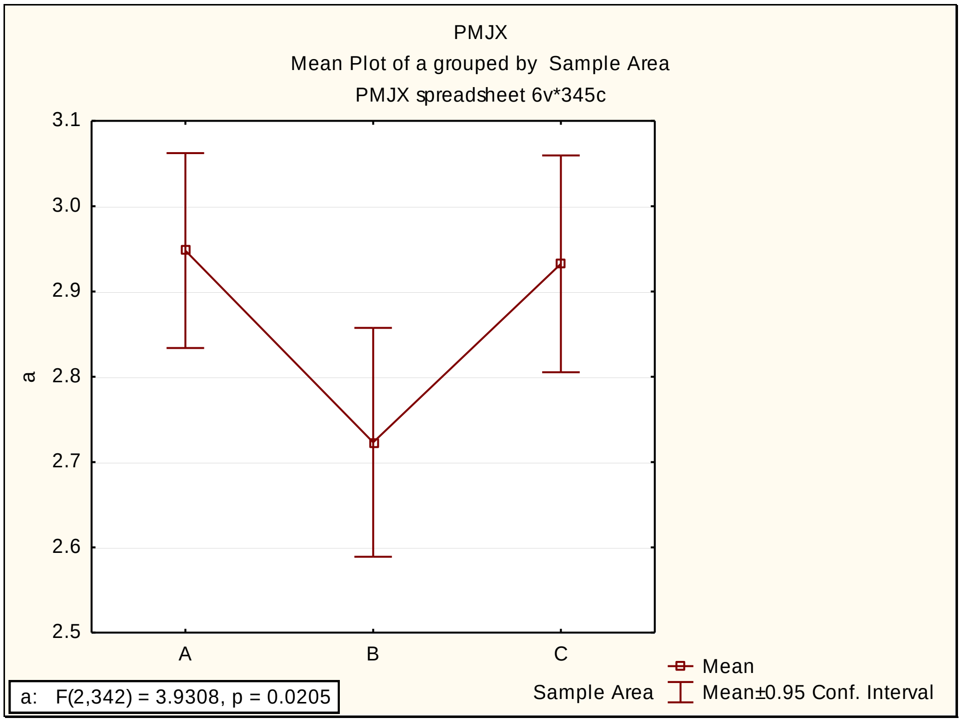
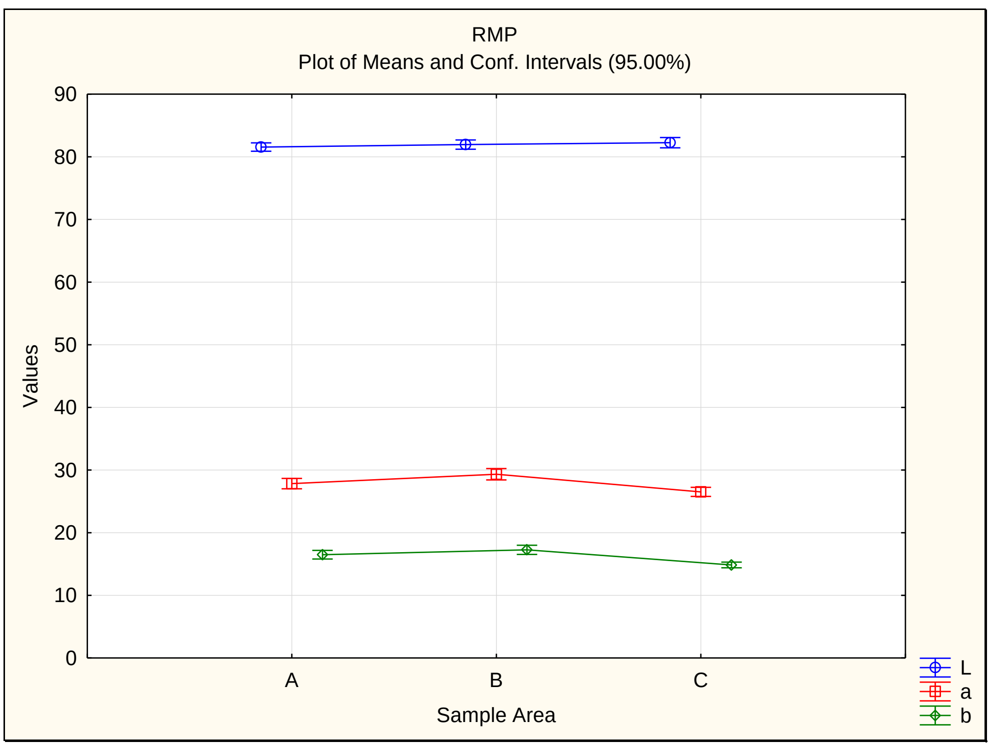
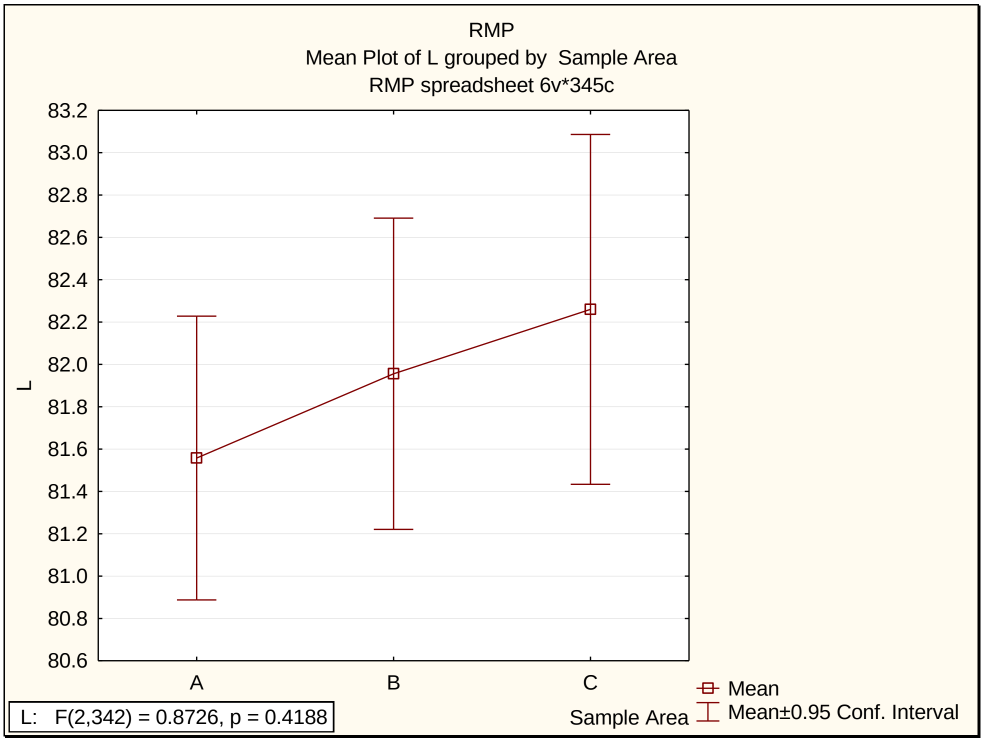
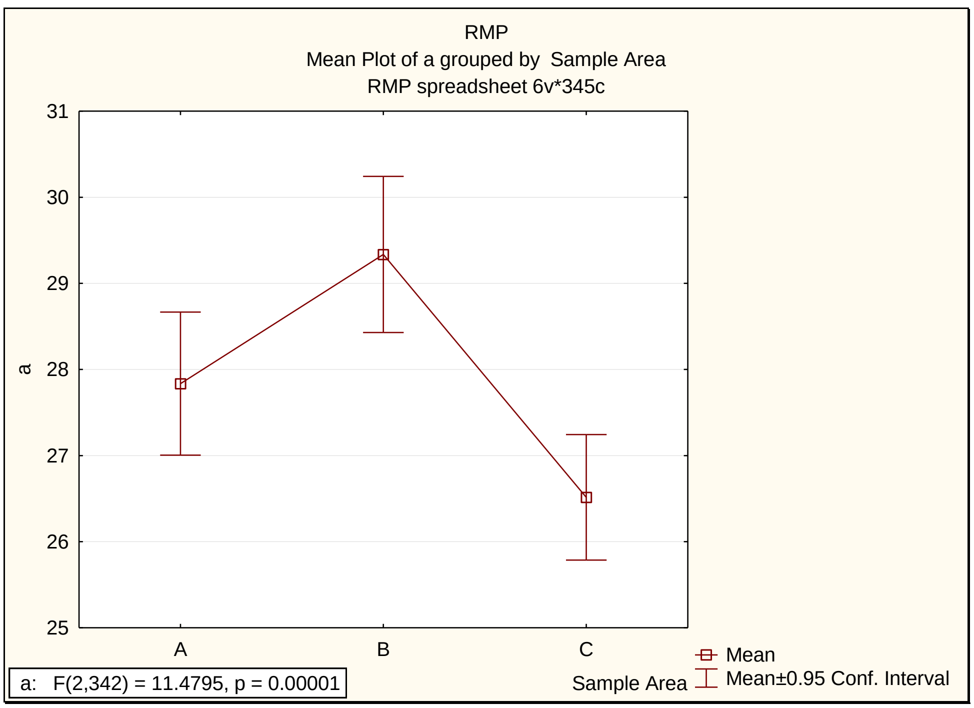


Figure 10.5 Mean plots for sample RMP grouped by 'Sample Area'




RMP
Mean Plot of L grouped by Sample Area
RMP spreadsheet 6v*345c
83.2
83.0
82.8
82.6
82.4
82.2
82.0
81.8
81.6
81.4
81.2
81.0
80.8
80.6
L
A
B
C
Sample Area
Mean
Mean±0.95 Conf. Interval
L: F(2,342) = 0.8726, p = 0.4188


RMP
Mean Plot of a grouped by Sample Area
RMP spreadsheet 6v*345c
31
30
29
28
27
26
25
a
A
B
C
Sample Area
Mean
Mean±0.95 Conf. Interval
a: F(2,342) = 11.4795, p = 0.00001

11. ANOVA Output for Aged Results- by 'Fiber'

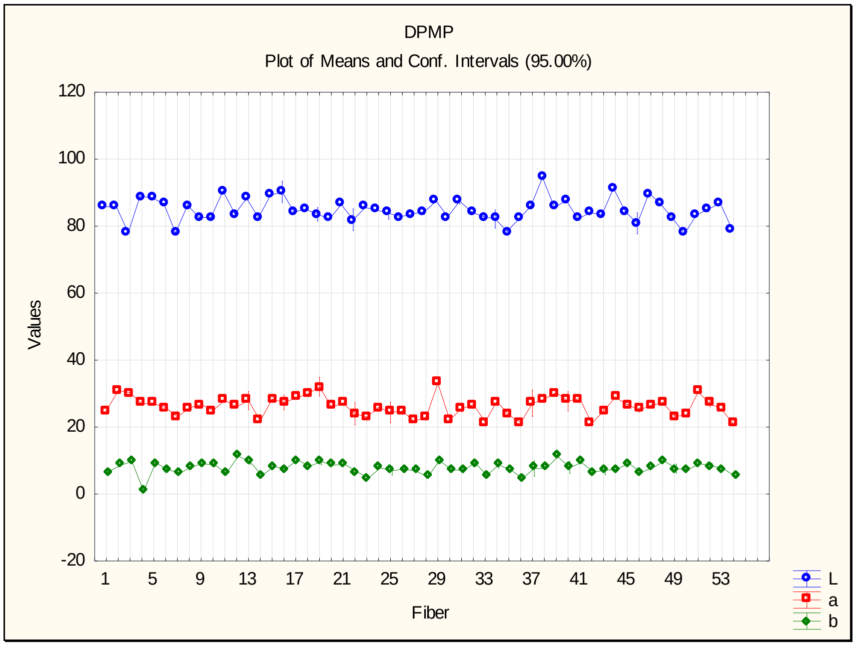
Table 11.1 ANOVA Output for reference samples grouped by 'Fiber'

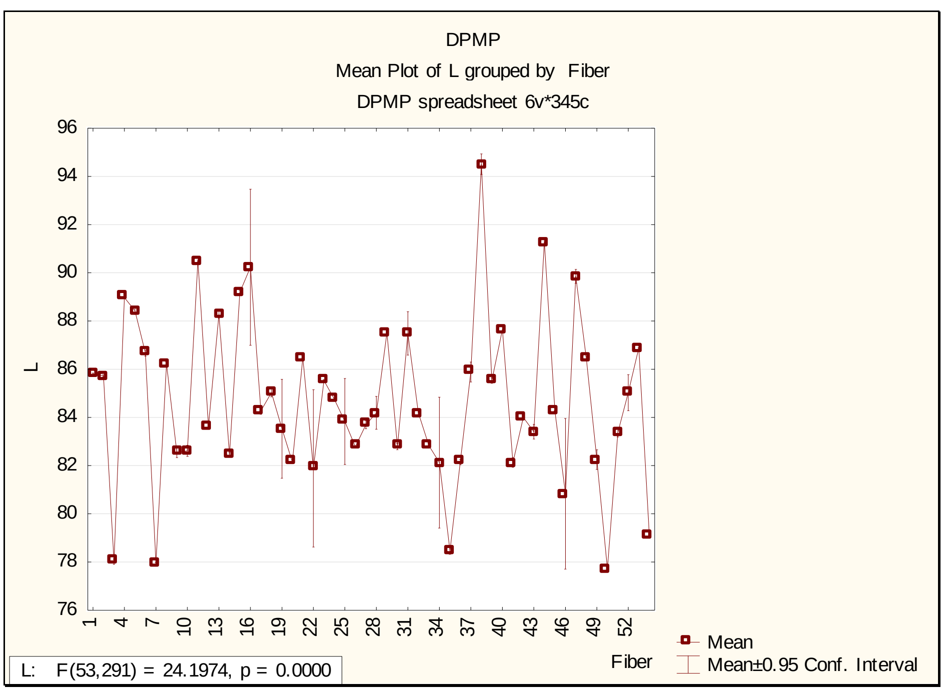
DPMP		Sum of Squares	df	Mean Square	F	Sig.
L	Between Groups	3729.974	53	70.377	24.197	.000
	Within Groups	846.357	291	2.908		
	Total	4576.331	344			
a	Between Groups	2590.726	53	48.882	11.772	.000
	Within Groups	1208.360	291	4.152		
	Total	3799.086	344			
b	Between Groups	964.170	53	18.192	16.174	.000
	Within Groups	327.302	291	1.125		
	Total	1291.472	344			
GMP		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
L	Between Groups	5582.6	53	105.331	17.454	.000
	Within Groups	1756.2	291	6.035		
	Total	7338.7	344			
a	Between Groups	246.2	53	4.646	35.870	.000
	Within Groups	37.690	291	.130		
	Total	283.9	344			
b	Between Groups	1270.6	53	23.973	16.416	.000
	Within Groups	425.0	291	1.460		
	Total	1695.6	344			
OSDP		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
L	Between Groups	5694.21	53	107.438	30.377	.000
	Within Groups	1029.22	291	3.537		
	Total	6723.44	344			
a	Between Groups	753.18	53	14.211	19.552	.000
	Within Groups	211.51	291	.727		
	Total	964.69	344			
b	Between Groups	7484.85	53	141.224	26.847	.000
	Within Groups	1530.76	291	5.260		
	Total	9015.61	344			
PMCL		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
L	Between Groups	5972.71	53	112.693	18.012	.000
	Within Groups	1820.65	291	6.257		
	Total	7793.36	344			
a	Between Groups	158.45	53	2.990	28.705	.000
	Within Groups	30.308	291	.104		
	Total	188.76	344			
b	Between Groups	464.20	53	8.758	32.502	.000
	Within Groups	78.417	291	.269		
	Total	542.62	344			

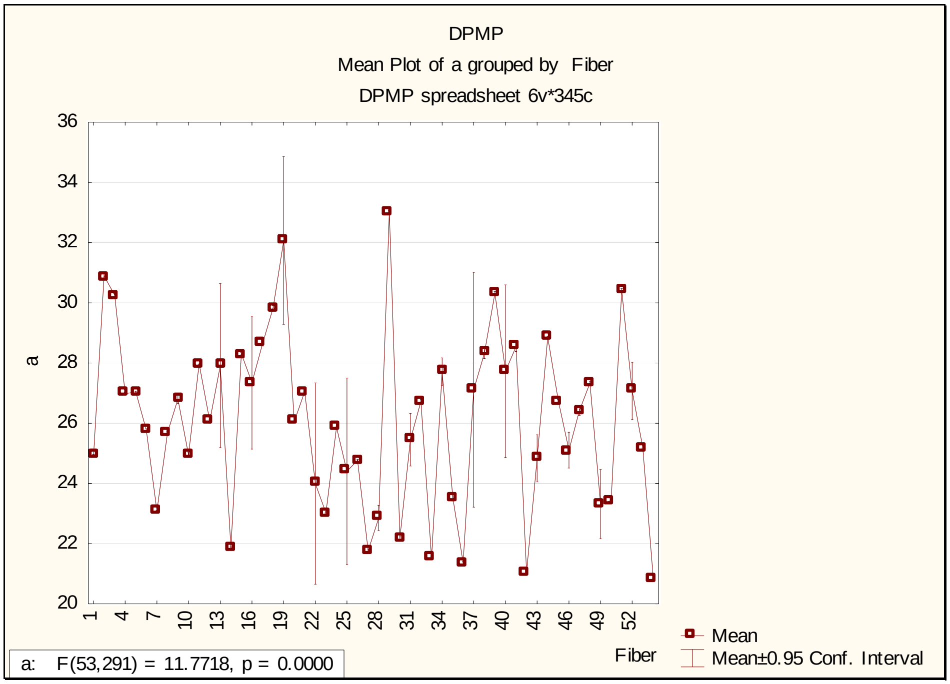
PMJX		Sum of Squares	df	Mean Square	F	Sig.
L	Between Groups	5621.41	53	106.064	58.524	.000
	Within Groups	527.385	291	1.812		
	Total	6148.79	344			
a	Between Groups	130.422	53	2.461	23.160	.000
	Within Groups	30.920	291	.106		
	Total	161.342	344			
b	Between Groups	546.357	53	10.309	28.840	.000
	Within Groups	104.016	291	.357		
	Total	650.373	344			
PMP		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
L	Between Groups	6011.57	53	113.426	28.306	.000
	Within Groups	1166.09	291	4.007		
	Total	7177.65	344			
a	Between Groups	659.299	53	12.440	34.481	.000
	Within Groups	104.982	291	.361		
	Total	764.281	344			
b	Between Groups	3149.89	53	59.432	46.654	.000
	Within Groups	370.704	291	1.274		
	Total	3520.59	344			
RMP		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
L	Between Groups	4772.382	53	90.045	31.094	.000
	Within Groups	842.716	291	2.896		
	Total	5615.098	344			
a	Between Groups	6101.980	53	115.132	28.351	.000
	Within Groups	1181.724	291	4.061		
	Total	7283.704	344			
b	Between Groups	3966.695	53	74.843	49.779	.000
	Within Groups	437.522	291	1.504		
	Total	4404.217	344			

12. Mean Plots of Aged Results

Figure 12.1: Mean plots of sample DPMP grouped by 'Fiber'






DPMP
Mean Plot of a grouped by Fiber
DPMP spreadsheet 6v*345c
a
Fiber
Mean
Mean±0.95 Conf. Interval
a: F(53,291) = 11.7718, p = 0.0000

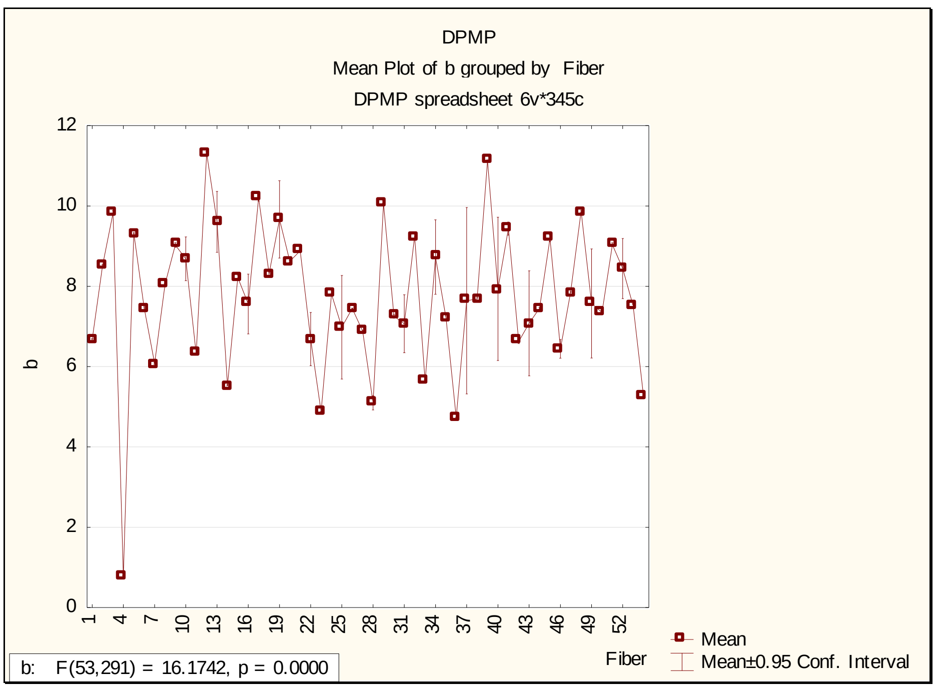
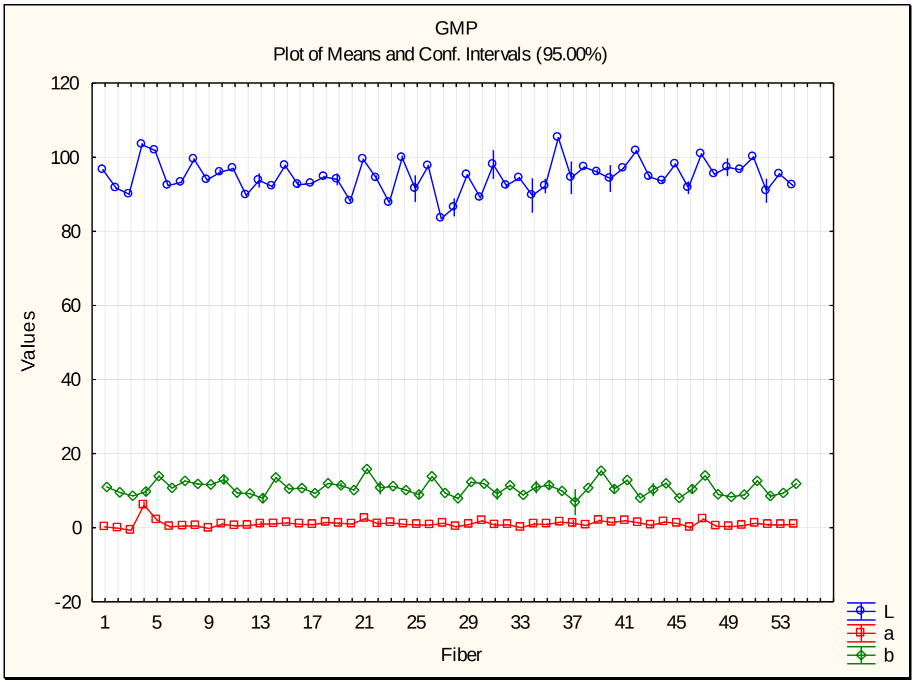
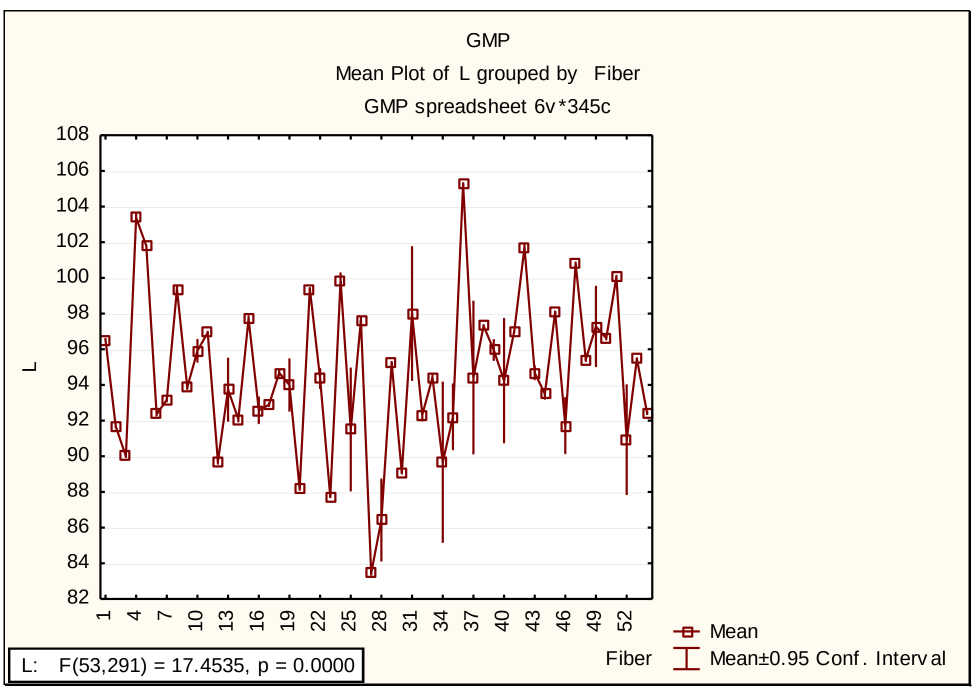
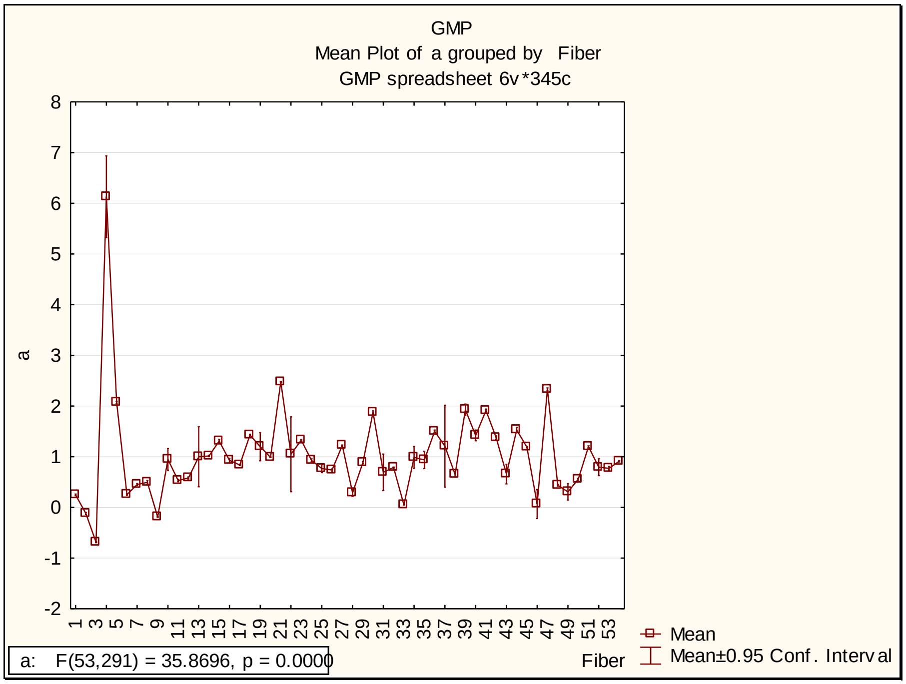

DPMP
Mean Plot of b grouped by Fiber
DPMP spreadsheet 6v*345c
b
Fiber
Mean
Mean±0.95 Conf. Interval
b: F(53,291) = 16.1742, p = 0.0000

Figure 12.2: Mean plots of sample GMP grouped by 'Fiber'






GMP
Mean Plot of a grouped by Fiber
GMP spreadsheet 6v*345c
a
Fiber
Mean
Mean±0.95 Conf. Interval
a: F(53,291) = 35.8696, p = 0.0000

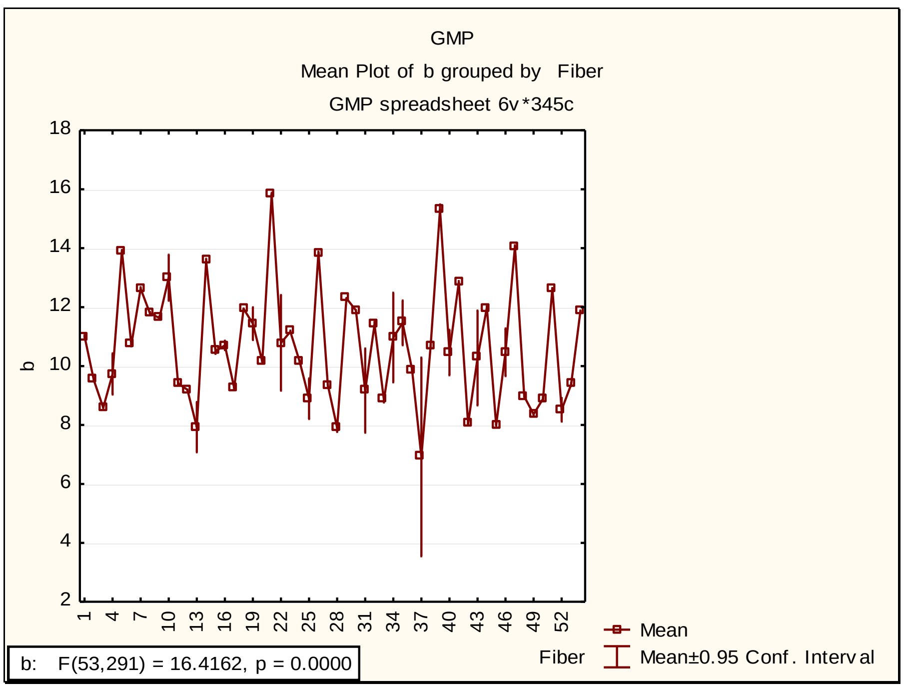
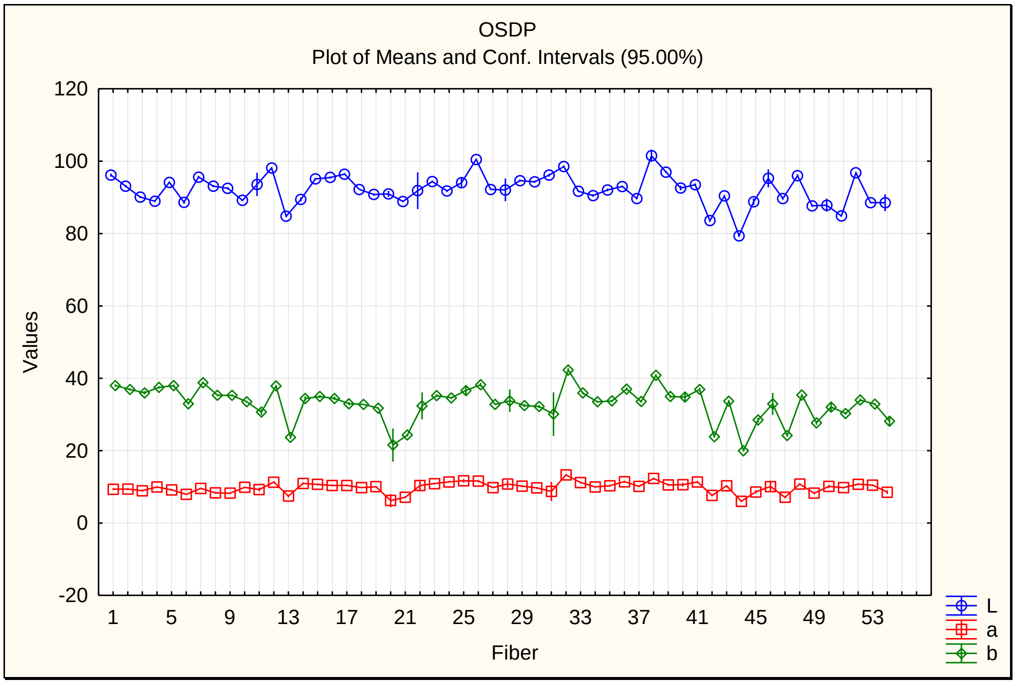
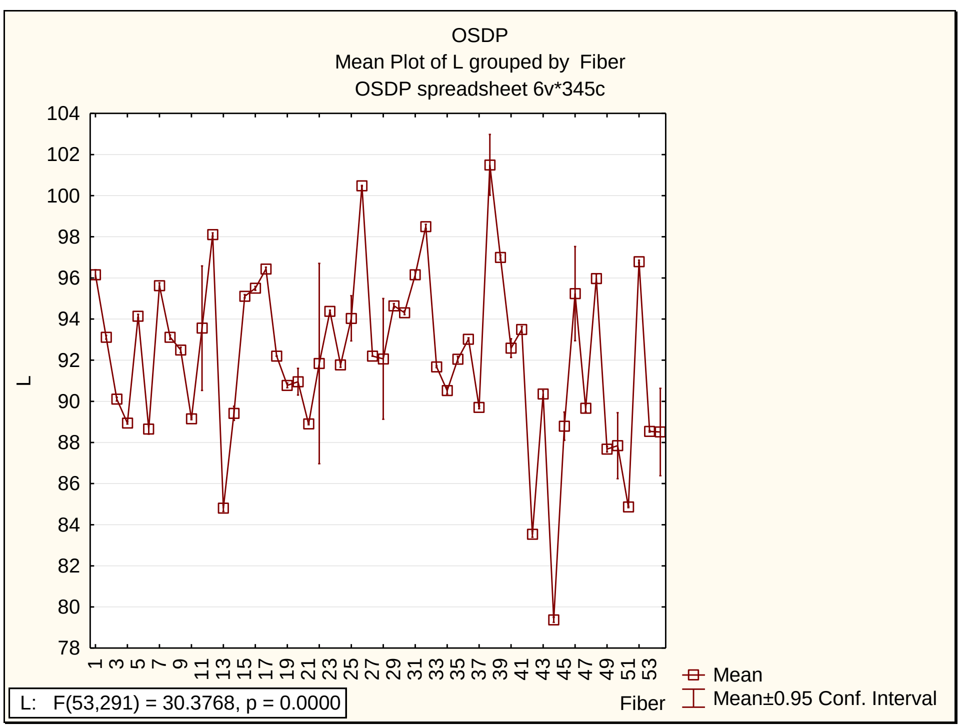
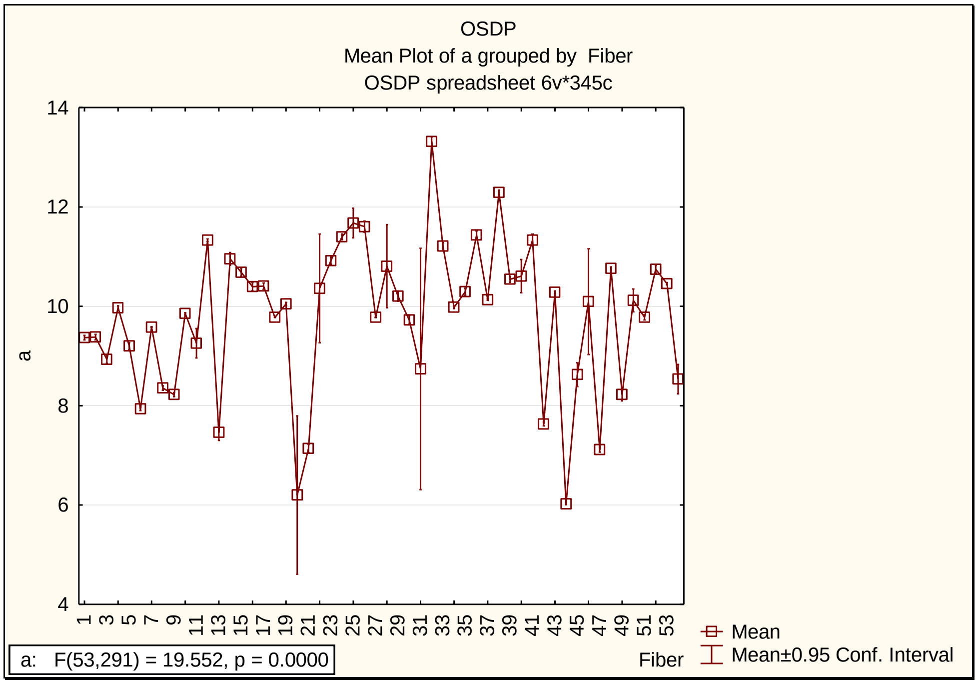

GMP
Mean Plot of b grouped by Fiber
GMP spreadsheet 6v*345c
b
Fiber
Mean
Mean±0.95 Conf. Interval
b: F(53,291) = 16.4162, p = 0.0000

Figure 12.3: Mean plots of sample OSDP grouped by 'Fiber'






OSDP
Mean Plot of a grouped by Fiber
OSDP spreadsheet 6v*345c
a
Fiber
Mean
Mean±0.95 Conf. Interval
a: F(53,291) = 19.552, p = 0.0000

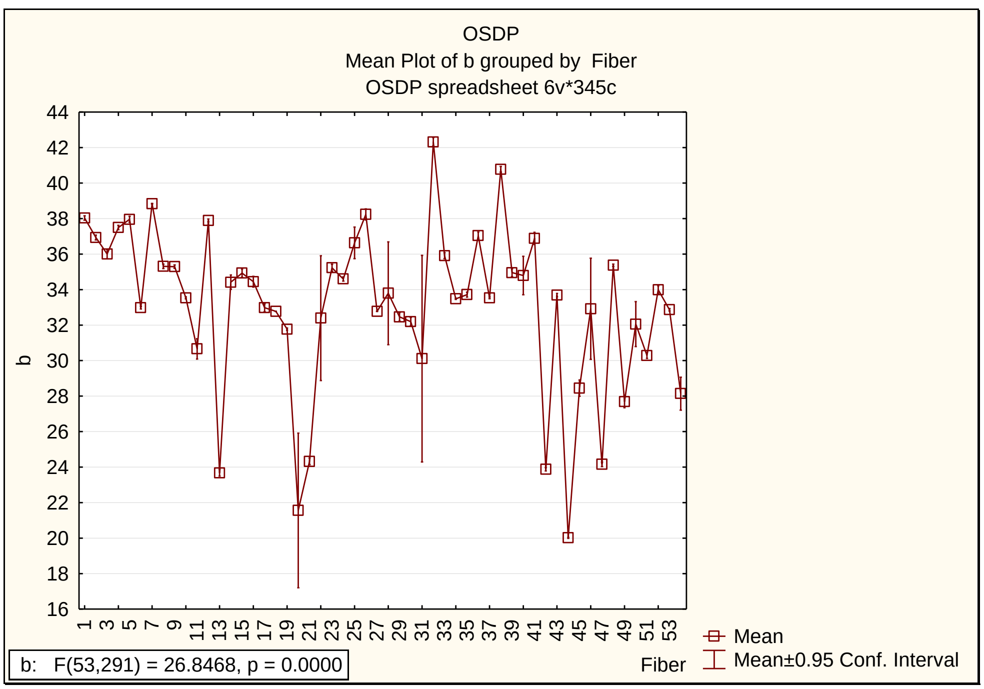
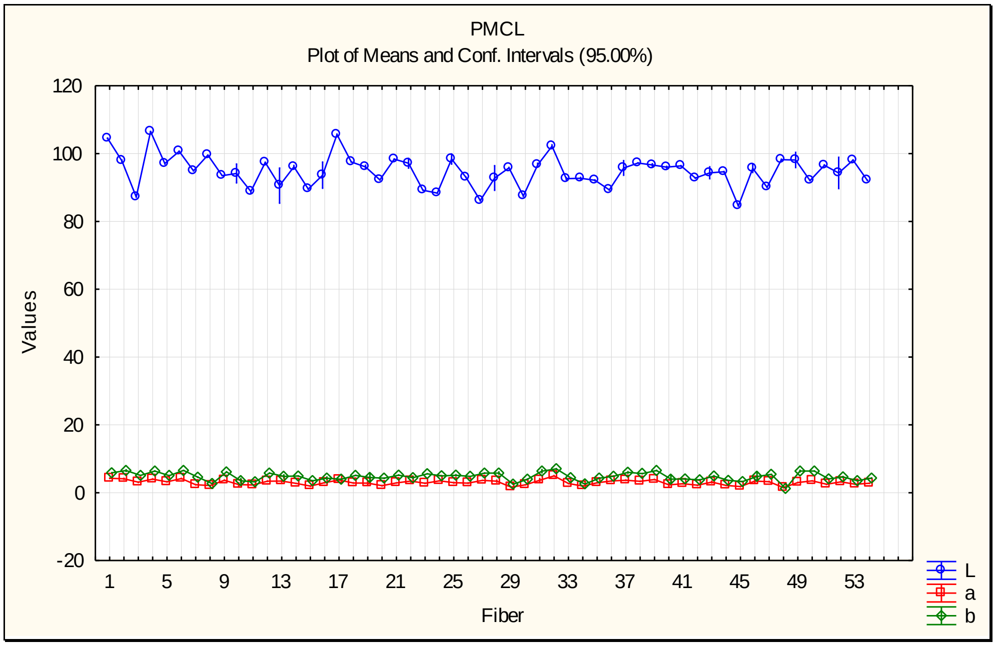
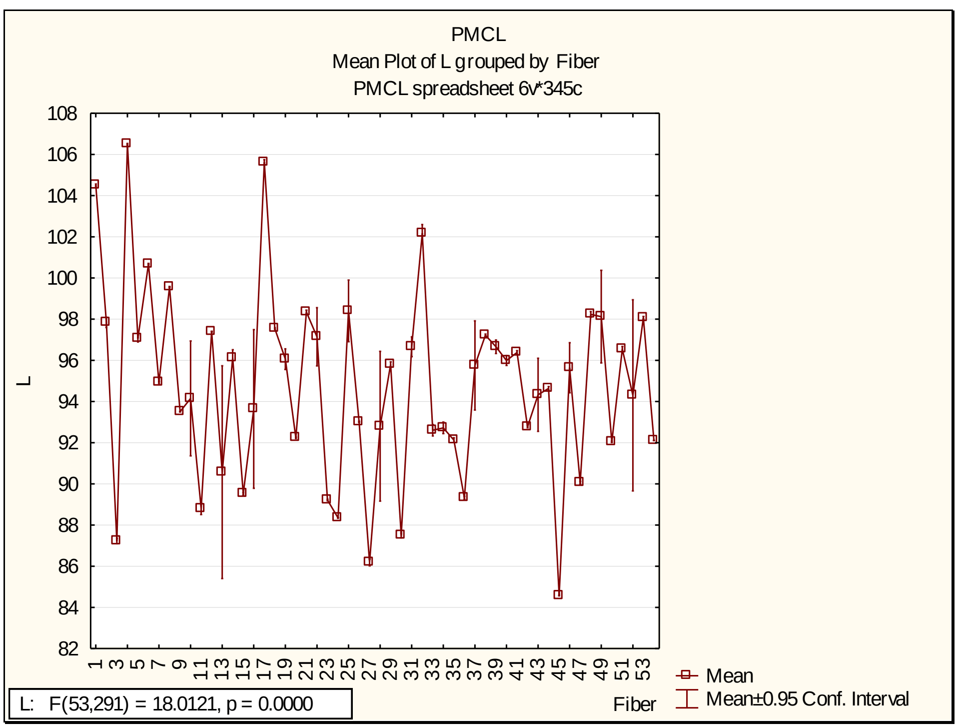
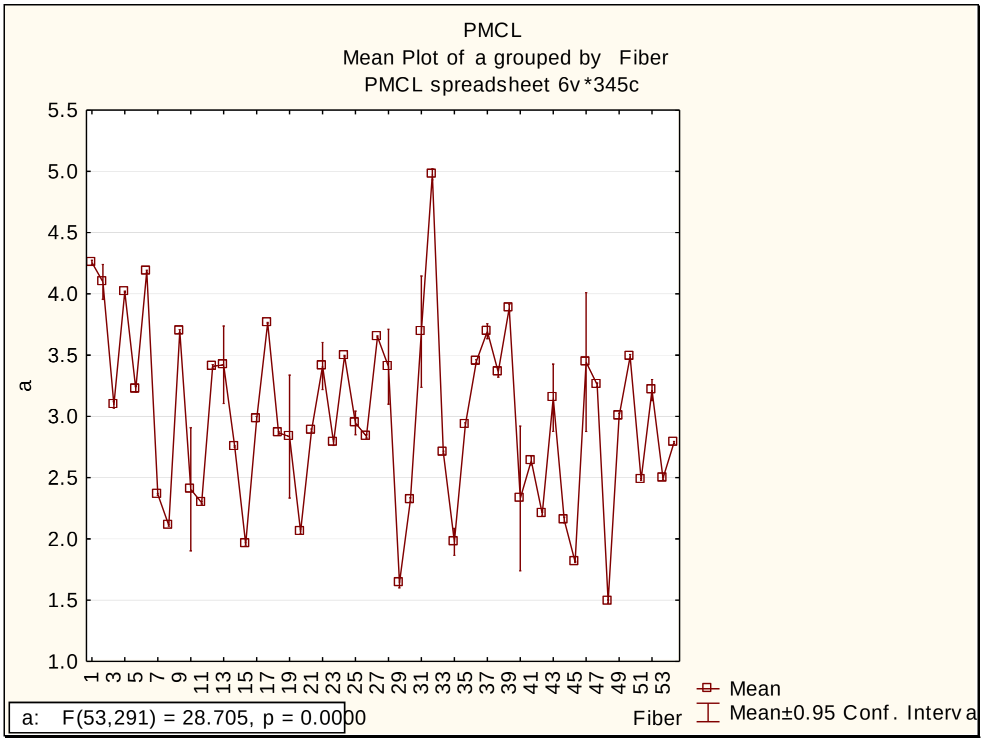

OSDP
Mean Plot of b grouped by Fiber
OSDP spreadsheet 6v*345c
b
Fiber
Mean
Mean±0.95 Conf. Interval
b: F(53,291) = 26.8468, p = 0.0000

Figure 12.4: Mean plots of sample PMCL grouped by 'Fiber'






PMCL
Mean Plot of a grouped by Fiber
PMCL spreadsheet 6v*345c
a
Fiber
Mean
Mean±0.95 Conf. Interval
a: F(53,291) = 28.705, p = 0.0000

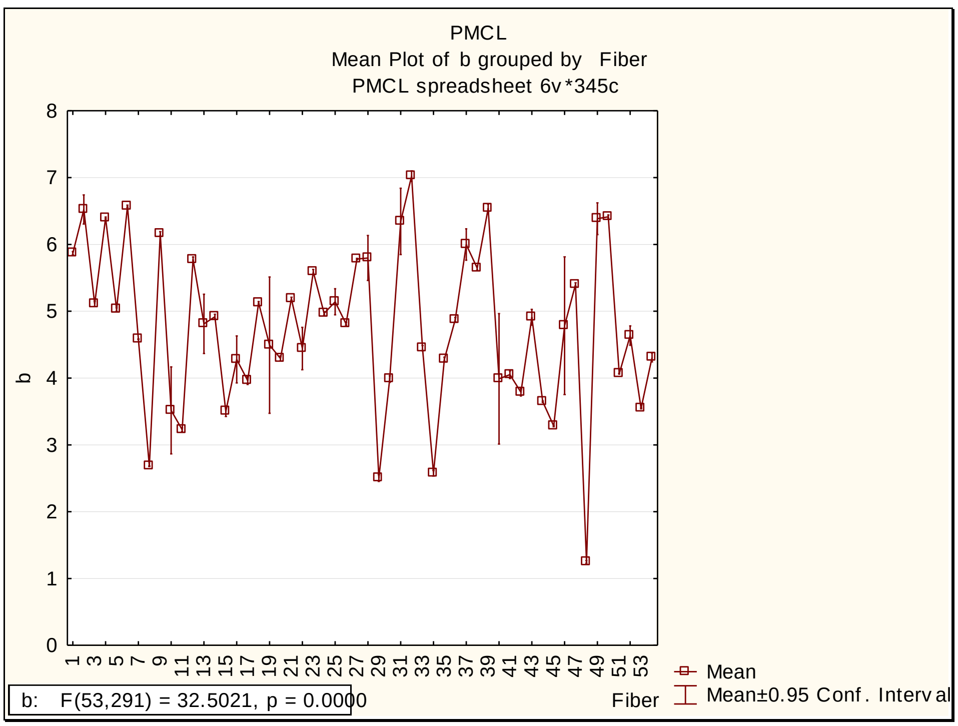
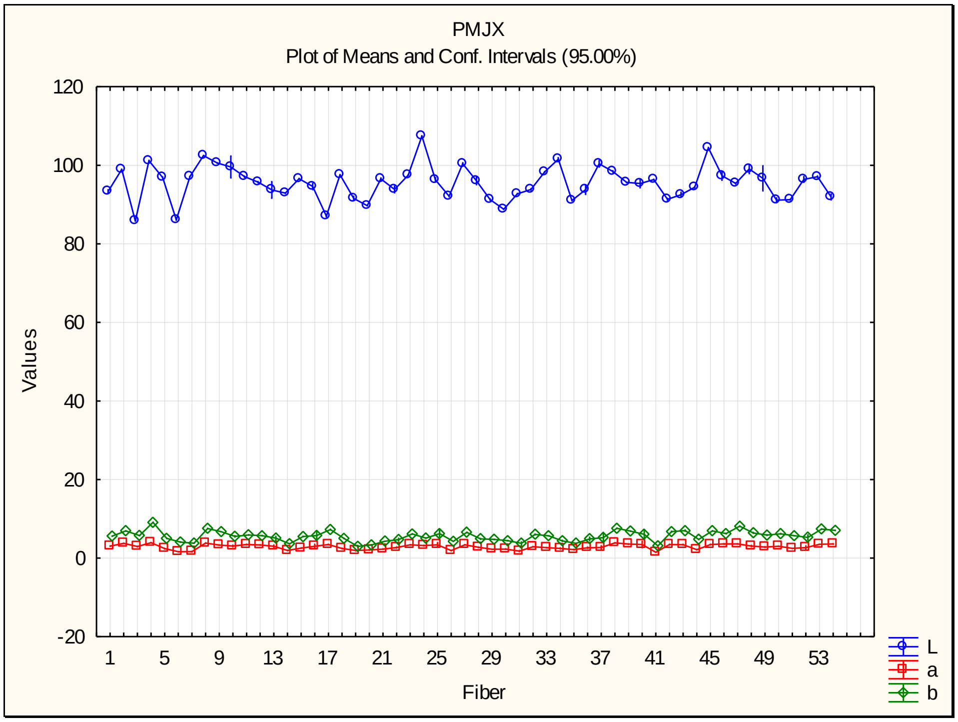
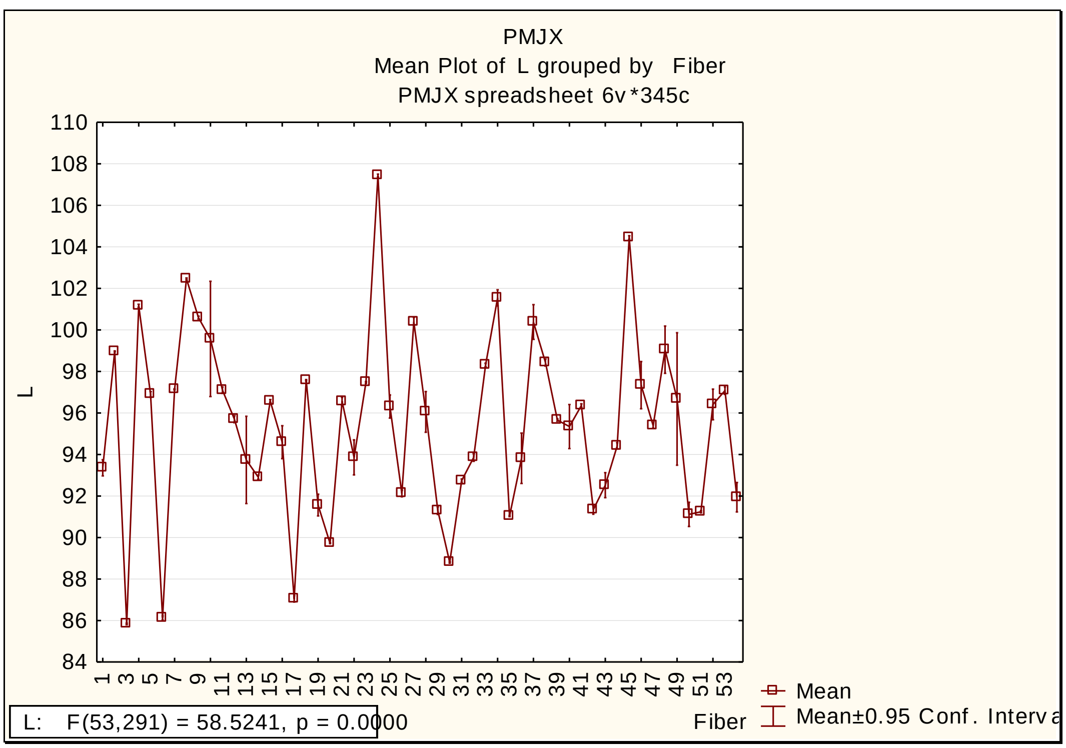

PMCL
Mean Plot of b grouped by Fiber
PMCL spreadsheet 6v*345c
b
Fiber
Mean
Mean±0.95 Conf. Interval
b: F(53,291) = 32.5021, p = 0.0000

Figure 12.5: Mean plots of sample PMJX grouped by 'Fiber'





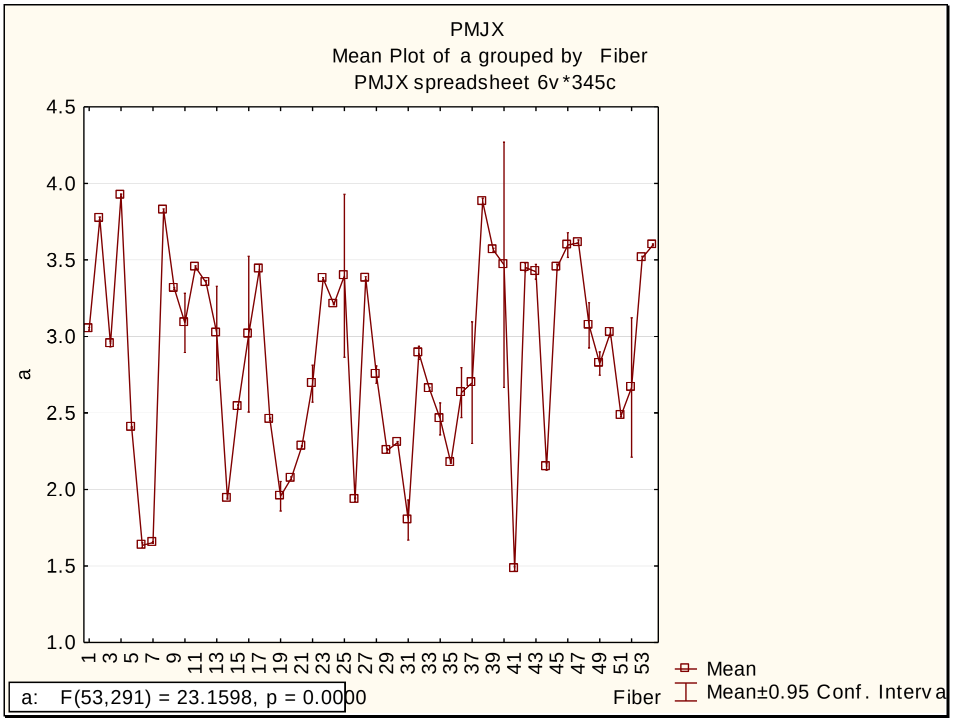
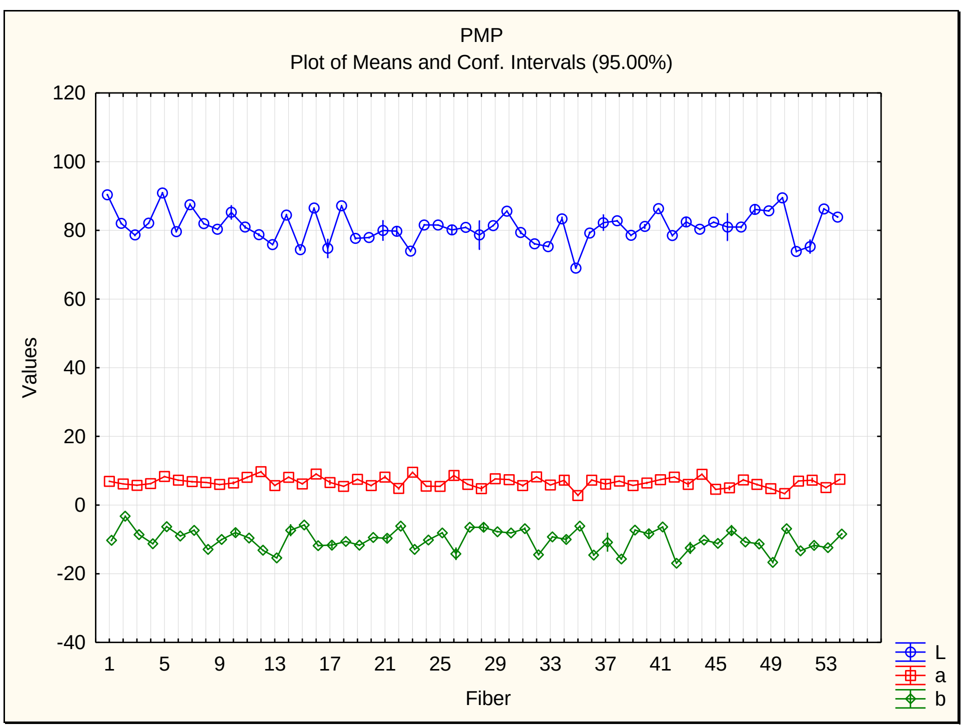
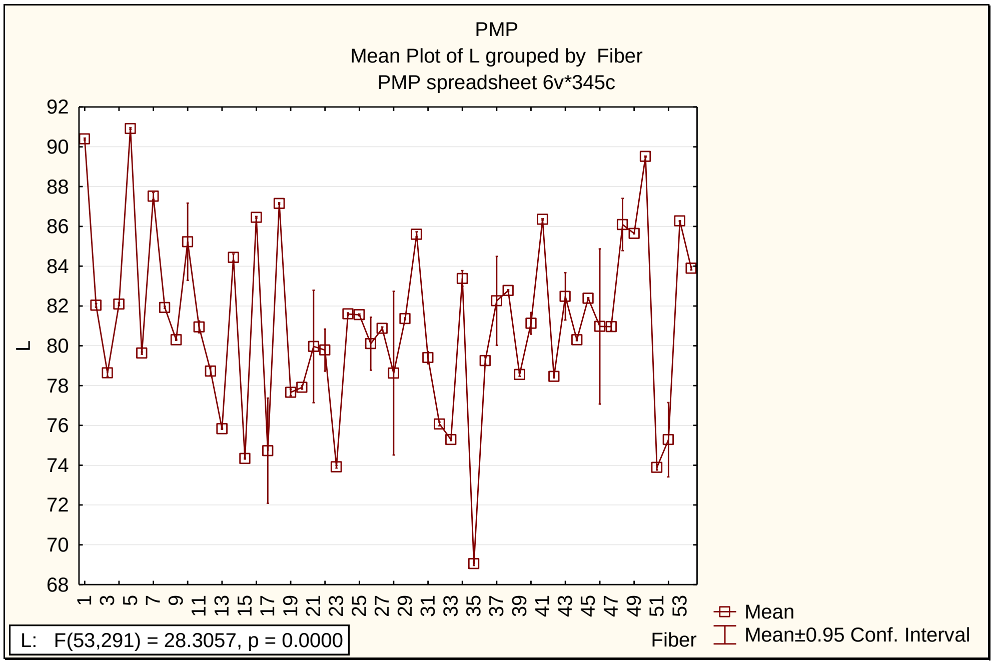
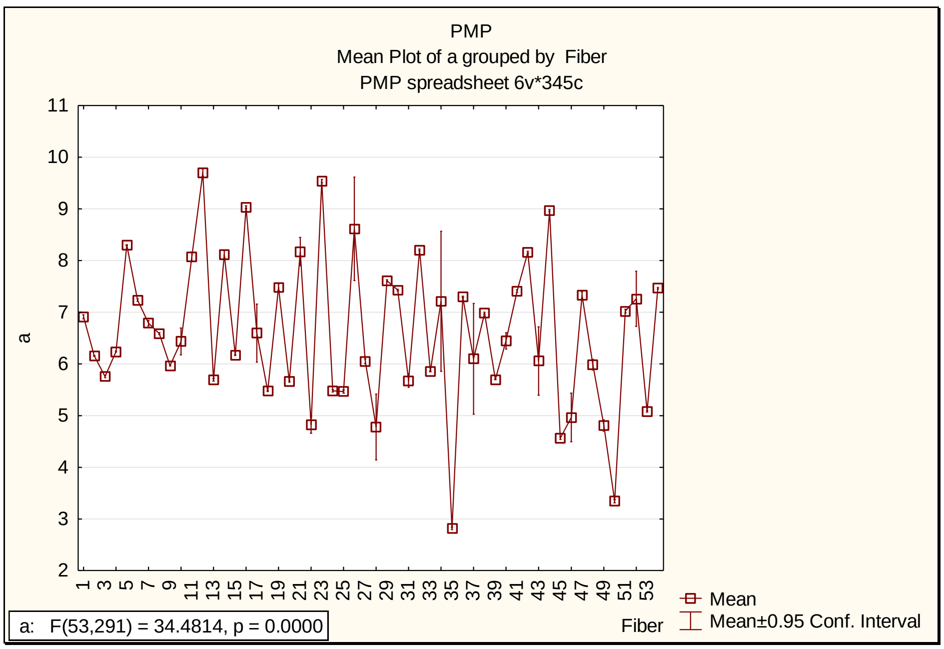


Figure 12.6: Mean plots of sample PMP grouped by 'Fiber'




PMP
Mean Plot of L grouped by Fiber
PMP spreadsheet 6v*345c
L
92
90
88
86
84
82
80
78
76
74
72
70
68
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53
Fiber
Mean
Mean±0.95 Conf. Interval
L: F(53,291) = 28.3057, p = 0.0000


PMP
Mean Plot of a grouped by Fiber
PMP spreadsheet 6v*345c
a
11
10
9
8
7
6
5
4
3
2
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53
Fiber
Mean
Mean±0.95 Conf. Interval
a: F(53,291) = 34.4814, p = 0.0000

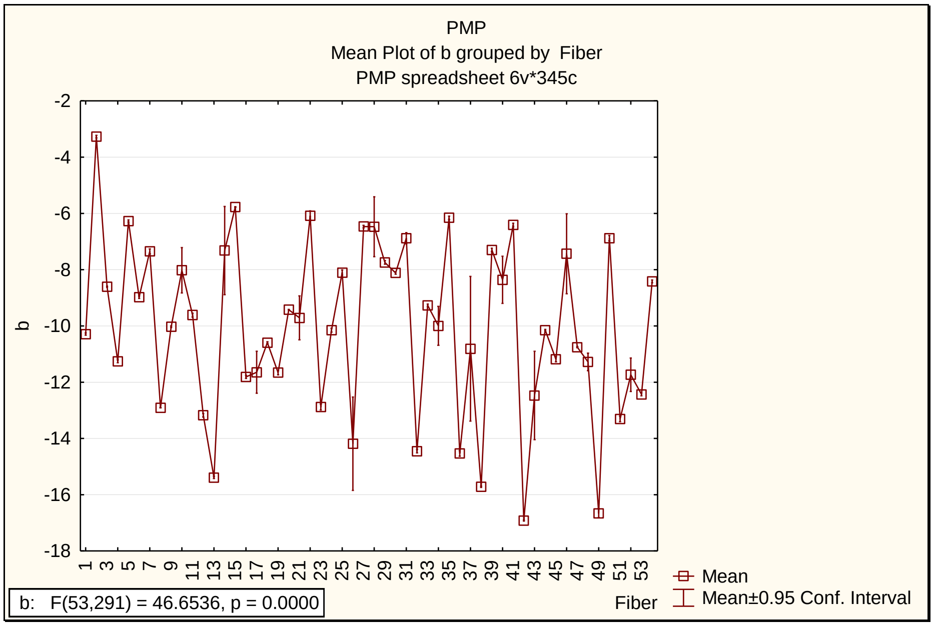
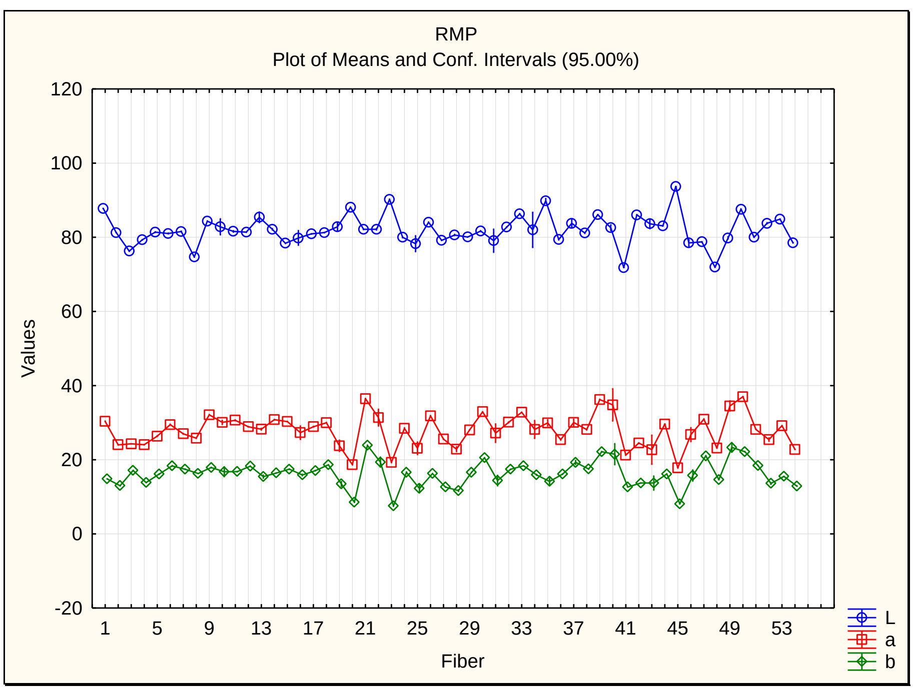
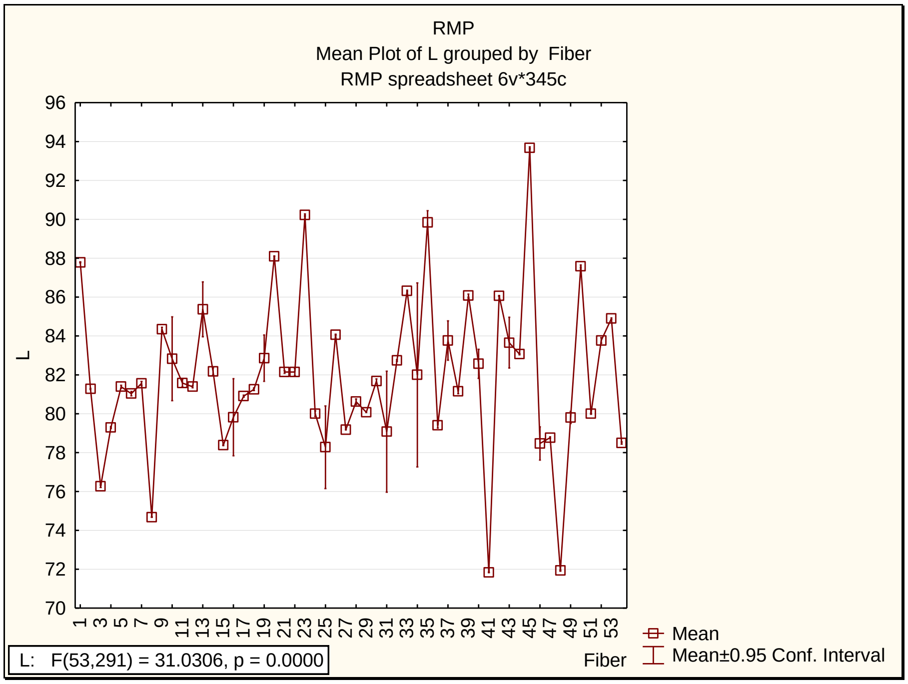
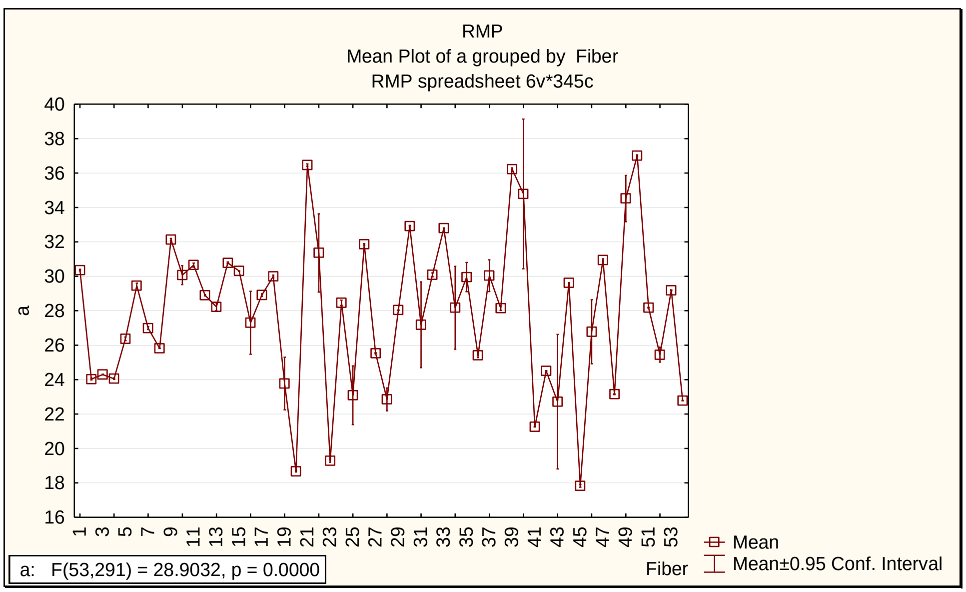
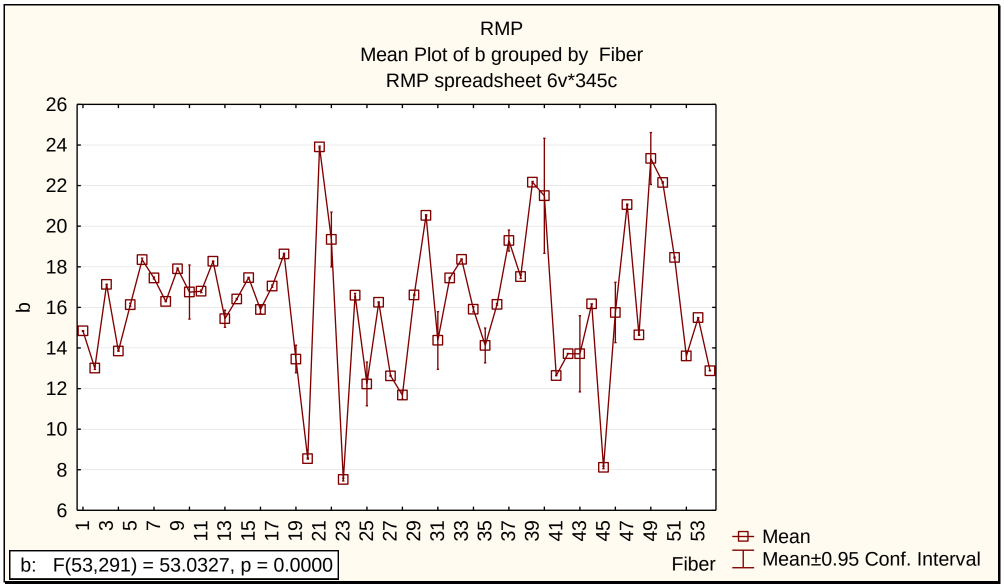


Figure 12.7: Mean plots of sample RMP grouped by 'Fiber'



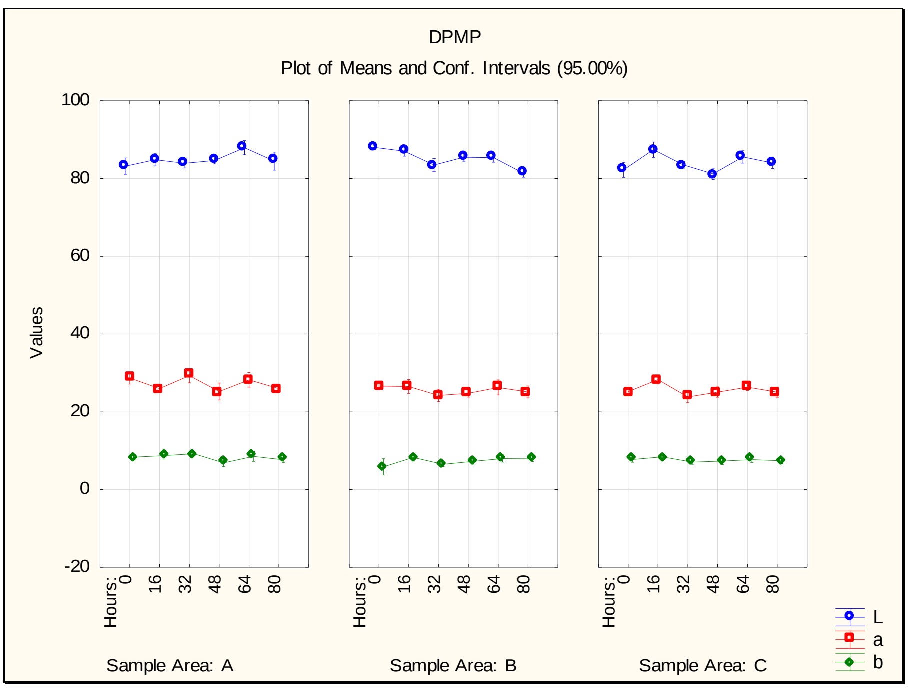

RMP
Mean Plot of L grouped by Fiber
RMP spreadsheet 6v*345c
L
Fiber
Mean
Mean±0.95 Conf. Interval
L: F(53,291) = 31.0306, p = 0.0000

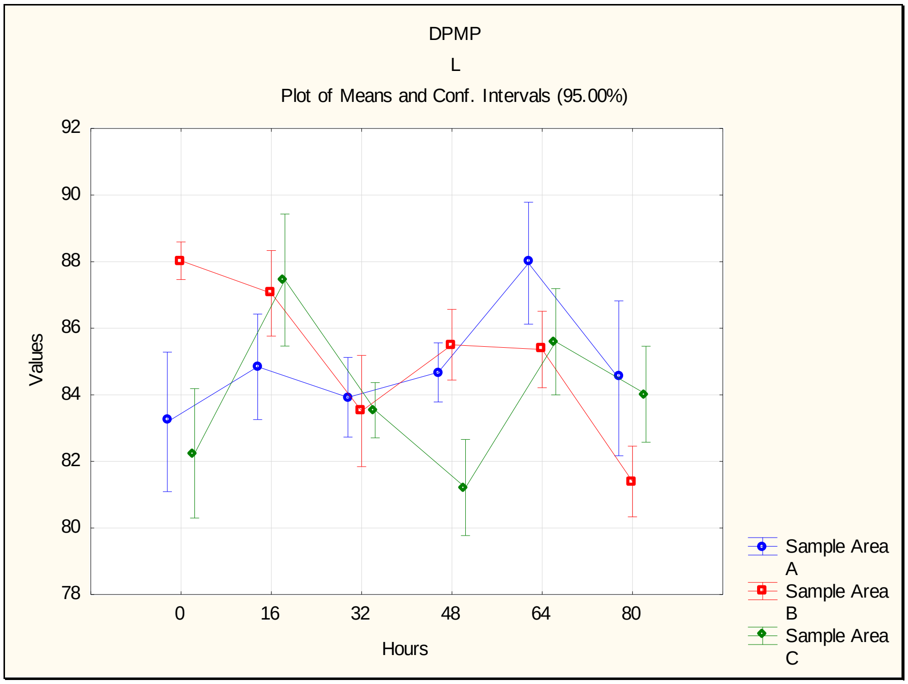

RMP
Mean Plot of a grouped by Fiber
RMP spreadsheet 6v*345c
a
Fiber
Mean
Mean±0.95 Conf. Interval
a: F(53,291) = 28.9032, p = 0.0000



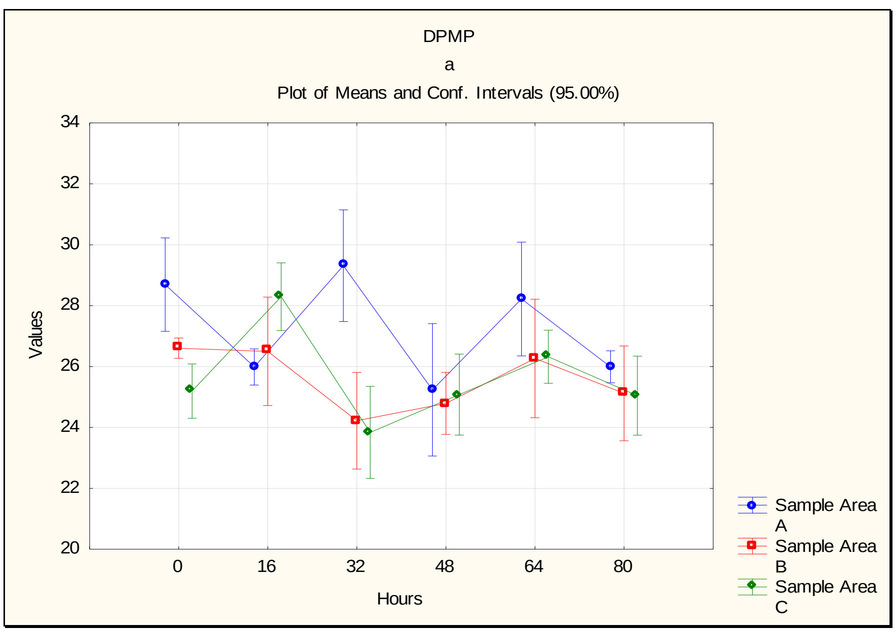
13. *ANOVA Interaction Plots*

Figure 13.1: Interaction plots of 'Hours Sample Area' for sample DPMP at each variable*





DPMP
L
Plot of Means and Conf. Intervals (95.00%)
Values
92
90
88
86
84
82
80
78
0
16
32
48
64
80
Hours
Sample Area A
Sample Area B
Sample Area C



DPMP
a
Plot of Means and Conf. Intervals (95.00%)
Values
34
32
30
28
26
24
22
20
0
16
32
48
64
80
Hours
Sample Area A
Sample Area B
Sample Area C

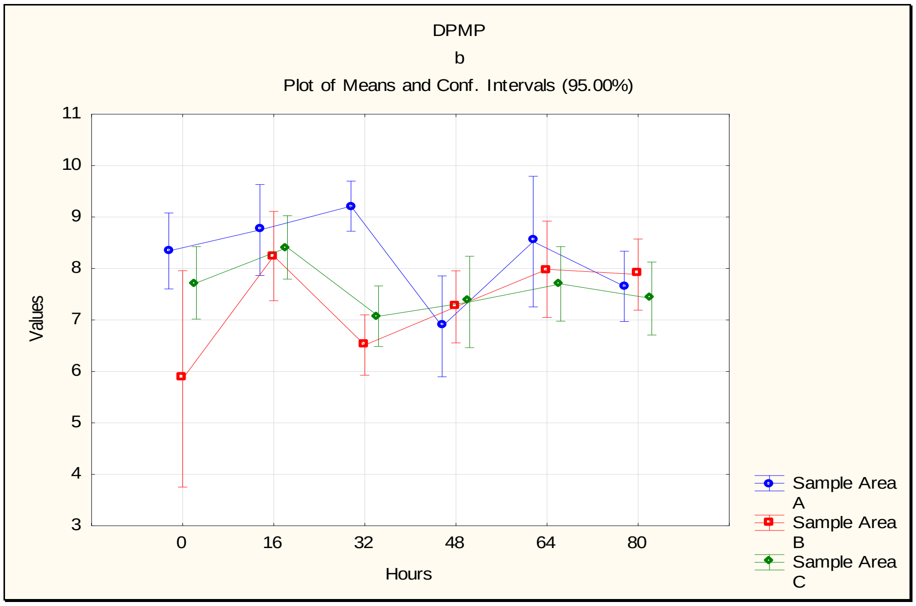
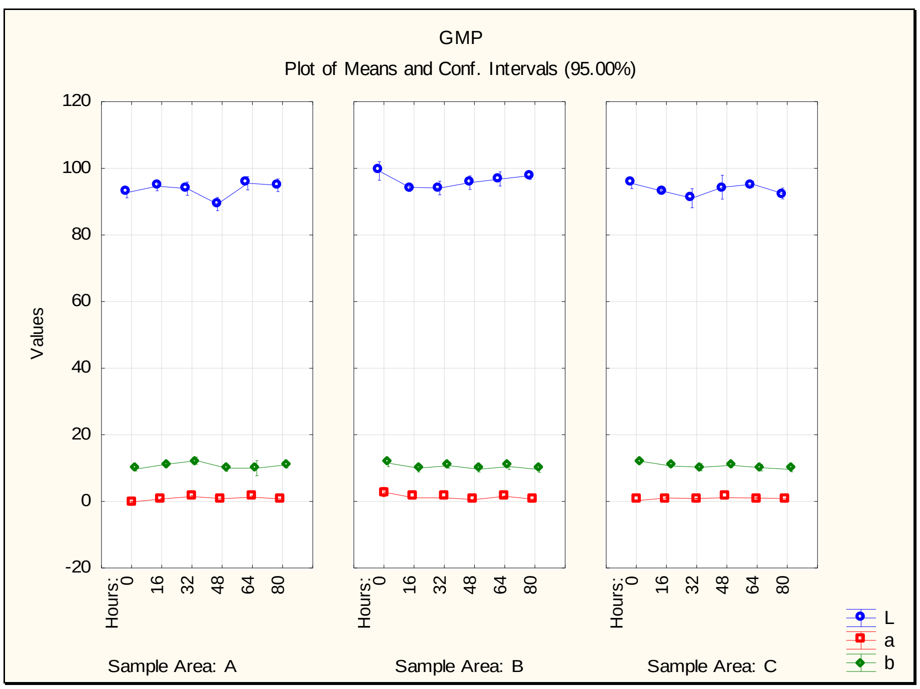
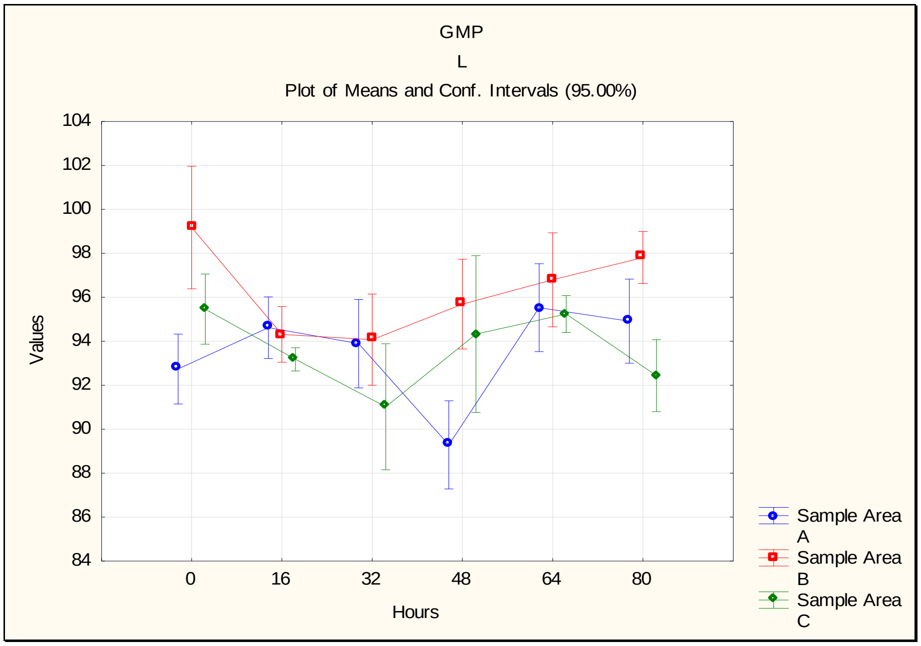
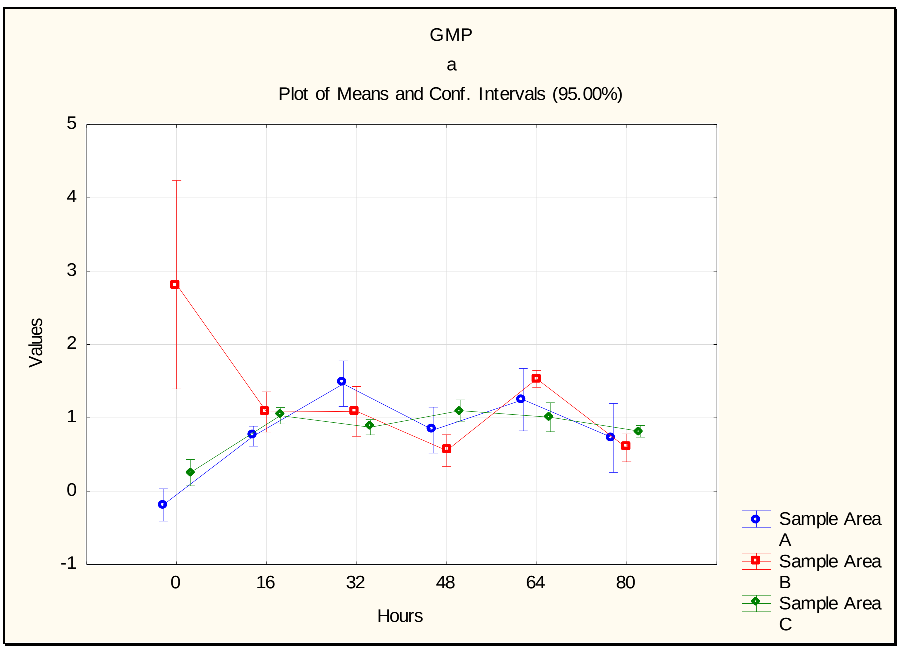


Figure 13.2: Interaction plots of 'Hours Sample Area' for sample GMP at each variable*




GMP
L
Plot of Means and Conf. Intervals (95.00%)
Values
104
102
100
98
96
94
92
90
88
86
84
0
16
32
48
64
80
Hours
Sample Area A
Sample Area B
Sample Area C


GMP
a
Plot of Means and Conf. Intervals (95.00%)
Values
5
4
3
2
1
0
-1
0
16
32
48
64
80
Hours
Sample Area A
Sample Area B
Sample Area C

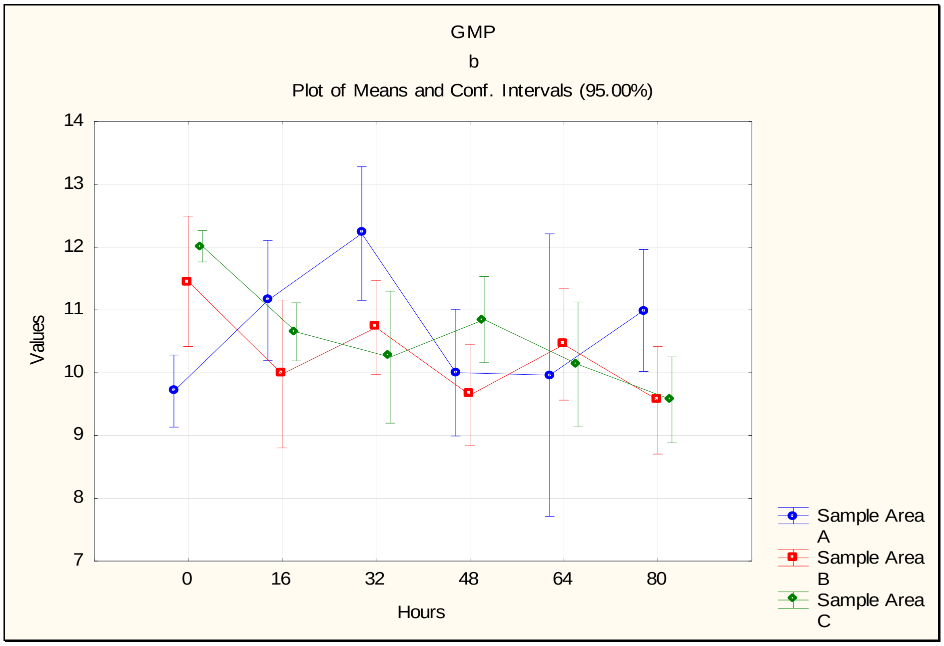
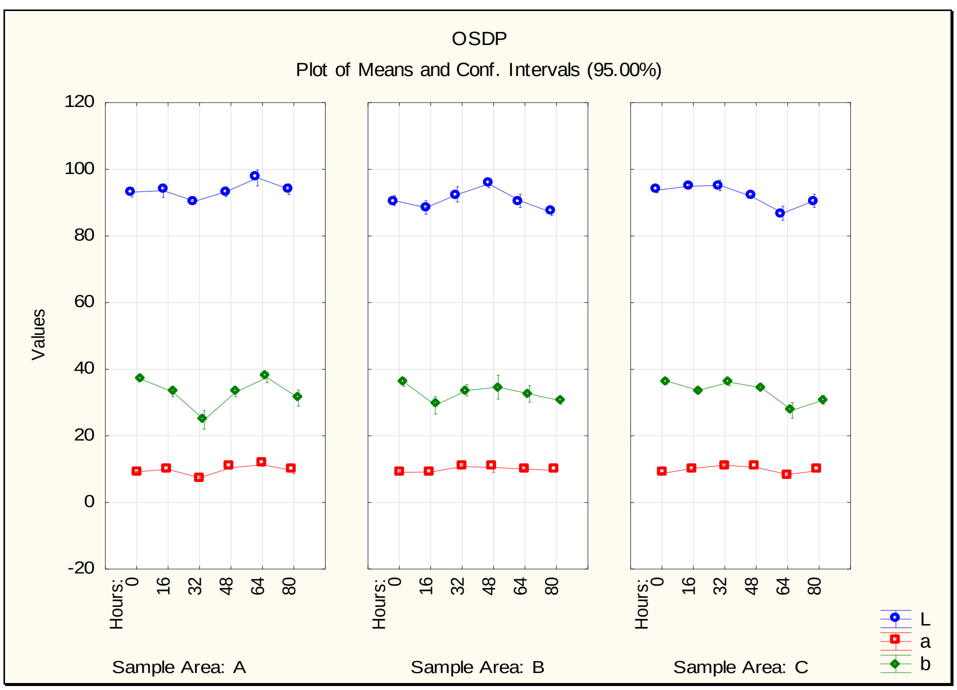
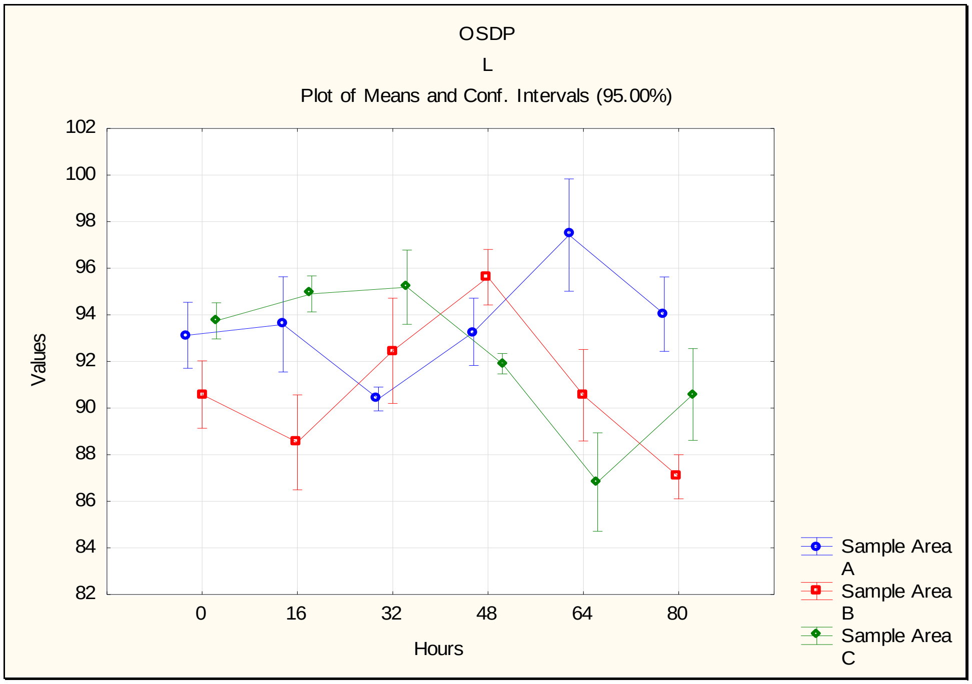
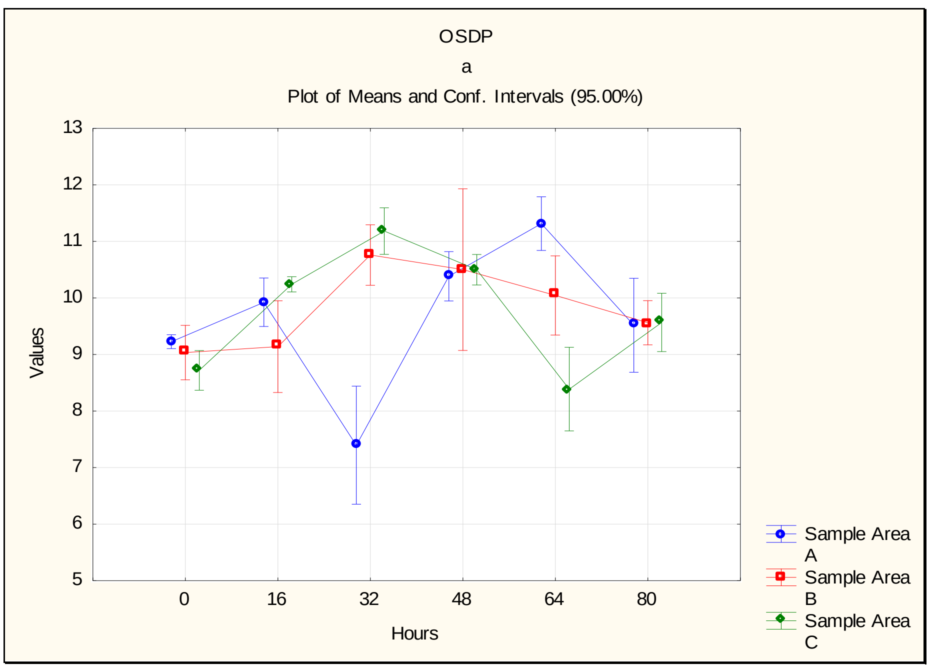


Figure 13.3: Interaction plots of 'Hours Sample Area' for sample OSDP at each variable*




OSDP
L
Plot of Means and Conf. Intervals (95.00%)
Values
Hours
0 16 32 48 64 80
82 84 86 88 90 92 94 96 98 100 102
Sample Area A
Sample Area B
Sample Area C


OSDP
a
Plot of Means and Conf. Intervals (95.00%)
Values
Hours
0 16 32 48 64 80
5 6 7 8 9 10 11 12 13
Sample Area A
Sample Area B
Sample Area C

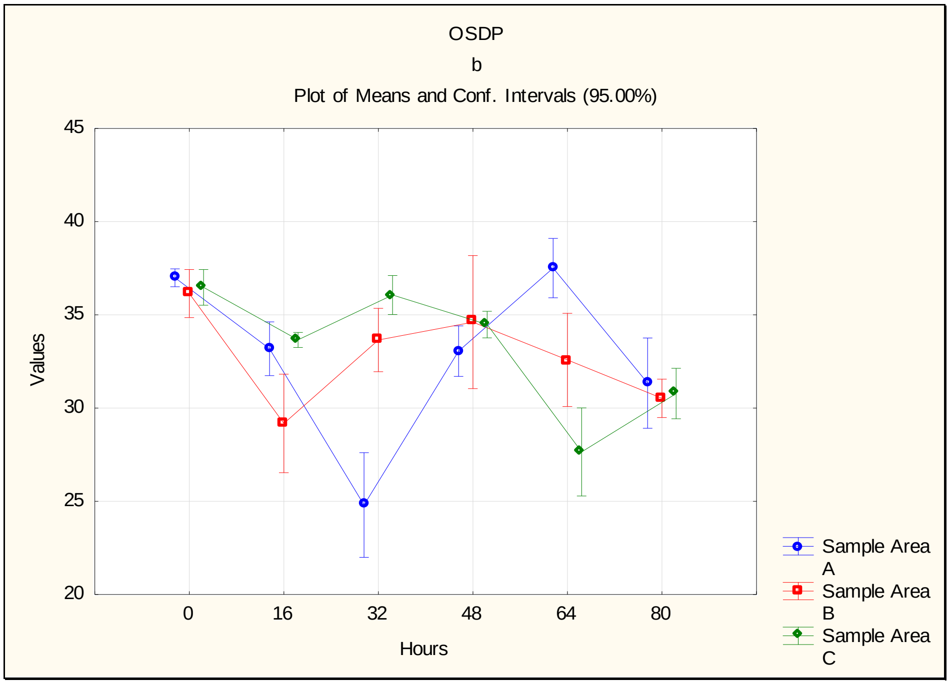
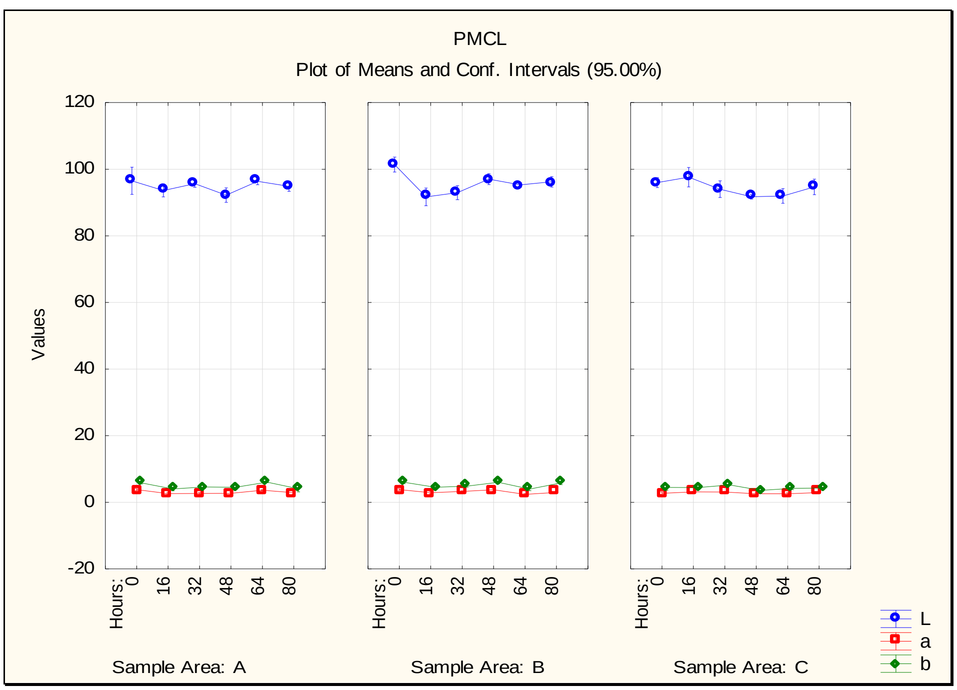
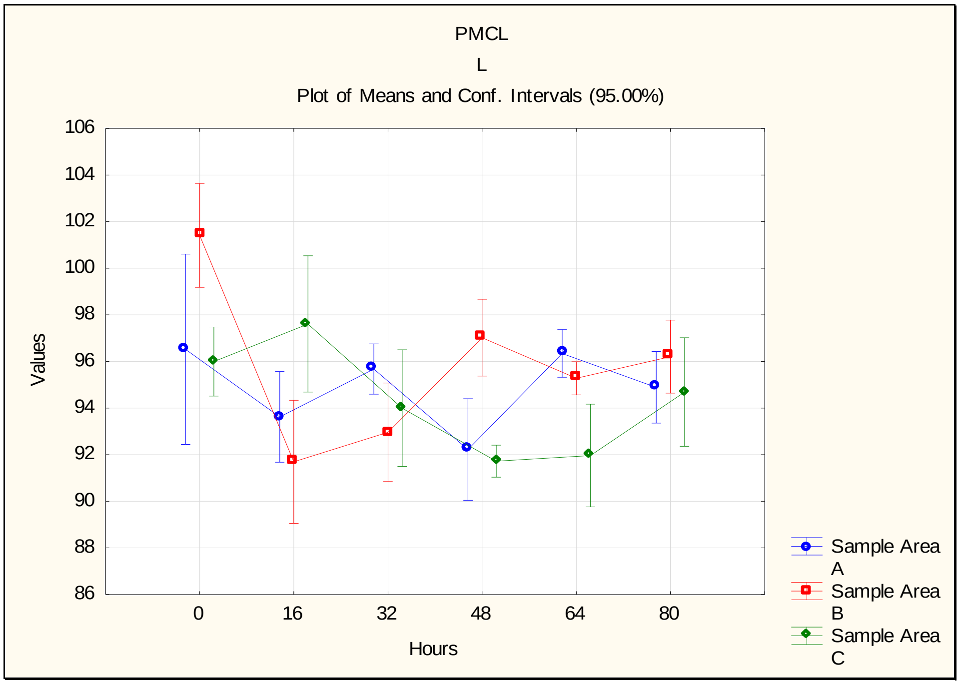
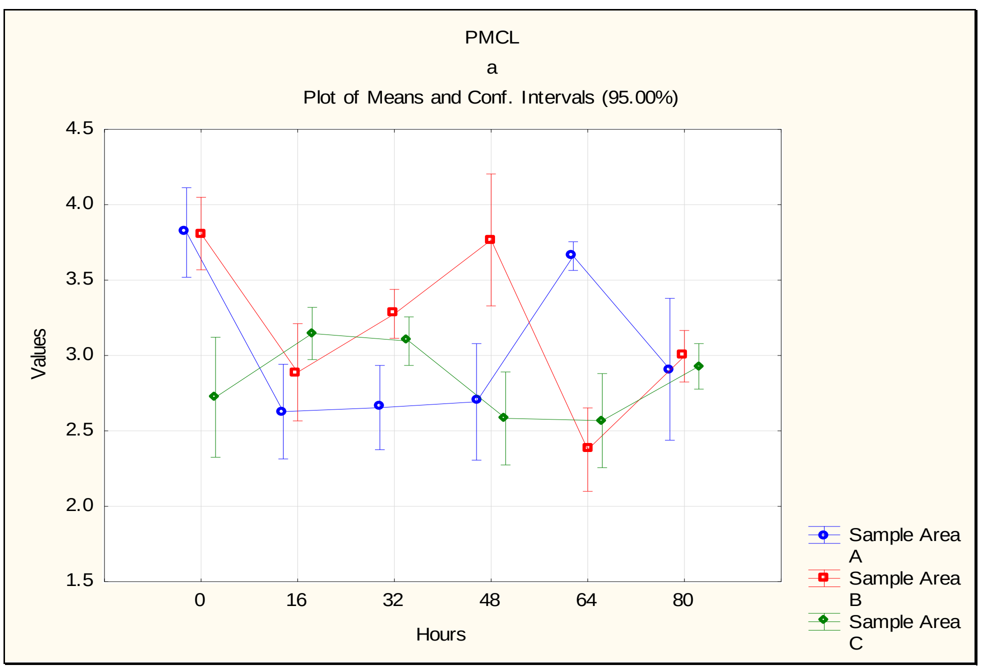


Figure 13.4: Interaction plots of 'Hours Sample Area' for sample PMCL at each variable*




PMCL
L
Plot of Means and Conf. Intervals (95.00%)
Values
106
104
102
100
98
96
94
92
90
88
86
0
16
32
48
64
80
Hours
Sample Area A
Sample Area B
Sample Area C


PMCL
a
Plot of Means and Conf. Intervals (95.00%)
Values
4.5
4.0
3.5
3.0
2.5
2.0
1.5
0
16
32
48
64
80
Hours
Sample Area A
Sample Area B
Sample Area C

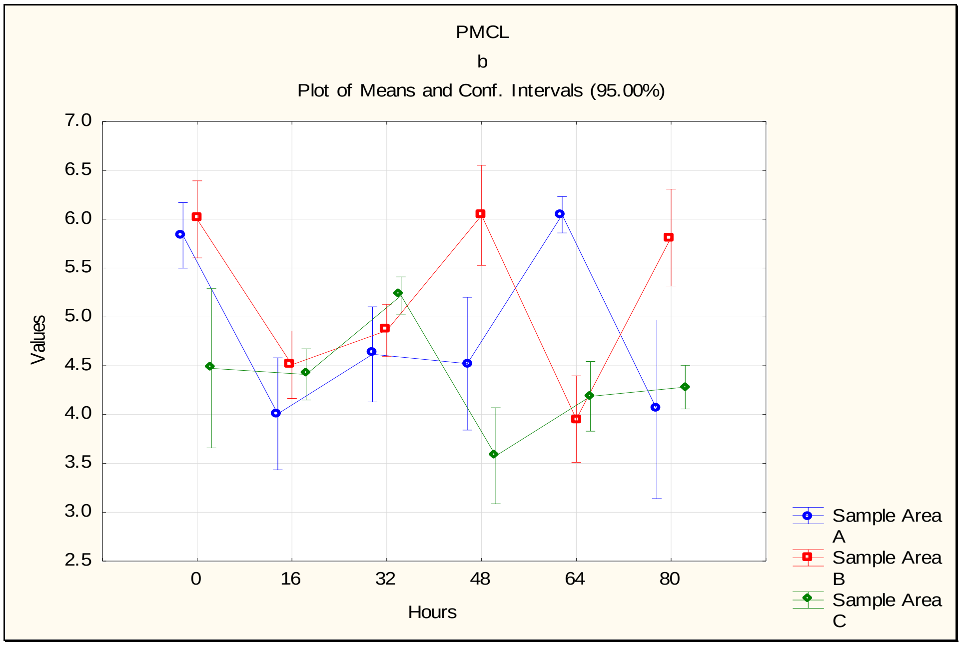
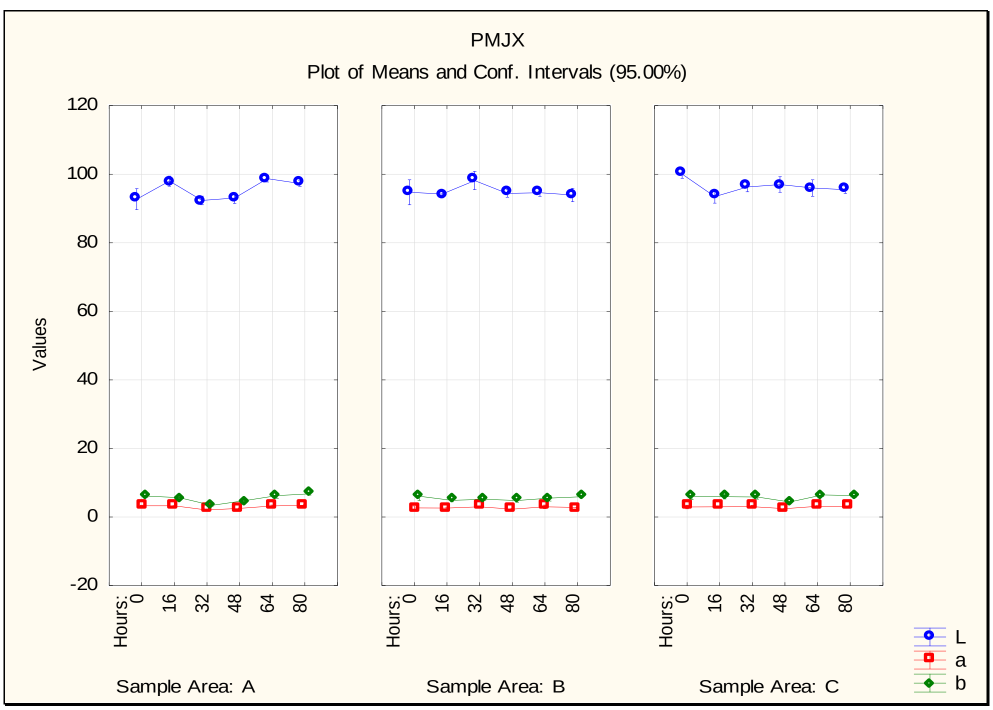
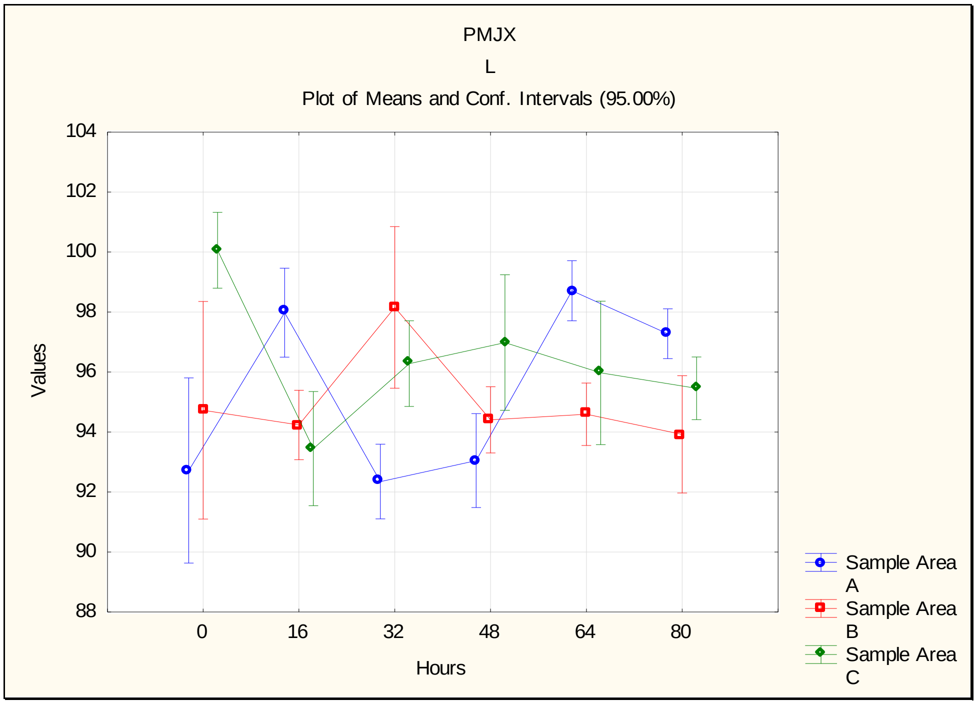
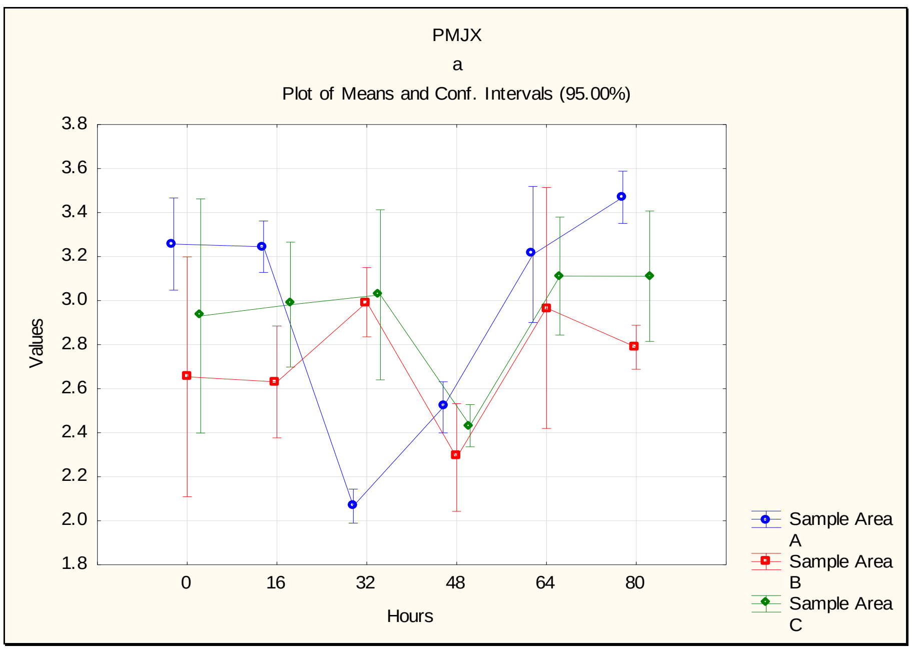


Figure 13.5: Interaction plots of 'Hours Sample Area' for sample PMJX at each variable*



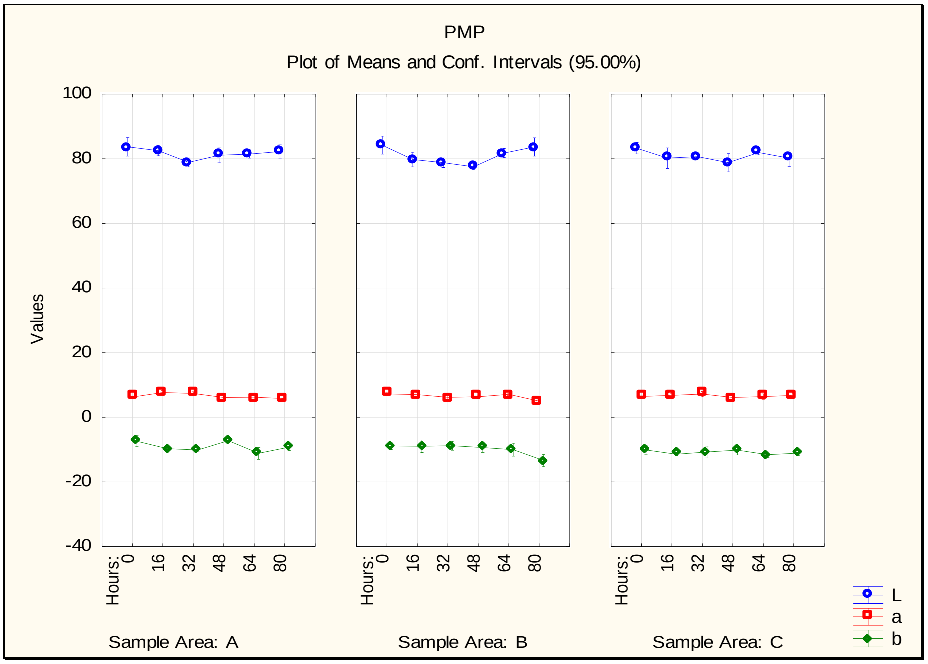


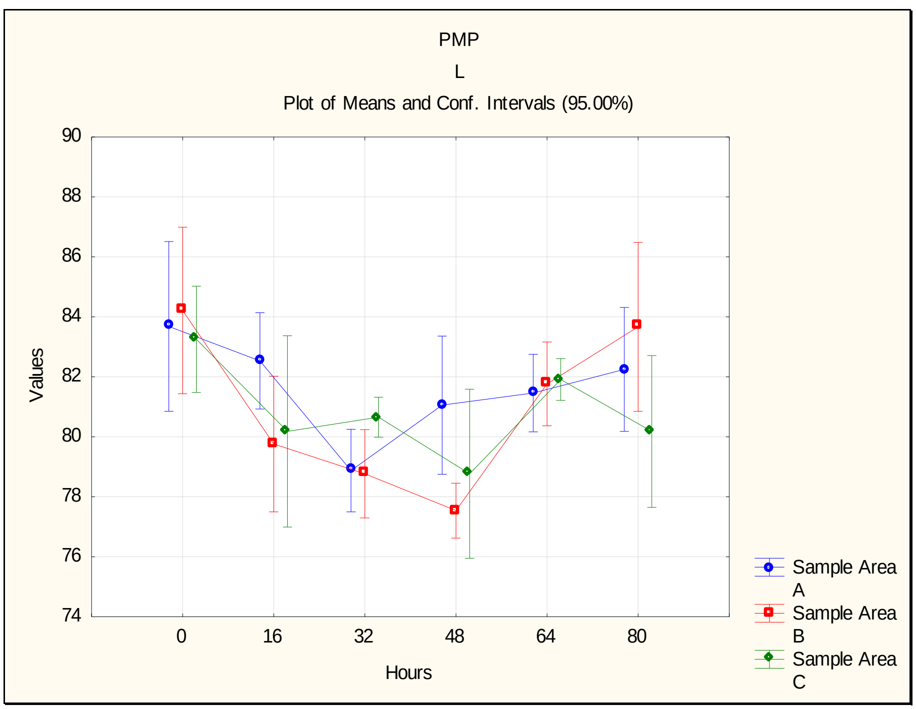
PMJX
L
Plot of Means and Conf. Intervals (95.00%)
104
102
100
98
96
94
92
90
88
Values
0
16
32
48
64
80
Hours
Sample Area A
Sample Area B
Sample Area C

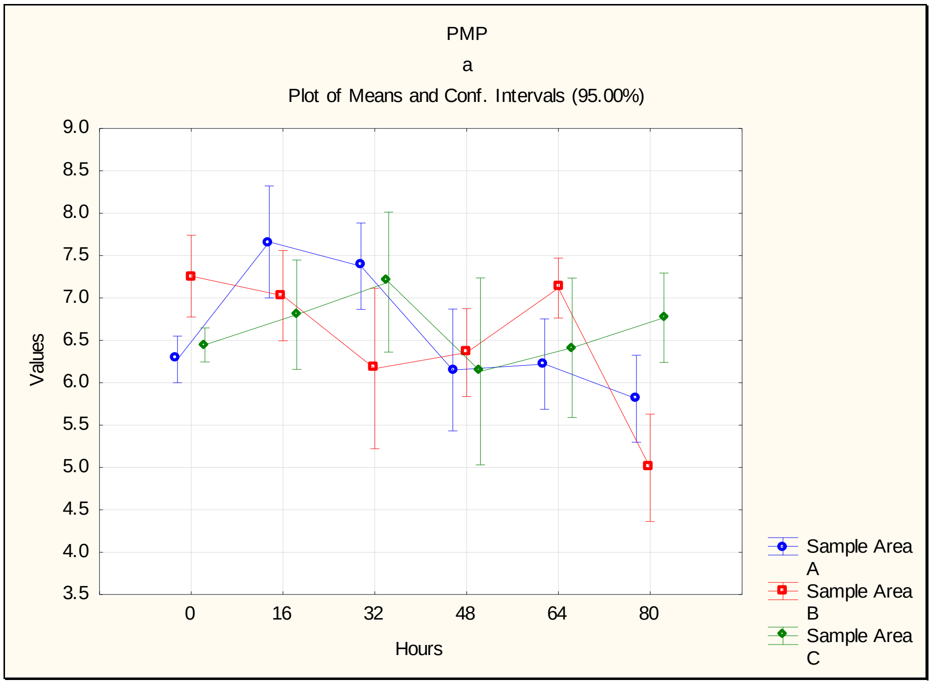


PMJX
a
Plot of Means and Conf. Intervals (95.00%)
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
Values
0
16
32
48
64
80
Hours
Sample Area A
Sample Area B
Sample Area C

Figure 13.6: Interaction plots of 'Hours Sample Area' for sample PMP at each variable*






PMP
a
Plot of Means and Conf. Intervals (95.00%)
Values
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
0
16
32
48
64
80
Hours
Sample Area A
Sample Area B
Sample Area C

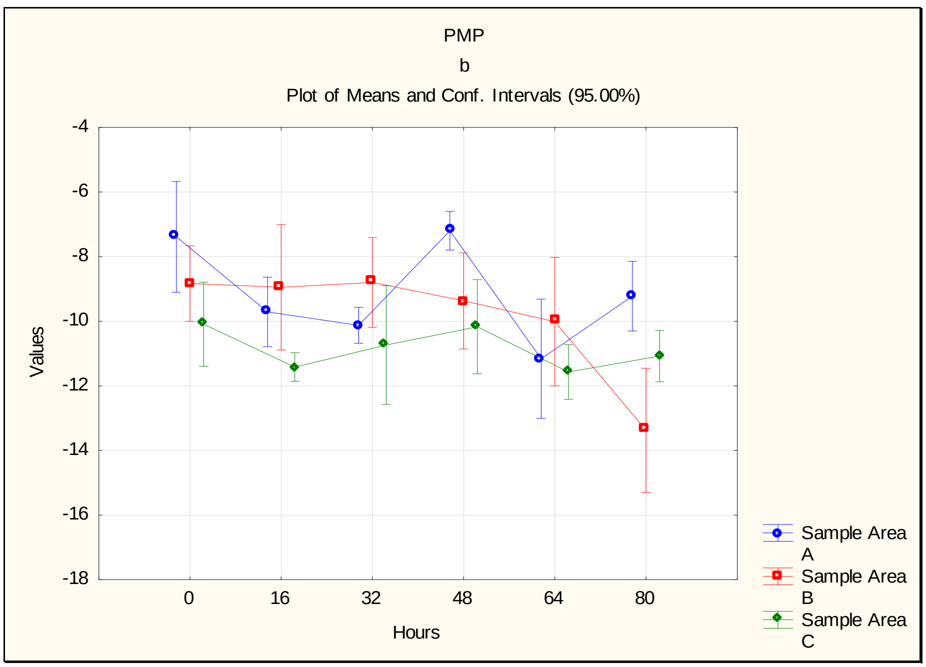
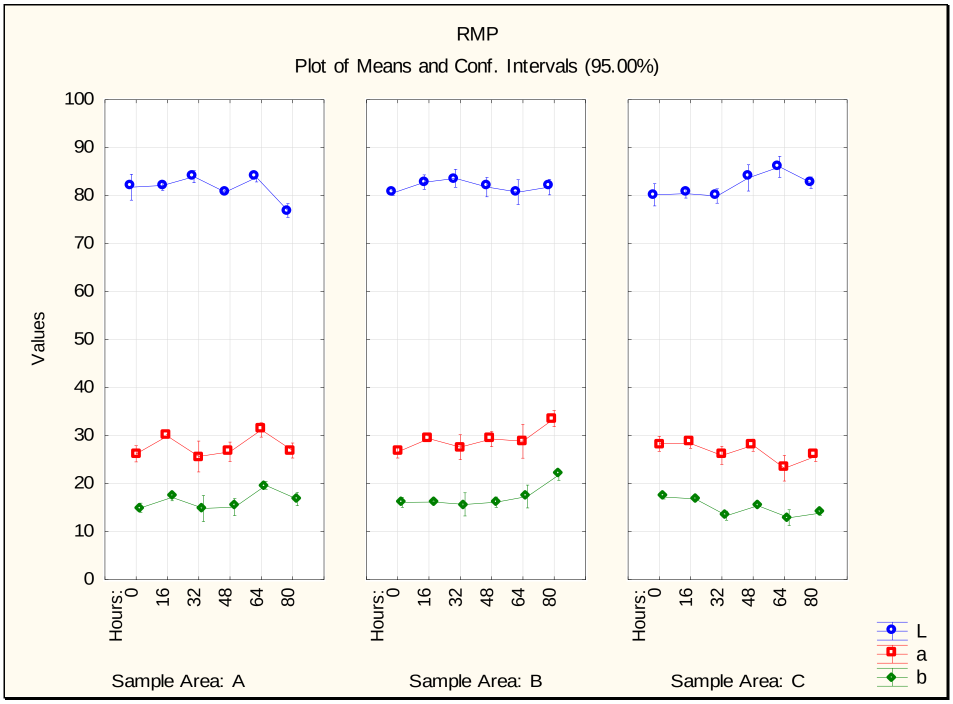
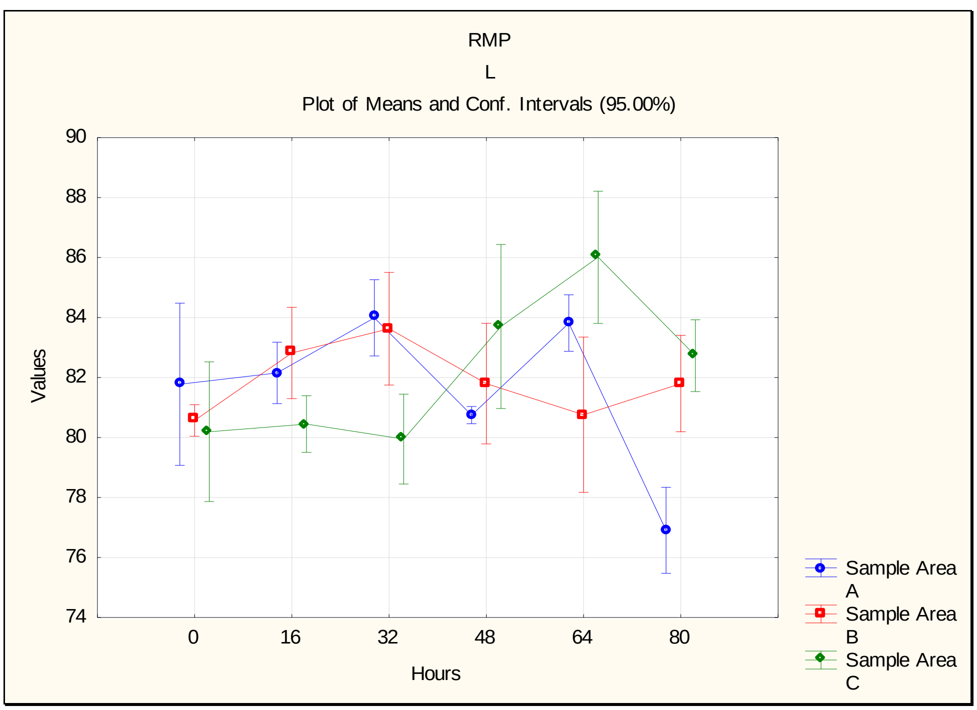
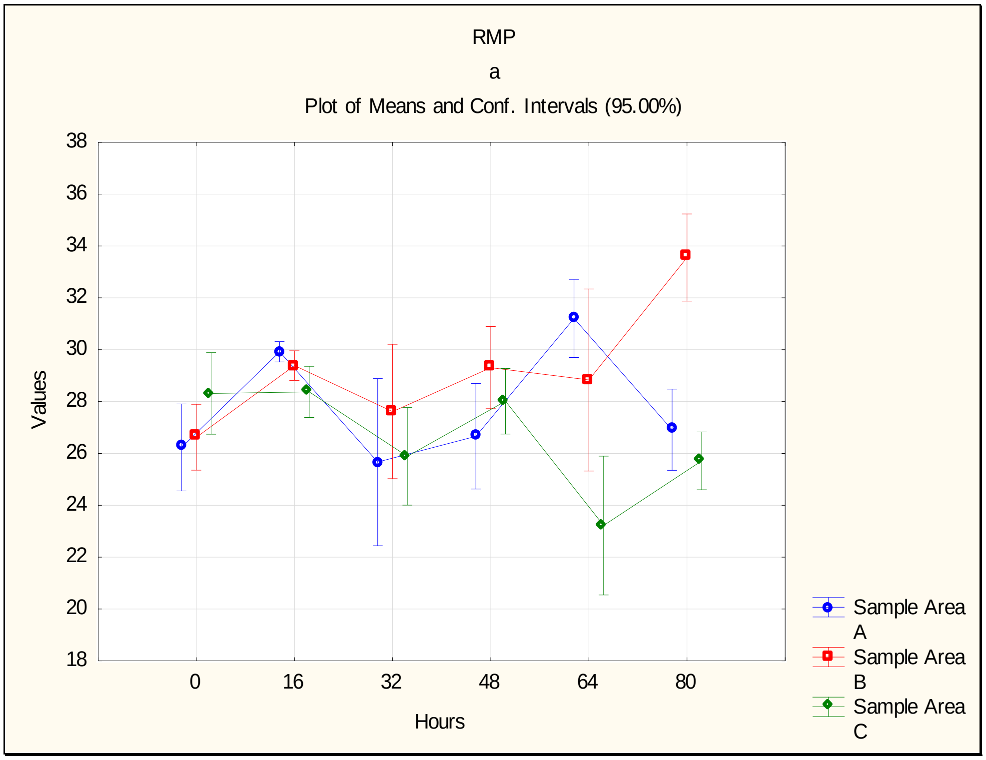
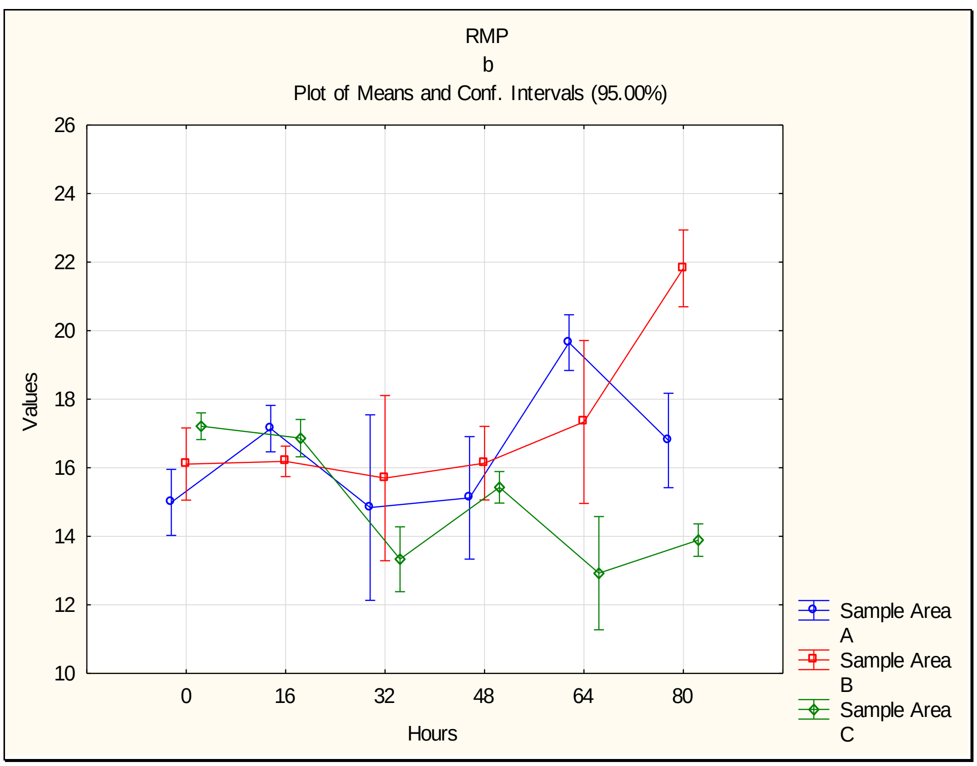

PMP
b
Plot of Means and Conf. Intervals (95.00%)
Values
-4
-6
-8
-10
-12
-14
-16
-18
0
16
32
48
64
80
Hours
Sample Area A
Sample Area B
Sample Area C

Figure 13.7: Interaction plots of 'Hours Sample Area' for sample RMP at each variable*






RMP
a
Plot of Means and Conf. Intervals (95.00%)
Values
Hours
38
36
34
32
30
28
26
24
22
20
18
0
16
32
48
64
80
Sample Area A
Sample Area B
Sample Area C


RMP
b
Plot of Means and Conf. Intervals (95.00%)
Values
Hours
26
24
22
20
18
16
14
12
10
0
16
32
48
64
80
Sample Area A
Sample Area B
Sample Area C

14. ANOVA Output for Washed-Aged Results

Figure 14.1 ANOVA Output for Washed-Aged Results for sample DPMP

Estimates: DPMP

Dependent Variable: a

Swatch	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	26.438[a]	0.244	25.959	26.917
2 w/ bleach	24.504[a]	0.244	24.025	24.983
3 w/o bleach	24.733[a]	0.244	24.255	25.212
4 w/o bleach	25.339[a]	0.244	24.86	25.818

a. Based on modified population marginal mean.

Pairwise Comparisons: DPMP

Dependent Variable: a

(I) Swatch	(J) Swatch	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
1 w/ bleach	2 w/ bleach	1.934[*,a,b]	0.345	0	1.257	2.611
	3 w/o bleach	1.705[*,a,b]	0.345	0	1.028	2.382
	4 w/o bleach	1.099[*,a,b]	0.345	0.001	0.422	1.776
2 w/ bleach	1 w/ bleach	-1.934[*,a,b]	0.345	0	-2.611	-1.257
	3 w/o bleach	-.229[a,b]	0.345	0.507	-0.906	0.448
	4 w/o bleach	-.835[*,a,b]	0.345	0.016	-1.512	-0.158
3 w/o bleach	1 w/ bleach	-1.705[*,a,b]	0.345	0	-2.382	-1.028
	2 w/ bleach	.229[a,b]	0.345	0.507	-0.448	0.906
	4 w/o bleach	-.606[a,b]	0.345	0.08	-1.283	0.072
4 w/o bleach	1 w/ bleach	-1.099[*,a,b]	0.345	0.001	-1.776	-0.422
	2 w/ bleach	.835[*,a,b]	0.345	0.016	0.158	1.512
	3 w/o bleach	.606[a,b]	0.345	0.08	-0.072	1.283

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Estimates: DPMP

Dependent Variable: b

Swatch	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	7.793[a]	0.135	7.529	8.058
2 w/ bleach	7.119[a]	0.135	6.854	7.384
3 w/o bleach	7.168[a]	0.135	6.903	7.433
4 w/o bleach	7.190[a]	0.135	6.925	7.454

a. Based on modified population marginal mean.

Pairwise Comparisons: DPMP

Dependent Variable: b

(I) Swatch	(J) Swatch	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach	.675[*,a,b]	0.191	0.000	0.3	1.049
	3 w/o bleach	.626[*,a,b]	0.191	0.001	0.251	1
	4 w/o bleach	.604[*,a,b]	0.191	0.002	0.229	0.978
2 w/ bleach	1 w/ bleach	-.675[*,a,b]	0.191	0.000	-1.049	-0.3
	3 w/o bleach	-.049[a,b]	0.191	0.798	-0.423	0.326
	4 w/o bleach	-.071[a,b]	0.191	0.711	-0.445	0.304
3 w/o bleach	1 w/ bleach	-.626[*,a,b]	0.191	0.001	-1	-0.251
	2 w/ bleach	.049[a,b]	0.191	0.798	-0.326	0.423
	4 w/o bleach	-.022[a,b]	0.191	0.909	-0.396	0.353
4 w/o bleach	1 w/ bleach	-.604[*,a,b]	0.191	0.002	-0.978	-0.229
	2 w/ bleach	.071[a,b]	0.191	0.711	-0.304	0.445
	3 w/o bleach	.022[a,b]	0.191	0.909	-0.353	0.396

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

3. Sample Area * Swatch: DPMP

Dependent Variable: b

Sample Area	Swatch	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	1 w/ bleach	7.530[a]	0.183	7.171	7.888
	2 w/ bleach	7.493[a]	0.2	7.1	7.886
	3 w/o bleach	7.331[a]	0.183	6.973	7.69
	4 w/o bleach	7.623[a]	0.2	7.23	8.015
B	1 w/ bleach	8.110[a]	0.2	7.717	8.502
	2 w/ bleach	6.807[a]	0.183	6.449	7.166
	3 w/o bleach	6.972[a]	0.2	6.579	7.365
	4 w/o bleach	6.829[a]	0.183	6.47	7.187

a. Based on modified population marginal mean.

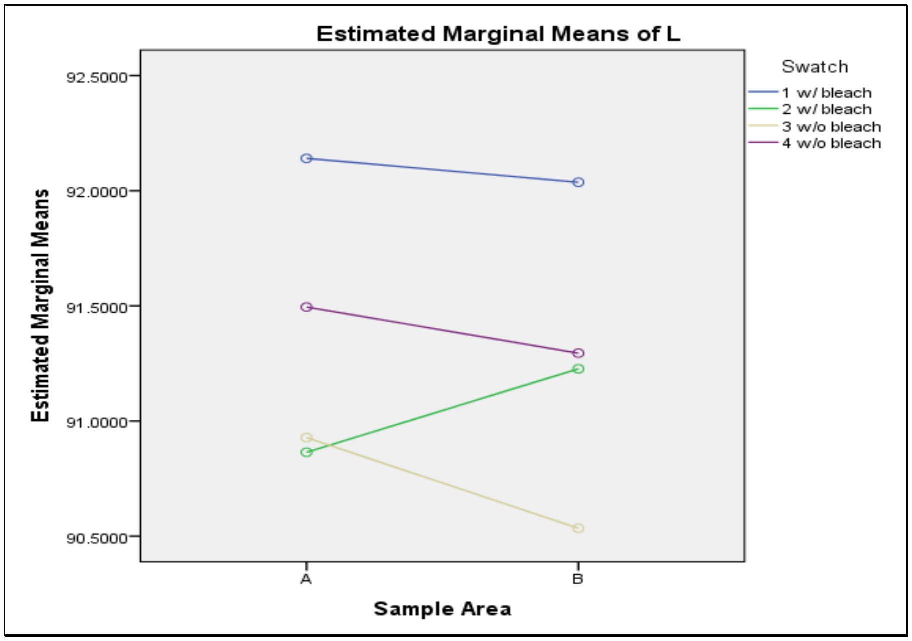
Figure 14.2 ANOVA Output for Washed-Aged Results for sample OSDP

5. Sample Area * Swatch: OSDP

Dependent Variable: L

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	1 w/ bleach	92.141[a]	.290	91.572	92.709
	2 w/ bleach	90.864[a]	.318	90.241	91.488
	3 w/o bleach	90.928[a]	.290	90.359	91.497
	4 w/o bleach	91.495[a]	.318	90.872	92.118
B	1 w/ bleach	92.037[a]	.318	91.414	92.660
	2 w/ bleach	91.227[a]	.290	90.658	91.796
	3 w/o bleach	90.534[a]	.318	89.911	91.158
	4 w/o bleach	91.295[a]	.290	90.726	91.863

a. Based on modified population marginal mean.



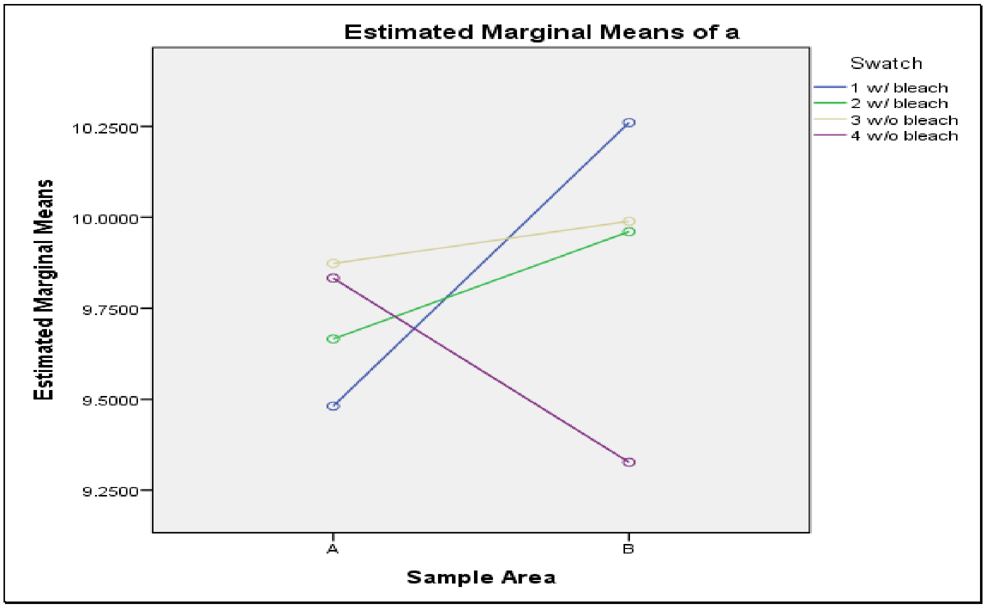
Variable 'a'

5. Sample Area * Swatch: OSDP

Dependent Variable: a

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	1 w/ bleach	9.481[a]	.140	9.207	9.755
	2 w/ bleach	9.666[a]	.153	9.366	9.966
	3 w/o bleach	9.873[a]	.140	9.599	10.147
	4 w/o bleach	9.833[a]	.153	9.533	10.133
B	1 w/ bleach	10.260[a]	.153	9.960	10.560
	2 w/ bleach	9.961[a]	.140	9.687	10.235
	3 w/o bleach	9.989[a]	.153	9.689	10.289
	4 w/o bleach	9.327[a]	.140	9.053	9.601

a. Based on modified population marginal mean.



Variable 'b'

5. Sample Area * Swatch: OSDP

Dependent Variable: b

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	1 w/ bleach	30.096[a]	.357	29.394	30.797
	2 w/ bleach	29.810[a]	.392	29.042	30.579
	3 w/o bleach	30.577[a]	.357	29.875	31.278
	4 w/o bleach	29.970[a]	.392	29.202	30.739
B	1 w/ bleach	30.873[a]	.392	30.105	31.642
	2 w/ bleach	30.853[a]	.357	30.151	31.554
	3 w/o bleach	30.534[a]	.392	29.766	31.303
	4 w/o bleach	29.581[a]	.357	28.879	30.282

a. Based on modified population marginal mean.

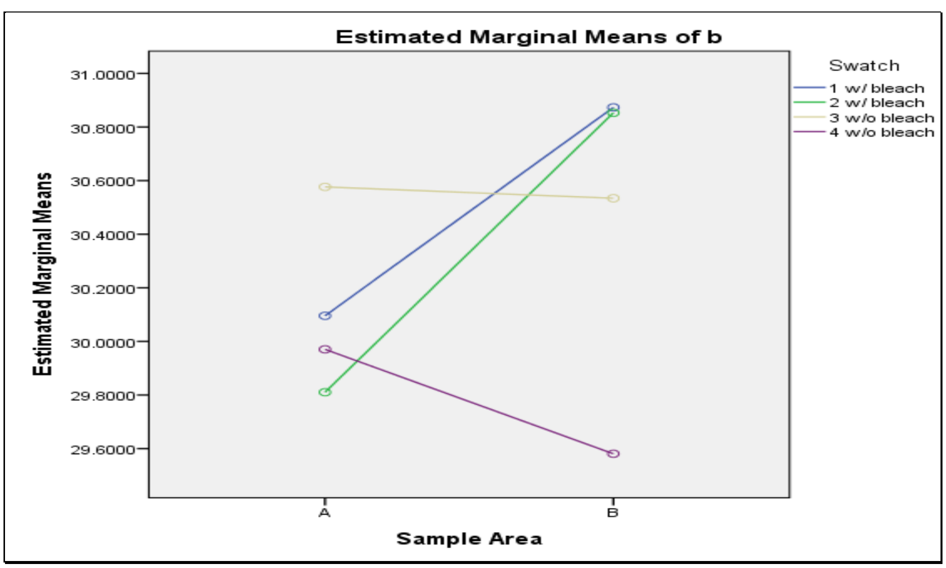


Figure 14.3 ANOVA Output for Washed-Aged Results for sample PMCL

Variable 'b'

Estimates: PMCL

Dependent Variable: b

Sample Area	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	4.303[a]	.061	4.183	4.424
B	4.554[a]	.061	4.434	4.674

a. Based on modified population marginal mean.

Pairwise Comparisons: PMCL

Dependent Variable: b

(I) Sample Area	(J) Sample Area	Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
A	B	-.251*,a,b	.087	.004	-.421	-.080
B	A	.251*,a,b	.087	.004	.080	.421

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

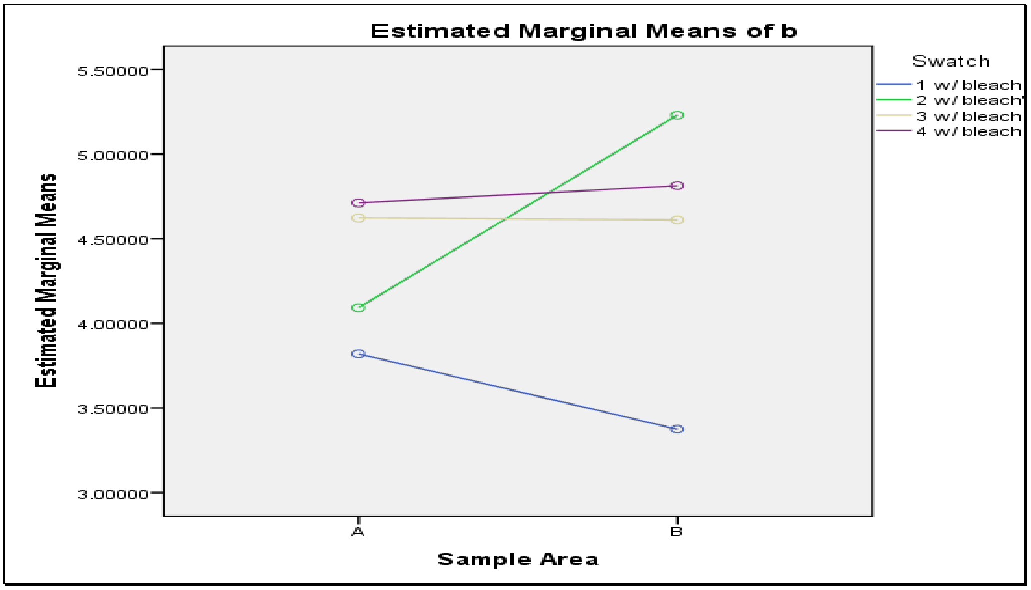
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

5. Swatch * Sample Area: PMCL

Dependent Variable: b

Swatch	Sample Area	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	A	3.820[a]	.117	3.589	4.050
	B	3.375[a]	.129	3.122	3.627
2 w/ bleach	A	4.092[a]	.129	3.839	4.344
	B	5.230[a]	.117	5.000	5.461
3 w/o bleach	A	4.623[a]	.117	4.393	4.853
	B	4.611[a]	.129	4.359	4.864
4 w/o bleach	A	4.712[a]	.129	4.459	4.964
	B	4.813[a]	.117	4.582	5.043

a. Based on modified population marginal mean.



8. Sample Area * Bleached

Dependent Variable: b

Sample Area	Bleached	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	w/ bleach	3.943[a]	.087	3.773	4.114
	w/o bleach	4.663[a]	.087	4.493	4.833
B	w/ bleach	4.387[a]	.087	4.217	4.557
	w/o bleach	4.721[a]	.087	4.551	4.891

a. Based on modified population marginal mean.

10. Bleached * Washing: PMCL

Dependent Variable: b

Bleached	Washing	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
w/ bleach	1W 0A	4.372[a]	.203	3.973	4.771
	1W 16A	4.415[a]	.144	4.133	4.697
	2W 32A	3.738[a]	.144	3.456	4.020
	3W 48A	3.786[a]	.144	3.504	4.069
	4W 64A	4.709[a]	.144	4.427	4.991
	5W 80A	4.074[a]	.144	3.792	4.357
w/o bleach	1W 0A	4.421[a]	.203	4.022	4.820
	1W 16A	4.621[a]	.144	4.339	4.904
	2W 32A	4.660[a]	.144	4.378	4.942
	3W 48A	4.565[a]	.144	4.283	4.847
	4W 64A	5.157[a]	.144	4.875	5.440
	5W 80A	4.592[a]	.144	4.310	4.874

a. Based on modified population marginal mean.

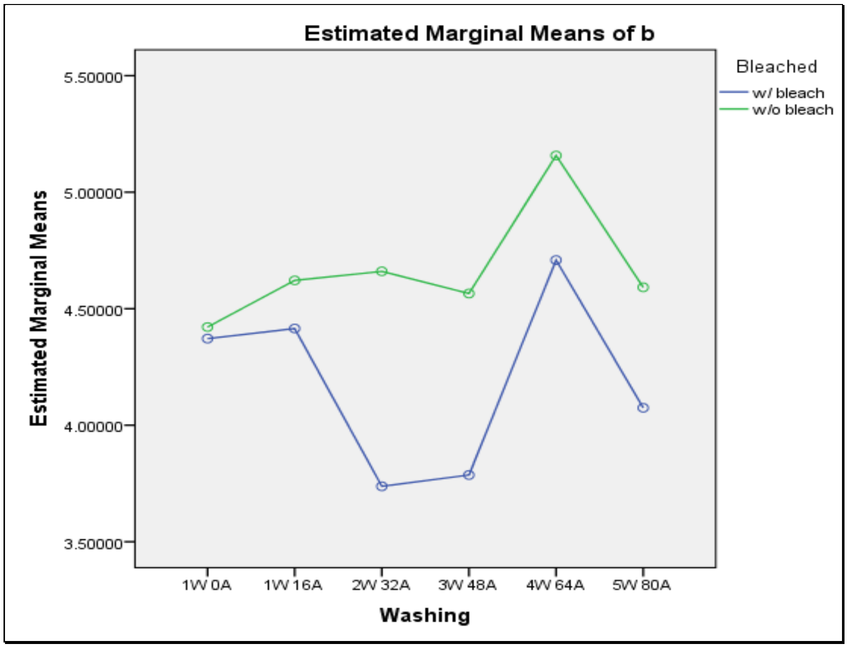


Table 14.4 ANOVA Output for Washed-Aged Results for sample PMJX

Variable 'b'

Estimates: PMJX

Dependent Variable: b

Sample Area	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A	5.123[a]	.061	5.003	5.243
B	5.163[a]	.061	5.043	5.284

a. Based on modified population marginal mean.

Pairwise Comparisons: PMJX

Dependent Variable: b

(I) Sample Area		Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
A	B	-.040[a,b]	.087	.641	-.211	.130
B	A	.040[a,b]	.087	.641	-.130	.211

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

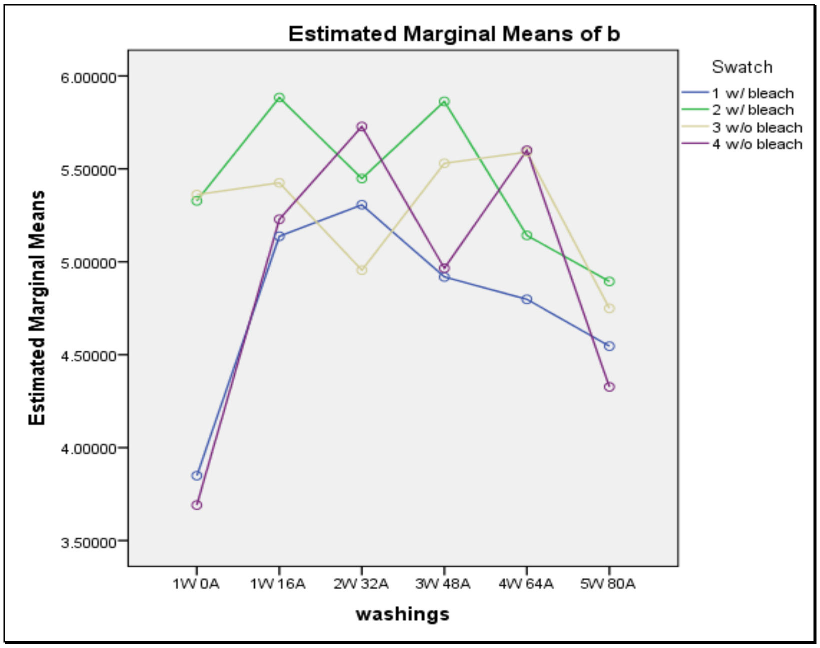
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

5. Sample Area * Swatch: PMJX

Dependent Variable: b

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	1 w/ bleach	5.059[a]	.117	4.829	5.290
	2 w/ bleach	5.765[a]	.129	5.512	6.017
	3 w/o bleach	4.883[a]	.117	4.653	5.114
	4 w/o bleach	4.845[a]	.129	4.592	5.097
B	1 w/ bleach	4.581[a]	.129	4.329	4.834
	2 w/ bleach	5.161[a]	.117	4.930	5.392
	3 w/o bleach	5.712[a]	.129	5.459	5.965
	4 w/o bleach	5.194[a]	.117	4.964	5.425

a. Based on modified population marginal mean.

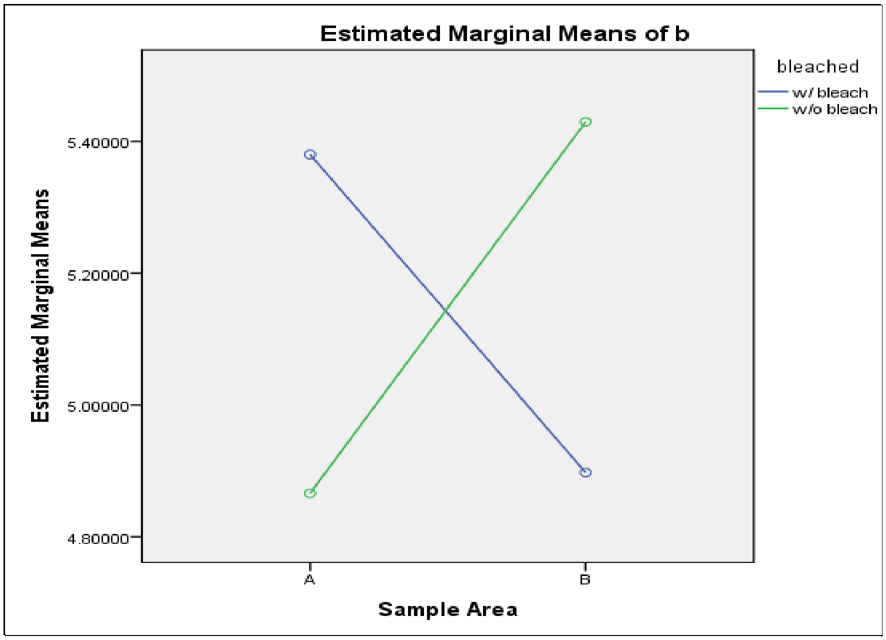


6. Sample Area * bleached: PMJX

Dependent Variable: b

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	w/ bleach	5.380[a]	.087	5.210	5.550
	w/o bleach	4.866[a]	.087	4.696	5.036
B	w/ bleach	4.897[a]	.087	4.727	5.068
	w/o bleach	5.429[a]	.087	5.259	5.600

a. Based on modified population marginal mean.



7. bleached * washings: PMJX

Dependent Variable: b

bleached		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
w/ bleach	1W 0A	4.589[a]	.203	4.189	4.988
	1W 16A	5.510[a]	.144	5.228	5.793
	2W 32A	5.377[a]	.144	5.095	5.660
	3W 48A	5.391[a]	.144	5.108	5.673
	4W 64A	4.970[a]	.144	4.688	5.253
	5W 80A	4.720[a]	.144	4.438	5.002
w/o bleach	1W 0A	4.526[a]	.203	4.127	4.925
	1W 16A	5.327[a]	.144	5.045	5.609
	2W 32A	5.341[a]	.144	5.059	5.624
	3W 48A	5.248[a]	.144	4.965	5.530
	4W 64A	5.595[a]	.144	5.313	5.878
	5W 80A	4.538[a]	.144	4.256	4.820

a. Based on modified population marginal mean.

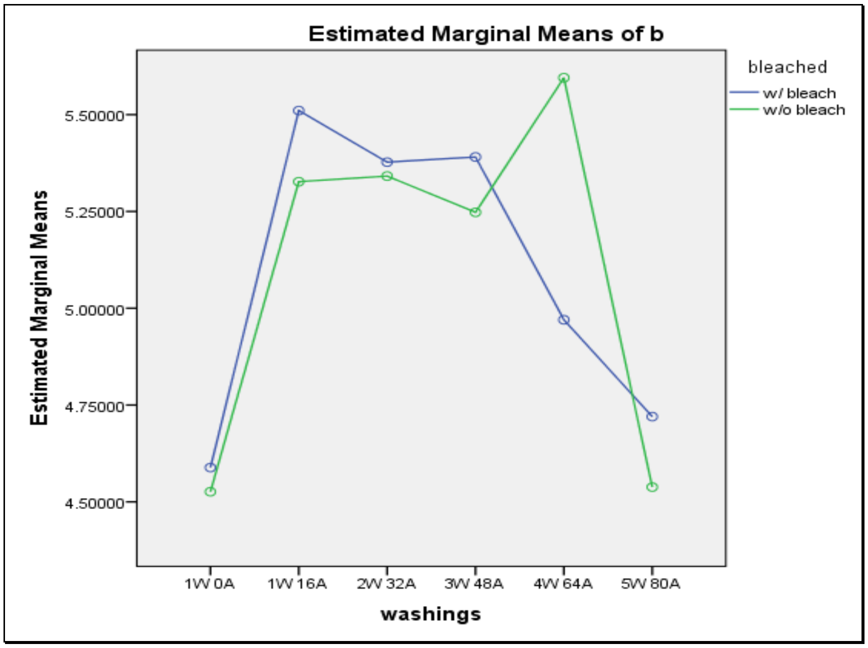


Table 14.5 ANOVA Output for Washed-Aged Results for sample PMP

Variable 'L'

Estimates: PMP

Dependent Variable: L

Sample Area	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	83.757[a]	.188	83.388	84.126
B	83.691[a]	.188	83.322	84.060

a. Based on modified population marginal mean.

Pairwise Comparisons: PMP

Dependent Variable: L

(I) Sample Area		Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	95% Confidence Interval for Difference[c] Upper Bound
A	B	.066[a,b]	.266	.805	-.456	.588
B	A	-.066[a,b]	.266	.805	-.588	.456

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Estimates: PMP

Dependent Variable: L

Bleached	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
w/ bleach	84.384[a]	.188	84.014	84.753
w/o bleach	83.064[a]	.188	82.695	83.434

a. Based on modified population marginal mean.

Pairwise Comparisons: PMP

Dependent Variable: L

(I) Bleached		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	95% Confidence Interval for Difference[d] Upper Bound
w/ bleach	w/o bleach	1.319[*,b,c]	.266	.000	.797	1.841
w/o bleach	w/ bleach	-1.319[*,b,c]	.266	.000	-1.841	-.797

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

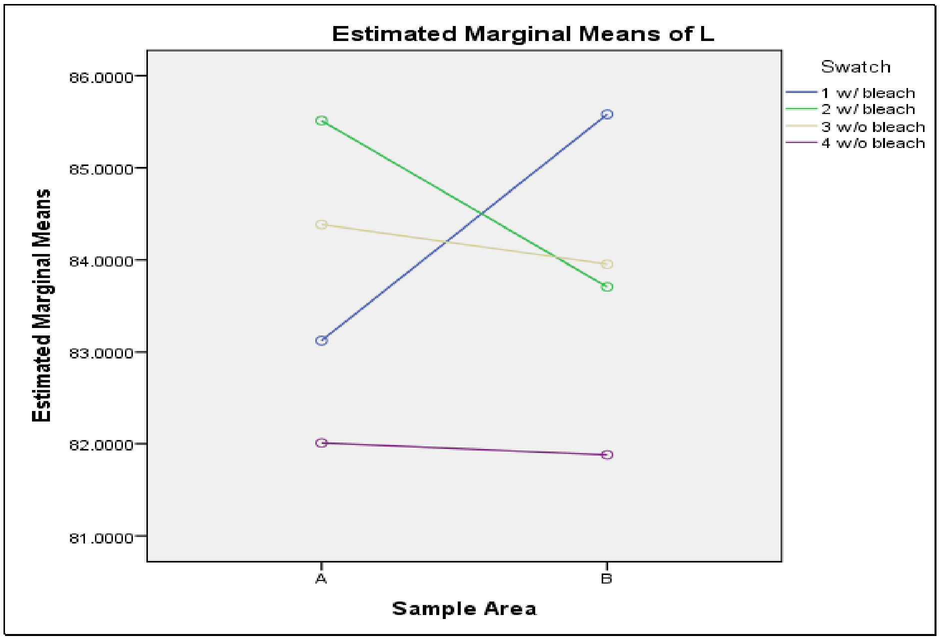
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

5. Sample Area * Swatch: PMP

Dependent Variable: L

Sample Area		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	1 w/ bleach	83.122[a]	.360	82.415	83.829
	2 w/ bleach	85.513[a]	.395	84.739	86.288
	3 w/o bleach	84.384[a]	.360	83.677	85.091
	4 w/o bleach	82.010[a]	.395	81.235	82.784
B	1 w/ bleach	85.581[a]	.395	84.807	86.356
	2 w/ bleach	83.706[a]	.360	82.999	84.413
	3 w/o bleach	83.953[a]	.395	83.178	84.727
	4 w/o bleach	81.883[a]	.360	81.176	82.590

a. Based on modified population marginal mean.

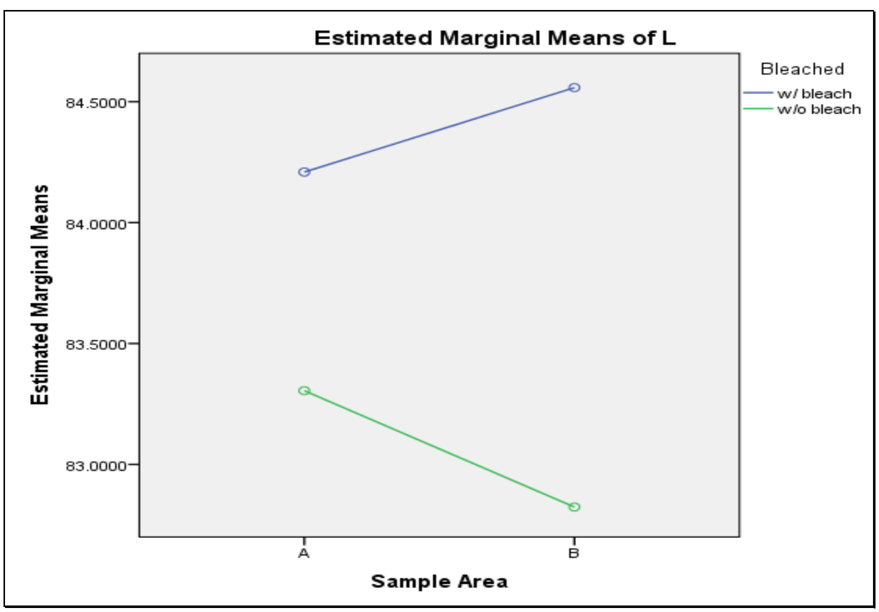


6. Sample Area * Bleached: PMP

Dependent Variable: L

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	w/ bleach	84.209[a]	.266	83.687	84.731
	w/o bleach	83.305[a]	.266	82.783	83.827
B	w/ bleach	84.558[a]	.266	84.036	85.080
	w/o bleach	82.824[a]	.266	82.302	83.346

a. Based on modified population marginal mean.

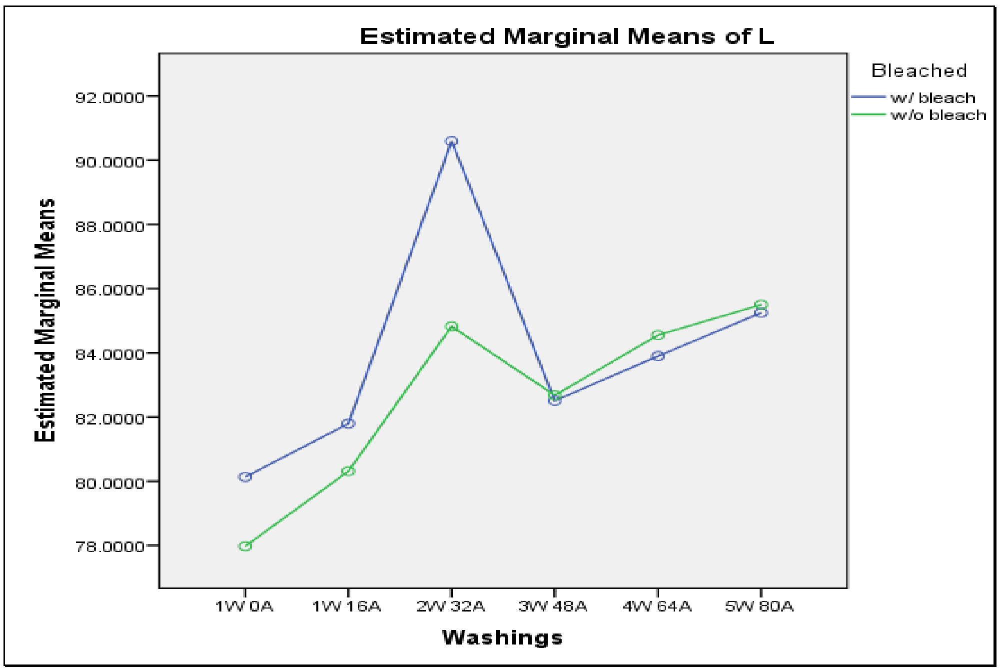


7. Bleached * Washings: PMP

Dependent Variable: L

Bleached		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
w/ bleach	1W 0A	80.132[a]	.624	78.907	81.356
	1W 16A	81.797[a]	.441	80.931	82.663
	2W 32A	90.592[a]	.441	89.726	91.458
	3W 48A	82.507[a]	.441	81.641	83.373
	4W 64A	83.899[a]	.441	83.033	84.765
	5W 80A	85.249[a]	.441	84.383	86.115
w/o bleach	1W 0A	77.973[a]	.624	76.749	79.198
	1W 16A	80.313[a]	.441	79.447	81.179
	2W 32A	84.824[a]	.441	83.958	85.689
	3W 48A	82.677[a]	.441	81.811	83.543
	4W 64A	84.553[a]	.441	83.687	85.419
	5W 80A	85.500[a]	.441	84.634	86.366

a. Based on modified population marginal mean.



Variable 'a'

Estimates: PMP

Dependent Variable: a

Swatch	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1 w/ bleach	6.519[a]	.087	6.348	6.689
2 w/ bleach	6.424[a]	.087	6.253	6.594
3 w/o bleach	6.345[a]	.087	6.174	6.515
4 w/o bleach	6.267[a]	.087	6.097	6.438

a. Based on modified population marginal mean.

Pairwise Comparisons: PMP

Dependent Variable: a

(I) Swatch		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach	.095[a,b]	.123	.440	-.146	.336
	3 w/o bleach	.174[a,b]	.123	.157	-.067	.415
	4 w/o bleach	.251[a,b,*]	.123	.041	.010	.492
2 w/ bleach	1 w/ bleach	-.095[a,b]	.123	.440	-.336	.146
	3 w/o bleach	.079[a,b]	.123	.521	-.162	.320
	4 w/o bleach	.156[a,b]	.123	.204	-.085	.397
3 w/o bleach	1 w/ bleach	-.174[a,b]	.123	.157	-.415	.067
	2 w/ bleach	-.079[a,b]	.123	.521	-.320	.162
	4 w/o bleach	.077[a,b]	.123	.529	-.164	.319
4 w/o bleach	1 w/ bleach	-.251[a,b,*]	.123	.041	-.492	-.010
	2 w/ bleach	-.156[a,b]	.123	.204	-.397	.085
	3 w/o bleach	-.077[a,b]	.123	.529	-.319	.164

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Estimates: PMP

Dependent Variable: a

Sample Area	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A	6.368[a]	.061	6.248	6.489
B	6.409[a]	.061	6.289	6.530

a. Based on modified population marginal mean.

Pairwise Comparisons: PMP

Dependent Variable: a

(I) Sample Area		Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
A	B	-.041[a,b]	.087	.639	-.211	.130
B	A	.041[a,b]	.087	.639	-.130	.211

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Bleach Estimates: PMP

Dependent Variable: a

Bleached	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
w/ bleach	6.471[a]	.061	6.351	6.592
w/o bleach	6.306[a]	.061	6.186	6.427

a. Based on modified population marginal mean.

Pairwise Comparisons: PMP

Dependent Variable: a

(I) Bleached		Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
w/ bleach	w/o bleach	.165[a,b]	.087	.058	-.005	.336
w/o bleach	w/ bleach	-.165[a,b]	.087	.058	-.336	.005

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

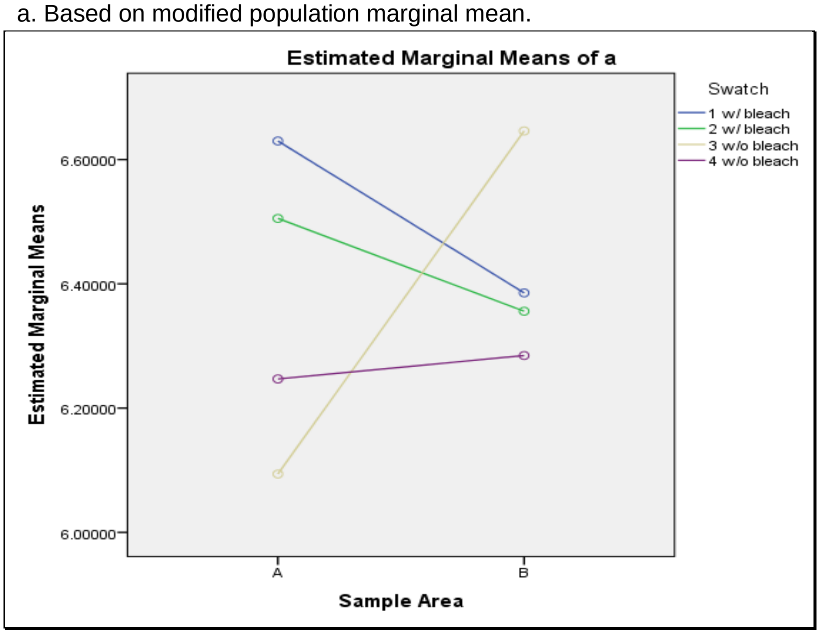
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

5. Sample Area * Swatch: PMP

Dependent Variable: a

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	1 w/ bleach	6.630[a]	.118	6.399	6.861
	2 w/ bleach	6.505[a]	.129	6.252	6.758
	3 w/o bleach	6.094[a]	.118	5.863	6.325
	4 w/o bleach	6.247[a]	.129	5.994	6.500
B	1 w/ bleach	6.385[a]	.129	6.133	6.638
	2 w/ bleach	6.356[a]	.118	6.125	6.587
	3 w/o bleach	6.646[a]	.129	6.393	6.899
	4 w/o bleach	6.285[a]	.118	6.054	6.515

a. Based on modified population marginal mean.

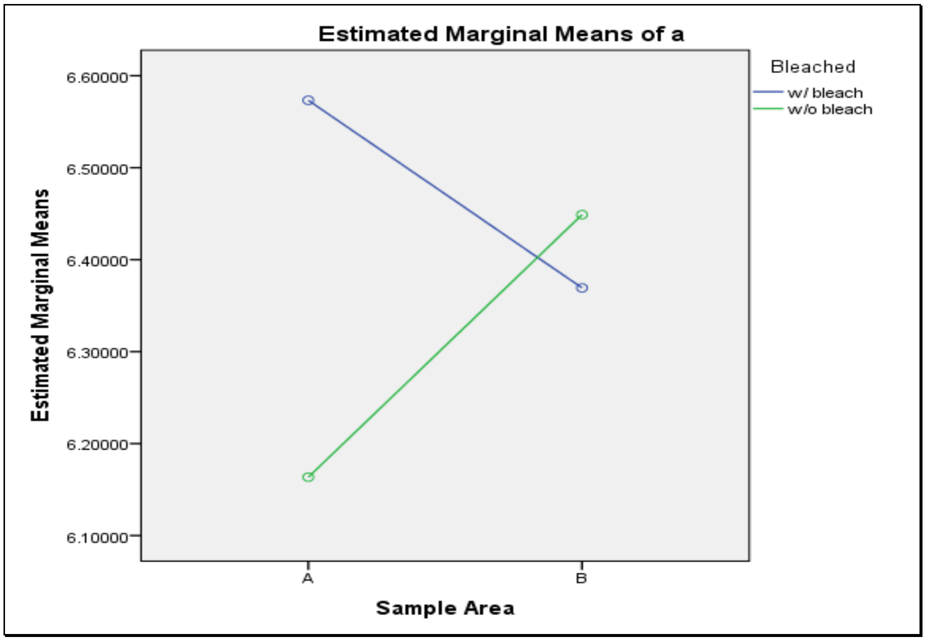


6. Sample Area * Bleached: PMP

Dependent Variable: a

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	w/ bleach	6.573[a]	.087	6.403	6.744
	w/o bleach	6.164[a]	.087	5.993	6.334
B	w/ bleach	6.369[a]	.087	6.199	6.540
	w/o bleach	6.449[a]	.087	6.278	6.619

a. Based on modified population marginal mean.



Variable 'b'

Sample Area Estimates: PMP

Dependent Variable: b

Sample Area	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A	-8.637[a]	.126	-8.886	-8.389
B	-8.815[a]	.126	-9.063	-8.566

a. Based on modified population marginal mean.

Pairwise Comparisons: PMP

Dependent Variable: b

(I) Sample Area		Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
A	B	.177[a,b]	.179	.322	-.174	.528
B	A	-.177[a,b]	.179	.322	-.528	.174

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Estimates: PMP

Dependent Variable: b

Swatch	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1 w/ bleach	-8.380[a]	.179	-8.731	-8.029
2 w/ bleach	-8.807[a]	.179	-9.158	-8.455
3 w/o bleach	-8.452[a]	.179	-8.803	-8.101
4 w/o bleach	-9.265[a]	.179	-9.616	-8.914

a. Based on modified population marginal mean.

Pairwise Comparisons: PMP

Dependent Variable: b

(I) Swatch		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
1 w/ bleach	2 w/ bleach	.427[a,b]	.253	.092	-.070	.923
	3 w/o bleach	.072[a,b]	.253	.775	-.424	.569
	4 w/o bleach	.885[a,b,*]	.253	.000	.389	1.382
2 w/ bleach	1 w/ bleach	-.427[a,b]	.253	.092	-.923	.070
	3 w/o bleach	-.354[a,b]	.253	.162	-.851	.142
	4 w/o bleach	.459[a,b]	.253	.070	-.038	.955
3 w/o bleach	1 w/ bleach	-.072[a,b]	.253	.775	-.569	.424
	2 w/ bleach	.354[a,b]	.253	.162	-.142	.851
	4 w/o bleach	.813[a,b,*]	.253	.001	.317	1.310
4 w/o bleach	1 w/ bleach	-.885[a,b,*]	.253	.000	-1.382	-.389
	2 w/ bleach	-.459[a,b]	.253	.070	-.955	.038
	3 w/o bleach	-.813[a,b,*]	.253	.001	-1.310	-.317

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Estimates: PMP

Dependent Variable: b

Bleached	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
w/ bleach	-8.593[a]	.126	-8.842	-8.345
w/o bleach	-8.859[a]	.126	-9.107	-8.610

a. Based on modified population marginal mean.

Pairwise Comparisons: PMP

Dependent Variable: b

(I) Bleached		Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c]	
					Lower Bound	Upper Bound
w/ bleach	w/o bleach	.265[a,b]	.179	.138	-.086	.617
w/o bleach	w/ bleach	-.265[a,b]	.179	.138	-.617	.086

Based on estimated marginal means

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

5. Sample Area * Swatch: PMP

Dependent Variable: b

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	1 w/ bleach	-8.386[a]	.242	-8.861	-7.911
	2 w/ bleach	-8.970[a]	.265	-9.491	-8.449
	3 w/o bleach	-8.310[a]	.242	-8.785	-7.835
	4 w/o bleach	-8.999[a]	.265	-9.520	-8.479
B	1 w/ bleach	-8.373[a]	.265	-8.894	-7.852
	2 w/ bleach	-8.670[a]	.242	-9.146	-8.195
	3 w/o bleach	-8.623[a]	.265	-9.143	-8.102
	4 w/o bleach	-9.487[a]	.242	-9.962	-9.011

a. Based on modified population marginal mean.

6. Sample Area * Bleached: PMP

Dependent Variable: b

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	w/ bleach	-8.651[a]	.179	-9.003	-8.300
	w/o bleach	-8.623[a]	.179	-8.974	-8.272
B	w/ bleach	-8.535[a]	.179	-8.886	-8.184
	w/o bleach	-9.094[a]	.179	-9.445	-8.743

a. Based on modified population marginal mean.

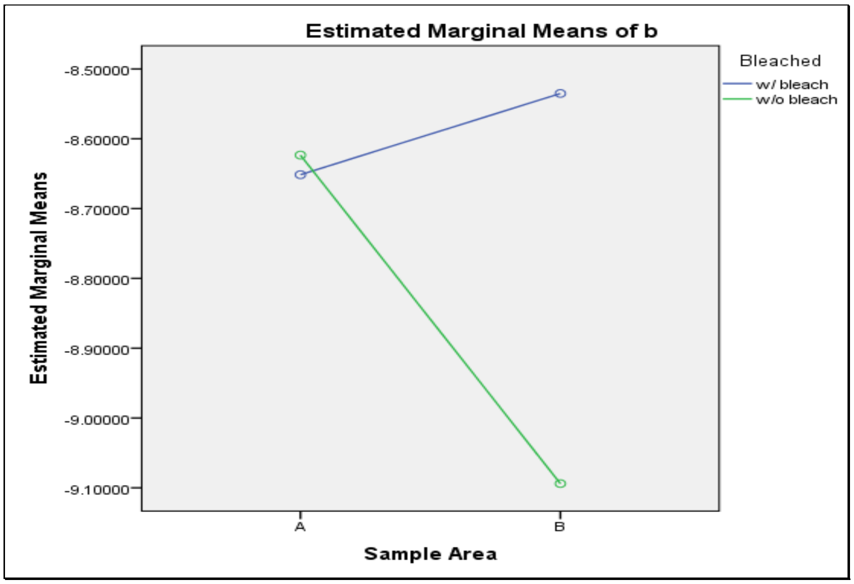


Table 14.6 ANOVA Output for Washed-Aged Results for sample RMP

Variable 'L'

Swatch Estimates: RMP

Dependent Variable: L

Swatch	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1 w/ bleach	84.681[a]	.226	84.237	85.125
2 w/ bleach	85.119[a]	.226	84.675	85.563
3 w/o bleach	84.071[a]	.226	83.627	84.515
4 w/o bleach	83.331[a]	.226	82.887	83.775

a. Based on modified population marginal mean.

Pairwise Comparisons: RMP

Dependent Variable: L

(I) Swatch		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	95% Confidence Interval for Difference[d] Upper Bound
1 w/ bleach	2 w/ bleach	-.438[a,b]	.320	.171	-1.065	.190
	3 w/o bleach	.610[a,b]	.320	.057	-.018	1.238
	4 w/o bleach	1.351[a,b,*]	.320	.000	.723	1.978
2 w/ bleach	1 w/ bleach	.438[a,b]	.320	.171	-.190	1.065
	3 w/o bleach	1.048[a,b,*]	.320	.001	.420	1.675
	4 w/o bleach	1.788[a,b,*]	.320	.000	1.161	2.416
3 w/o bleach	1 w/ bleach	-.610[a,b]	.320	.057	-1.238	.018
	2 w/ bleach	-1.048[a,b,*]	.320	.001	-1.675	-.420
	4 w/o bleach	.741[a,b,*]	.320	.021	.113	1.368
4 w/o bleach	1 w/ bleach	-1.351[a,b,*]	.320	.000	-1.978	-.723
	2 w/ bleach	-1.788[a,b,*]	.320	.000	-2.416	-1.161
	3 w/o bleach	-.741[a,b,*]	.320	.021	-1.368	-.113

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. An estimate of the modified population marginal mean (I).

b. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Sample Area Estimates: RMP

Dependent Variable: L

Sample Area	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A	84.336[a]	.160	84.022	84.650
B	84.265[a]	.160	83.952	84.579

a. Based on modified population marginal mean.

Pairwise Comparisons: RMP

Dependent Variable: L

(I) Sample Area		Mean Difference (I-J)	Std. Error	Sig.[c]	95% Confidence Interval for Difference[c] Lower Bound	Upper Bound
A	B	.070[a,b]	.226	.756	-.374	.514
B	A	-.070[a,b]	.226	.756	-.514	.374

Based on estimated marginal means
a. An estimate of the modified population marginal mean (I).
b. An estimate of the modified population marginal mean (J).
c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Bleach Estimates: RMP

Dependent Variable: L

Bleached	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
w/ bleach	84.900[a]	.160	84.586	85.214
w/o bleach	83.701[a]	.160	83.387	84.015

a. Based on modified population marginal mean.

Pairwise Comparisons: RMP

Dependent Variable: L

(I) Bleached		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	Upper Bound
w/ bleach	w/o bleach	1.199[*,b,c]	.226	.000	.755	1.643
w/o bleach	w/ bleach	-1.199[*,b,c]	.226	.000	-1.643	-.755

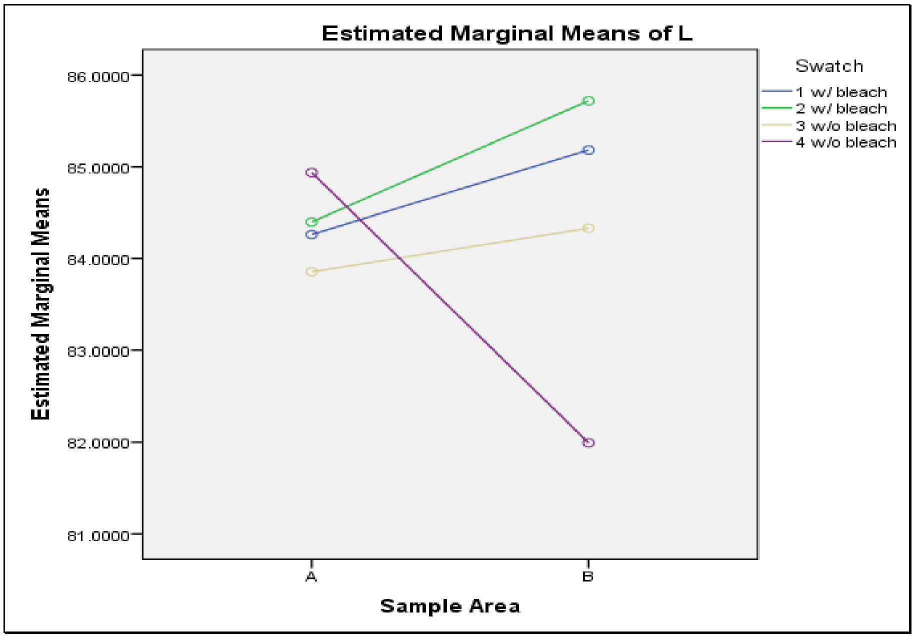
Based on estimated marginal means
*. The mean difference is significant at the .05 level.
b. An estimate of the modified population marginal mean (I).
c. An estimate of the modified population marginal mean (J).
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

5. Sample Area * Swatch: RMP

Dependent Variable: L

Sample Area		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
A	1 w/ bleach	84.262[a]	.306	83.661	84.863
	2 w/ bleach	84.399[a]	.335	83.741	85.057
	3 w/o bleach	83.855[a]	.306	83.254	84.456
	4 w/o bleach	84.938[a]	.335	84.279	85.596
B	1 w/ bleach	85.184[a]	.335	84.526	85.842
	2 w/ bleach	85.719[a]	.306	85.118	86.320
	3 w/o bleach	84.331[a]	.335	83.673	84.989
	4 w/o bleach	81.992[a]	.306	81.391	82.593

a. Based on modified population marginal mean.

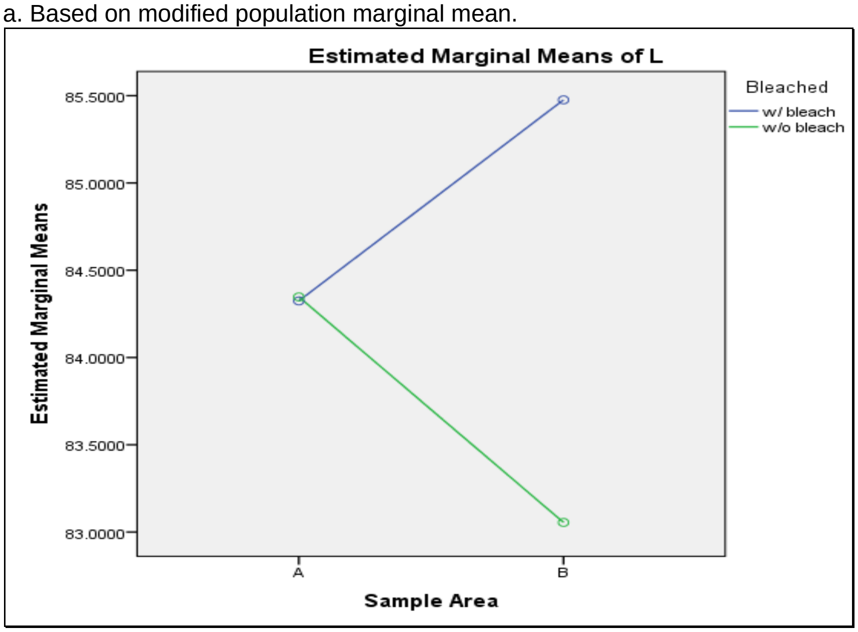


6. Sample Area * Bleached: RMP

Dependent Variable: L

Sample Area		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
A	w/ bleach	84.324[a]	.226	83.881	84.768
	w/o bleach	84.347[a]	.226	83.903	84.791
B	w/ bleach	85.476[a]	.226	85.032	85.920
	w/o bleach	83.055[a]	.226	82.611	83.499

a. Based on modified population marginal mean.

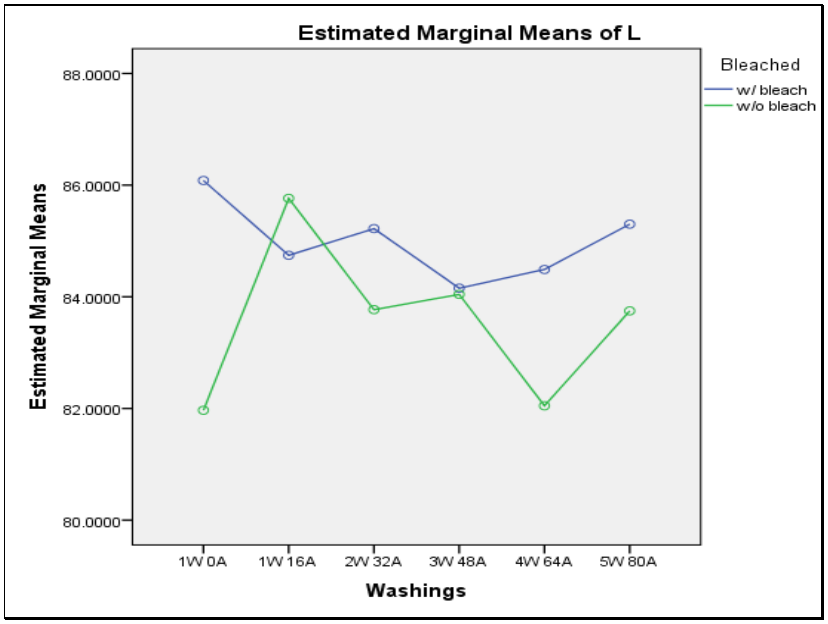


7. Bleached * Washings: RMP

Dependent Variable: L

Bleached		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
w/ bleach	1W 0A	86.084[a]	.530	85.043	87.125
	1W 16A	84.743[a]	.375	84.007	85.479
	2W 32A	85.222[a]	.375	84.486	85.958
	3W 48A	84.154[a]	.375	83.418	84.890
	4W 64A	84.490[a]	.375	83.754	85.226
	5W 80A	85.300[a]	.375	84.564	86.036
w/o bleach	1W 0A	81.968[a]	.530	80.927	83.009
	1W 16A	85.763[a]	.375	85.027	86.499
	2W 32A	83.770[a]	.375	83.034	84.506
	3W 48A	84.043[a]	.375	83.307	84.779
	4W 64A	82.048[a]	.375	81.312	82.784
	5W 80A	83.748[a]	.375	83.011	84.484

a. Based on modified population marginal mean.



Variable 'a'

Sample Area Estimates: RMP

Dependent Variable: a

Sample Area	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A	27.760[a]	.194	27.380	28.140
B	27.035[a]	.194	26.655	27.415

a. Based on modified population marginal mean.

Pairwise Comparisons: RMP

Dependent Variable: a

(I) Sample Area		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	Upper Bound
A	B	.725[*,b,c]	.274	.008	.187	1.263
B	A	-.725[*,b,c]	.274	.008	-1.263	-.187

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Bleach Estimates: RMP

Dependent Variable: a

Bleached	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
w/ bleach	27.095[a]	.194	26.715	27.475
w/o bleach	27.700[a]	.194	27.320	28.080

a. Based on modified population marginal mean.

Pairwise Comparisons: RMP

Dependent Variable: a

(I) Bleached		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d] Lower Bound	Upper Bound
w/ bleach	w/o bleach	-.605[*,b,c]	.274	.027	-1.143	-.068
w/o bleach	w/ bleach	.605[*,b,c]	.274	.027	.068	1.143

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

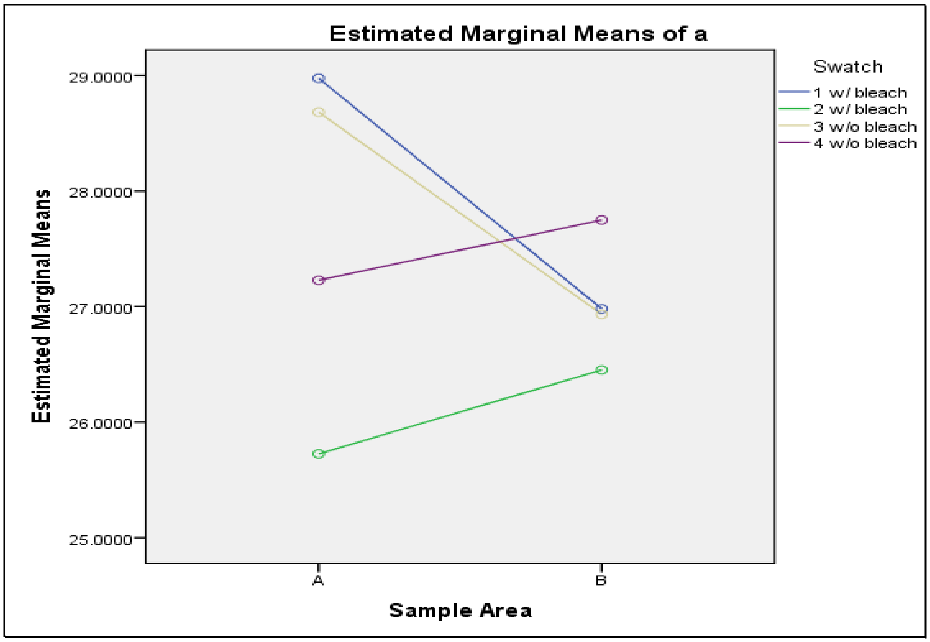
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

5. Sample Area * Swatch: RMP

Dependent Variable: a

Sample Area		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
A	1 w/ bleach	28.977[a]	.371	28.249	29.704
	2 w/ bleach	25.724[a]	.406	24.927	26.521
	3 w/o bleach	28.684[a]	.371	27.956	29.412
	4 w/o bleach	27.228[a]	.406	26.431	28.025
B	1 w/ bleach	26.980[a]	.406	26.183	27.777
	2 w/ bleach	26.452[a]	.371	25.724	27.179
	3 w/o bleach	26.933[a]	.406	26.135	27.730
	4 w/o bleach	27.750[a]	.371	27.022	28.478

a. Based on modified population marginal mean.



6. Sample Area * Bleached: RMP

Dependent Variable: a

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	w/ bleach	27.498[a]	.274	26.961	28.036
	w/o bleach	28.022[a]	.274	27.484	28.560
B	w/ bleach	26.692[a]	.274	26.154	27.229
	w/o bleach	27.378[a]	.274	26.841	27.916

a. Based on modified population marginal mean.

Variable 'b'

Sample Area Estimates: RMP

Dependent Variable: b

Sample Area	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A	15.976[a]	.162	15.658	16.294
B	15.517[a]	.162	15.199	15.834

a. Based on modified population marginal mean.

Pairwise Comparisons: RMP

Dependent Variable: b

(I) Sample Area		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
A	B	.459[*,b,c]	.229	.045	.010	.909
B	A	-.459[*,b,c]	.229	.045	-.909	-.010

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Bleach Estimates: RMP

Dependent Variable: b

Bleached	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
w/ bleach	15.326[a]	.162	15.008	15.643
w/o bleach	16.167[a]	.162	15.849	16.485

a. Based on modified population marginal mean.

Pairwise Comparisons: RMP

Dependent Variable: b

(I) Bleached		Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
w/ bleach	w/o bleach	-.841[*,b,c]	.229	.000	-1.291	-.392
w/o bleach	w/ bleach	.841[*,b,c]	.229	.000	.392	1.291

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (I).

c. An estimate of the modified population marginal mean (J).

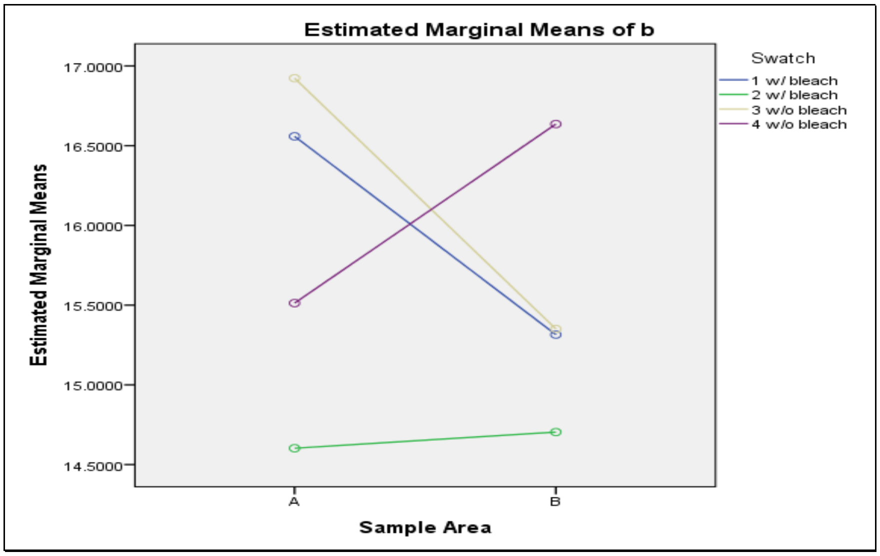
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

5. Sample Area * Swatch: RMP

Dependent Variable: b

Sample Area		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
A	1 w/ bleach	16.559[a]	.310	15.950	17.167
	2 w/ bleach	14.603[a]	.340	13.936	15.269
	3 w/o bleach	16.923[a]	.310	16.315	17.532
	4 w/o bleach	15.513[a]	.340	14.846	16.179
B	1 w/ bleach	15.315[a]	.340	14.648	15.981
	2 w/ bleach	14.704[a]	.310	14.095	15.312
	3 w/o bleach	15.351[a]	.340	14.684	16.017
	4 w/o bleach	16.636[a]	.310	16.027	17.244

a. Based on modified population marginal mean.



6. Sample Area * Bleached: RMP

Dependent Variable: b

Sample Area		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
A	w/ bleach	15.670[a]	.229	15.220	16.119
	w/o bleach	16.282[a]	.229	15.833	16.732
B	w/ bleach	14.982[a]	.229	14.532	15.431
	w/o bleach	16.051[a]	.229	15.602	16.501

a. Based on modified population marginal mean.

Table 14.7 ANOVA Output Between-Subject Factors for all colors

Between-Subjects Factors: all colors

		Value Label	N
Swatch	1	1 w/ bleach	1540
	2	2 w/ bleach	1540
	3	3 w/o bleach	1540
	4	4 w/o bleach	1540
Sample Area	A	A	3080
	B	B	3080
Bleached	1	bleached	3080
	2	w/o bleached	3080
Washing	1	1W 0A	560
	2	1W 16A	1120
	3	2W 32A	1120
	4	3W 48A	1120
	5	4W 64A	1120
	6	5W 80A	1120
Color	dk pink		880
	Green		880
	Orange		880
	pink-C		880
	Pink-J		880
	Purple		880
	Red		880