1-1-1948

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Burch H. Schneider

A. H. VanLandingham.

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Feeding Value of Hay Stored in Stack And in Mow

By

B. H. Schneider and A. H. VanLandingham

Agricultural Experiment Station
College of Agriculture, Forestry, and Home Economics
West Virginia University
C. R. Orton, Director
Morgantown

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¹In charge of the Lakin Experimental Farm, Lakin, W. Va.

²In charge of the Reymann Memorial Farms, Wardensville, W. Va.

³In charge of the University Experiment Farm, Kearneysville, W. Va.

⁴In cooperation with the U. S. Department of Agriculture.

Feeding Value of Hay Stored in Stacks and in Mows

B. H. Schneider and A. H. VanLandingham

MANY WEST VIRGINIA FARMERS stack hay in small conical stacks in the field instead of providing barn storage. Such stacks are usually built with a pole through the center and have been humorously called "cow-lollypops." They can be seen dotting the hillsides over many sections of the state as well as in neighboring states.

This practice of stacking hay outside is usually considered wasteful and uneconomical by experiment station and extension workers and by numerous farmers of the state. In many instances the hay is not only stacked outside but is fed to livestock on the ground around the stack; or they are permitted to eat directly from the stack. Because of the prevailing opinion that poor quality of hay may result and that methods of feeding in vogue are wasteful, the practice of stacking has been discouraged by agricultural workers for many years. Nevertheless, one still sees many such stacks today, for the cost of building a barn for hay storage is such that a farmer may well consider whether the superior quality of hay stored in a mow over that stored in a good stack is sufficient to justify the expense of the barn, if the same care is exercised in the feeding of the stacked hay (after the storage period) as is used in feeding the mow hay.

LITERATURE REVIEW

Experimental evidence is rather meager with regard to the relative merits of storing hay by the two methods. Several individuals have expressed opinions and have made certain recommendations based for the most part upon general observations rather than on demonstrated facts.

Parker (1929) recommends storage of loose hay in barns and sheds which protect it from rain damage and permit thorough curing and sweating without incurring rain losses during the storage period. He states, "The desire to avoid pushing hay long distances causes the building of many small, irregular piled stacks in the field. Such stacks expose relatively large exterior areas to weather damage, absorb much moisture from snow and rain, or may cause over-dried hay in windy climates. In stacking of alfalfa hay intended for market the possible saving in labor from the practice of throwing up numerous small stacks in a field, as compared with the practice of building a small number of large well-made stacks is usually more than offset by the loss in quality. The small additional costs of drawing the hay far enough to build a large stack and in keeping two men on the stack to build a symmetrical, well-tramped stack will be returned usually with an extra profit in high grade and increased sale value of the hay. The percentage of weather-damaged hay

on the outside of the stack to total stack tonnage is much less in large stacks than in small stacks.

"Stacks of less than 15 tons are not as resistant to the weather as larger stacks, yet many stacks of 5 to 10 tons are put up every year in the extensive alfalfa areas, and from such stacks many car lots of U. S. No. 2 and U. S. No. 3 alfalfa, mixed with some sample grade, unsound alfalfa hay are shipped to market."

Pollock and Hostermann (1937) pointed out that "In the central states as well as in Maryland, Virginia and West Virginia, timothy and clover hay are often stacked by hand, in low, flat stacks or tall narrow stacks, about a central pole of two to four tons in a stack. Such stacks weather badly and often become severely stained and partly rotten. When used for feed or shipped to market the returns are usually very low either in animal products or in cash returns."

Kite (1941) recommended a relatively low-priced type of barn that will hold about 40 tons of hay. He estimated that a stack 14 ft. in diameter and 14 ft. high containing 2 tons of hay would have 600 sq. ft. of surface exposed to the weather and that at least 4 in., which would amount to about two-fifths of a ton of hay, are lost on the outside of the stack.

More recently Whistler (1946) stated that farmers must use more efficient harvesting and storing methods for their hay. He added, "... losses to farmers in the United States through weathering and improper handling methods amount to \$500,000,000 annually in forage feed value. Any saving the farmer can attain through reducing these losses will show up directly as increased profits in livestock and livestock products."

In addition to the above citations, several reports of experiments are available on the effects of certain factors such as wetting or leaching, which should throw some light on what might be expected of hay stored in mows or in small stacks with relatively large amounts of the hay exposed to the weather.

When hay is subject to leaching, the nutrients are reduced. It may be reasoned that this occurs in stacked hay. At least leaching is a factor to contend with and to this extent influences our problem. Some of the evidence on this question is given as follows:

The experiments of Ames and Boltz (1912), Guilbert, Mead, and Jackson (1931), Headen (1896), Kellner (1911), Piper (1924), and Wolff (1895) show losses of certain hay nutrients up to 90 percent as a result of soaking or sprinkling hay or of subjecting it to natural rainfall. Losses were noted in total dry matter, total ash (or silicon-free ash), phosphorus, potassium, calcium, magnesium, sodium, chlorine, nitrogen (or protein), fat (conflicting data), and nitrogen-free extract (some workers reported sugar and not N-F.E.). No fiber was lost. The relative amount of fiber was increased in some cases as other feed nutrients were leached out. Kreusler *et al.* (1879) in experiments with meadow hay found that either moistening or steaming lessened the amount of digestible protein and of the other digestible nutrients.

Zielstorff and Nehring (1929) noted that in perfect weather there was no difference in the composition and digestibility of the original fresh-mown grass and hay, but in bad weather the usual method of dry-

ing on the ground produced much poorer hay than other methods of drying. Wolff *et al.* (1872) conducted some early experiments showing the adverse effect of weathering on utilization of hays by sheep.

Le Clerc and Breazeale (1908) state that when grass was dried before leaching with water a much larger amount of ash washed out. Freshly cut hay is only slightly injured by rain, whereas if rain comes after the hay has dried the loss is considerable, sometimes as much as half of the ash ingredients being thus removed. In drying, plants exude salts upon their surfaces; the rain then washes them back into the soil. Ames and Boltz (1917) call attention to the luxuriant growth of aftermath, which they state may well be explained when a crop remains on the ground for some time after it is cut, because of the leaves and of the essential elements dissolved out in a very available form for the second growth. Since dry hay is more affected by rain during curing than freshly cut green hay, stored hay should be expected to undergo considerable leaching by extended exposure.

Guilbert and Mead (1931) conducted digestion trials with (a) hay cured in cocks, (b) hay exposed 21 days and wet twice by a total of 0.31 inches of rain, and (c) hay exposed 34 days wet 3 times by a total of 0.73 inches of rain. The digestibility as well as the amounts of all nutrients except fiber were decreased by significant amounts by each additional exposure to leaching. These losses were shown by later experiments to be due to leaching by rain only and were not influenced by extended exposure to the sun. In these experiments all the leaves were recovered as the hay was spread out on a cement pavement. Thus the effect of the treatment was less severe than that in field-curing, where loose leaves are lost. The hay cured in cocks was much more palatable to the sheep used in the experiments than that exposed to rain. Thus the palatability also was affected by the weathering process.

Fingerling (1906) noted that in meadow hay exposed to rain all nutrients and the digestibility of all nutrients were reduced except crude fiber. The T.D.N. of the hay exposed to rain was 46.1 and of the unexposed, 52.4. This corroborated his earlier experiment (1905), in which he noted that in hay which had been exposed to rain after curing, all nutrients and coefficients of digestibility were lowered except with crude fiber. The leached hay was significantly lower in digestible protein and in T.D.N.

Senior and Sheehy (1941) noted that the digestibility of nutrients of clover grass-mixed hay was less than in the freshly cut crop. Weathered hay contained less digestible nutrients than carefully cured hay. There was loss of soluble nutrients by weathering, and the digestibility was reduced. The difference between fresh-cut grass and *good* hay was small and in some cases nil.

Crasemann and Steiner (1931) found that the losses of starch equivalent and digestible true protein were greater with increase of rainfall on the freshly cut crop—62 percent starch equivalent and 45 percent digestible true protein in extreme cases.

Fraps (1941) in digestion experiments with Texas feeding stuffs found that prairie hay, cut after frost and presumably exposed to considerable weather after drying, had higher digestibility and feeding

value than that cut before frost. This is contrary to the observations of others that "weathering" decreases the feed value. There is a difference, however, in this case in that the hay crop had not been cut before it was exposed.

Another factor to consider is that all hay deteriorates with storage. This is true whether storage is in stacks or in hay mows. This is demonstrated by the following experiments:

Dietrich and Koenig (1891) quoted experiments of early German workers showing that, the longer hay is kept in storage, the lower the content of crude and digestible nutrients.

Hoffmeister (1873) working with sheep found that the amounts of total and digestible nutrients were decreased in red clover hay the longer it is kept in storage. Wolff *et al.* (1873) reported the same thing with second-cutting meadow hay. These workers conducted experiments with sheep on vetch hay also, which was kept for varying periods of time, and found that the total amount of nutrients and also the digestible nutrients decreased with age. In later experiments, they showed repeatedly that the total nutrients and also the digestible nutrients were considerably decreased the longer hay was kept in storage.

Honcamp *et al.* (1914) found that the composition and digestibility of meadow hay and of red clover ryegrass mixed hay remained unchanged after 21 months and 36 months, respectively, when it was kept in strong paper containers. From this we may conclude that, the better the hay is protected, the less the deterioration which may be expected during extended storage.

Lepchne (1927) stated that in his experiments with red clover hay dried with special care to prevent mechanical loss the following losses occurred in digestible nutrients from the time of cutting to the time when the hay was fed: dry matter, 40.6 percent, crude protein, 43.4 percent, N-F.E., 47.3 percent. By ordinary methods of drying hay on the ground there was a loss of crude protein of 55.8 percent and of starch value, 63.9 percent. Thus even in hay dried without mechanical loss, considerable decrease in nutrients is caused by respiration and curing processes.

Emery and Kilgore (1894) describe digestion experiments to determine the effect of storage of hay as follows: "The crimson clover hay fed in these experiments had been cut and stored in a barn for more than a year, it being a portion of the same lot of hay, the digestibility of which was determined a year ago. Comparison of the compositions of the new and one-year-old hay shows a decrease of one percent, in total protein—slightly less fat, and an increase of nitrogen-free extract and crude fiber in the year-old hay. The new hay was slightly more digestible than the old; the decrease in the old hay falling upon the fat and nitrogen-free extract, but the difference in digestibility of total dry matter in the old and the new hay is no more than would be expected to be found in different experiments with exactly the same food."

Exposure in curing hay causes losses. Any curing, preserving, or storing procedure that lessens exposure improves quality of hay. It can be concluded that exposure after curing will likewise cause losses of nutrients from hay. There is no definite point at which curing stops

and storage begins. Curing continues long after hay is put in the stack or mow. Thus it is easily understood that anyone might well assume that the same processes of deterioration continue and that they are affected by the same influences. We can learn something of the effects of exposure from the following research:

Baseler (1936) cured hay by several methods. He dried it on the ground, being careful that there were no mechanical losses, and also on riders or trestles of various kinds and in certain so-called "cottages" where curing was entirely by air convection. He also made part of the same crop into silage. He found no difference in the various drying methods but concluded that ensiling gave the most nutrients from the crop. Differing somewhat in their conclusions, Zielstorff and Keller (1929) dried hay on racks and stated that it was far superior to hay dried on the ground. The digestion coefficients for hay dried on "swedish riders" (drying racks) were as high as, or higher than, digestion coefficients of silage made from the same crop. Silage showed the least loss of digestible nutrients and best maintained the starch value of the original grass.

Kirsch and Jantzon (1942a) made comparative estimates of the efficiency of various methods of fodder conservation and their relative values in preserving the feeding value of clover-grass mixtures. When drying conditions were favorable, *i.e.*, with wind and sunshine but no rain, there was little difference between ordinary field-cured hay and hay cured by other methods. When the hay passed through the fermentation stage, the authors stated that the starch value was increased. Liebscher (1942) claimed that there was less loss of crude and digestible nutrients when hay was cured on special racks than by other outdoor processes. although little difference was found in methods of curing hay except when there was storm and rain.

In curing, protection from the elements produces better hay. It is only reasonable to infer that such protection would maintain better hay in storage, and that therefore mow hay would be significantly superior to stack hay. We could infer this conclusion from some of the following experiments:

Meier (1933) compared artificially dried hay and that dried on the ground or on trestles. He found that artificial drying saved more nutrients although high temperatures decreased the digestibility of the protein. Bruemer (1943) presents data showing that artificially dried alfalfa hay is superior in digestibility of nitrogen-free extract to air-dried hay, but other nutrients are about equally digested when dried by these two methods. Honcamp (1915) in repeated tests found that field-dried grass always showed greater losses of total and digestible nutrients than artificially dried hay.

Newlander *et al.* (1938) found that sun-cured alfalfa, timothy, or soybean hay showed greater losses in nutrients than artificially dried hay or silage from the same crop. Artificially dried hay had the most T.D.N., more than silages or sun-cured hay from the same field. Artificial drying proved superior to any other method of curing. Later the same authors (1940) found a greater recovery of T.D.N. from artificially dried hay than from silages or sun-cured hay. Snell (1934) found no

significant difference between field-cured and machine-dried soybean hay. He concluded that there appears to be more variation from year to year than between methods of drying.

Liebscher (1941) found that the digestion coefficients of organic matter are decreased as hay dries and passes through the fermentation stage. The digestion coefficient of crude protein was lowered most. Fermentation lowered the digestibility of N-F.E. but increased that of crude fiber. Fermentation apparently increased the percentage of protein and crude fiber in the hay but lowered the total amount of N-F.E. Also, he notes that long fermentation of hay destroys the carotene. He states that, although there is a little absolute loss of crude fiber by fermentation, the remainder is more digestible.

Kirsch and Jantzon (1942b) in digestibility trials with sheep stated that the organic matter of hay baled by a pick-up press had a slightly higher digestibility than hay from the same crop made in the ordinary way.

These references give us a number of facts from which we may be led to reason regarding the possible effects of different ways of storing hay. We note that losses in nutritive value in hay result with any way of storing under practical conditions. Experiments on curing indicate that hay subject to any kind of leaching loses nutritive value. Comparisons of "ordinary" curing on the ground were made with a number of other methods of curing, dehydrating, preserving, or handling. In the experiments cited, this loss of nutritive value is measured in several ways—by market grade, by chemical analysis, and by digestion experiments. In none of these experiments were mow hay and stack hay compared by means of growth trials with animals. From all of these we might infer that hay not protected would deteriorate more rapidly than hay sheltered by a roof.

Although these numerous experiments offer evidence regarding the relative value of hay crops that have been handled in different ways, *there is not enough specific information on the problem of stack versus mow storage of hay.* This is the problem that concerns the authors of this bulletin and the farmers of West Virginia. Accordingly the following experiments were planned to throw more light on this question.

EXPERIMENTAL

HAY USED

The feeding value of mixed legume and grass hay grown on the same field and cured in the same way, but stored in stacks and in a mow, was compared by feeding it to comparable groups of sheep each year for a period of 3 yr. The plan followed was to cut sufficient hay for each year's trial at one time. The hay was tedded to aid in curing as soon as it was dry enough. The first year the hay was raked, cocked, and loaded by hand. Alternate cocks were stored in the hay mow, the rest in the haystacks. For the other two years a hay loader was available; the division of the hay was made by taking alternate windrows.

The hay was weighed as it was hauled to the stack or mow and sampled during unloading. Dry-matter determinations were made on representative composite samples of hay as it was put in storage. During

the last 2 yr. of the experiment, weighed samples of hay were placed in net bags and buried in the stacks and in the mow. Duplicate bags were taken for dry-matter determinations when the bags were put in storage. When the buried bags were uncovered they were taken to the chemical laboratory for dry-matter determinations. By knowing the weight of dry material in the samples when buried in the stacks and in the mow, as well as the weight of the dry matter in the same sample when removed from storage, it was possible to calculate the loss in dry matter during the storage process.

It was desired to use first-cutting hay each year so as to give a longer storage period before winter feeding, but this was feasible for only one year, the third one of the experiment. In previous years the weather was such that it was impossible to obtain hay of the desired quality: *i.e.*, not severely wet by rain during the curing process. For the first 2 yr., when second-cutting hay was used, the hay was put in storage on August 11 and 6 respectively. For the third year, when first-cutting hay was used, the hay was stored on June 25. In the first year 0.7 in. of rain fell during the night after the hay was cut, and 0.1 in. the following day. No rain fell on the hay used in the second and third year before it was put in storage.

Mixed hays were used throughout the experiment. The approximate proportions of grasses and legumes were as follow:

	ALFALFA	TIMOTHY	CLOVER	FOREIGN MATTER
	<i>percent</i>	<i>percent</i>	<i>percent</i>	<i>percent</i>
1st year	trace	44	26	30
2rd year	8	trace	80	10
3rd year	10	35	44	10

In the first year the hay was in storage for 162 days, and the stacks had 7.6 in. of rainfall before beginning of the feeding trial. In the second year the hay was in storage for 144 days, and the stacks had 14.4 in. of rainfall. In the third year, when first-cutting hay was used, the hay was in storage for 196 days, and 32.5 in. of rain fell on the stacks.

FEEDING TRIALS

In each of the 3 winters following the storage of the hay described, 40 uniform Western feeder lambs were purchased. These were divided into 2 comparable groups of 20 lambs each, the division being made on basis of body weight, sex, and general appearance. The lambs were weighed at beginning of the feeding trials and at regular intervals throughout the feeding period. One group received the hay stored in stacks and the other the hay stored in the mow. The feeding and handling of the lambs otherwise was the same for both groups.

The lambs were housed in a shed with the south side open. The shed space and the run areas outside the shed were of equal size. In one year the lots for the 2 groups were reversed to avoid positional effects as far as possible. When the feeding trials were ready to begin, a stack

was opened, and all hay considered unfit for feeding was weighed and discarded. Representative samples of the discarded hay were taken and dry matter was determined. In this way was estimated the amount of hay dry matter discarded. The good hay was taken to a bin in the sheep shed. If the stack when opened was not all taken into the bin, the open stack was covered with a tarpaulin for protection. Hay from the mow was also hauled to a similar bin in the sheep shed.

The two groups of lambs were offered equal amounts of dry matter. Whenever the percentage of dry matter in the hay was less, as it frequently was in the case of the stacked hay, more of this hay was fed so that both lots received the same amounts of dry matter. The lambs were fed all the hay that both groups would clean up. The amounts of hay consumed varied from 1.5 to 2.1 lb. per lamb per day; they also varied with the year and from the beginning to the end of the feeding period.

The hay was classified and the percentage dry matter determined in representative samples as follow:

1. Discarded hay: hay that was discarded by the feeder as being unfit to offer to the lambs.
2. Good hay: hay offered to the lambs.
3. Refused hay: hay the lambs did not eat and left in the mangers.
4. Wasted hay: hay that was scattered over the pens as the lambs ate it.

In each year were recorded the weights of hay put into the stack and into the mow, and the amounts discarded, consumed, refused, and wasted.

RESULTS

The hay used in the first year graded U.S. sample grade timothy light clover mixed.* This hay was thrown into sample grade because of excessive amounts of foreign matter (weeds), chiefly plantain of various kinds. Otherwise the mow hay would have graded No. 2 and the stacked hay No. 3. The stacked hay had approximately 25 percent color and the mow hay 35 percent color. In the second year the stacked hay graded as U. S. No. 2 clover and the mow hay as U. S. No. 2 green clover. In the third year the stacked hay graded as U. S. No. 2 timothy medium clover mixed, and color was estimated at 40 percent. The mow hay was graded as U. S. No. 1 mixed hay with 55 percent color.

In the first year the difference between the hay stored and that fed or discarded left a discrepancy of 10.4 percent in the stack hay and 11.4 percent in the mow hay of hay unaccounted for. In the following year bags of hay buried both in the stack and in the mow showed that 4.6 percent of the dry matter in stack and 7.1 percent in the mow was lost through oxidation, not through mechanical loss. In the third year, when first-cutting hay was stored for a longer period and subjected in the stack to much greater rainfall (32.5 in.), the total amount of hay dry matter lost or unaccounted for was 25.0 percent in the stack and 17.9

*The authors are indebted to Mr. W. H. Hosterman, Chief Hay Section, Commodity Inspection Division, U. S. Dept. of Agriculture, for grading hays in all three years.

percent in the mow. However, in this latter case the losses by oxidation as measured by bags of hay buried in the stack and in the mow were of the same order as previously, with the second-cutting hay stored for a shorter period and subjected to less rainfall (5.2 and 7.3 percent, respectively).

The percentages of stacked hay discarded for each of the 3 yr. were 1.8, 1.0, and 4.0 percent, respectively. The larger amount of unfit hay discarded in the last year can be explained logically by the longer period of storage and the much greater amount of rainfall.

These losses leave from the dry matter of the hays 87.7 percent of the mow hay and 88.6 percent of the stack hay for second cutting and 75 percent of stack hay and 82.1 percent of mow hay of first-cutting hay available for feeding.

Of the hay which was offered, 86.7 percent of the stack hay and 85.7 percent of the mow hay was consumed with second-cutting hay in the first and second years. In the third year with first-cutting hay, 88.2 percent of stack hay and 84.5 percent of mow hay was consumed. While these differences are not thought to be significant, it was noted that the mow hay was drier and lighter, while the stack hay tended to stick or mat together. For this reason, the mow hay appeared to be scattered more easily as the sheep ate it and made the weight of "scattered" hay greater for mow than for stack hay.

The lambs receiving the mow hay made slightly greater gains each year. The mow hay lots gained an average of 2 lb. more during the 12-week period each winter. The data pertaining to these facts are given in Table 1.

Table 1—Summary of Feeding Trials with Lambs

	1st Year		2nd Year		3rd Year		3-Yr. Ave.	
	Stack	Mow	Stack	Mow	Stack	Mow	Stack	Mow
	pounds	pounds	pounds	pounds	pounds	pounds	pounds	pounds
Average hay dry matter offered daily	2.30	2.20	2.51	2.44	1.40	1.44		
Average corn per day	.22	.22	—	—	.20	.20		
Average linseed oil meal per day	.09	.09	—	—	.07	.07		
Average initial weight	59.6	59.4	65.7	65.8	64.6	65.5	63.3	63.6
Average final weight	71.1	73.4	80.4	83.2	69.2	70.8	73.5	75.8
Average gains	11.5	14.0	14.7	17.4	4.6	5.3	10.2	12.2
Greater gain of mow over stack hay		2.5		2.7		0.7		2.0

*Twenty lambs were used in each lot except for 1 lamb killed by dogs during the last week of this experiment. There is no difference in the interpretation of the results whether this lamb was omitted or included with the estimated final weight.

The analysis of variance is shown in Table 2.

A study of the data gives the impression that a more efficient experiment (with replication of lots on the same kind of hay each year) would have led to results that were statistically more significant. However, it is not believed that a difference of 2 lb. per lamb is of importance

whether or not the data are significant. These differences might, of course, become larger if we should continue feeding the hay for a longer period, but we cannot be certain of this.

In each year a record was kept of the free-choice salt consumption of the lambs. In the first year the lambs on mow hay consumed 13.5 and those on stacked hay, 15.75 lb. of salt. In the second year only did there appear to be a marked difference in the salt consumed by the lots; in that year the lot on mow hay consumed 26.75 lb. of salt while the lot on stacked hay consumed 45.00 lb. of salts in 12 weeks. In the third year the salt consumption was 18.5 and 19.5 lb., respectively.

In the first year, after the close of the experimental feeding period, the lambs were continued on the same hays but were fed sufficient corn and linseed oil meal to gain about 18 lbs. during a 6-week period. No significant difference in the gains was noted between the stack and the mow hay lots. In this "fattening" experiment the same amount of concentrates was fed to the 2 lots in such quantity that, if any difference between hays existed, it was completely obscured.

Table 2—Analysis of Variance

SOURCES OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F
Kind of hay storage	1	115.5	115.5	10.2*
Years	2	2,611.5	1,305.7	
Interaction between years and kind of storage	2	22.6	11.3	
Individuals	114	2,619.7	23.2	
Total	119	5,401.5		

*In this analysis the difference between the two kinds of hay storage is not statistically significant. Because of the poor gains in both lots in the third year, the question of whether the **percentage** differences in gains were significant was investigated. In an analysis of variance with the logarithms of the average gains, the differences between stack and mow hay were significant at the 5-percent level.

DISCUSSION

On the basis of the experiments and recommendations which have been quoted previously, and on the basis of losses in nutritive value of hay when cured under unfavorable drying conditions, it is somewhat surprising that greater differences in feeding value were not obtained for hay stored in a mow as compared with the same kind of hay stored in stacks.

In this experiment the storage periods were not unusually long but were in keeping with what might be expected under moderately good farm practice. Hay held in storage for long periods shows a decrease in nutritive value even though it be stored in a mow. This is indicated in the case of the third year's trial, when first-cutting hay was used. However, the loss suffered by the stacked hay in this trial exceeded that of the hay stored in the mow by only 4 percent, which is not excessive. When

second-cutting hay was used, the loss of stacked hay over mow hay was only 1 to 2 percent.

It appears that certain recommendations for hay storage have been made on the basis of mistaken ideas as to what the losses really are of hay stored in stacks. The losses in hay unfit for feeding purposes in this experiment were much less than one would believe from reading certain reports. Certainly there was not 4 to 6 in. of unusable hay on the outside of the stack. Had these stacks been permitted to stand for 2 or more seasons, the results might have been different.

Swanson *et al.* (1919) noted a total loss of 39.07 percent of dry matter in stacks of brown or black alfalfa (stacked without being completely dried) which, because of high moisture content, had gone through excessive fermentation. Wiegner (1925) compared the losses due to hay making with the nutrients in the crop as first cut. It appears that our losses are well within the limits which he gives. He presents the following data:

SOURCE OF LOSSES	TOTAL DRY MATTER	DIGESTIBLE DRY MATTER	STARCH EQUIVALENT
	<i>percent</i>	<i>percent</i>	
Respiration	up to 10	5 - 15	5 - 15
Mechanical losses	5 - 10	5 - 10	5 - 10
Fermentation in stack	5 - 10	5 - 10	5 - 10
Loss in metabolism of animal	- - -	- - -	10 - 15
Total	10 - 30	15 - 35	25 - 50

It should be recalled that the hay stored in the mow graded about one grade higher than that stored in stacks. This difference was based mostly on color. This is indicated also by carotene determinations on samples taken during the second year's work. For this one year the mow hay contained 1.72 mg. and the stacked hay 1.06 mg. of carotene per 100 g. of hay.

This difference in market grade was not substantiated by corresponding differences in feeding value as indicated by the feeding trials with lambs.

When the hays were fed on the basis of equal dry matter, an average gain of only 2 lb. per lamb for the mow hay over the stacked hay is of little practical significance. It must be remembered that in these trials the hays were handled in like manner during the feeding period. This is not the usual practice on most farms in West Virginia. Many farmers feed the stacked hay on the ground around the stack or permit their animals to eat directly from the stack. This is apparently a very wasteful and inefficient method of feeding and should be considered separate and apart from losses due to storage.

From the results obtained in this study it can be recommended that all the mow storage available should be used by all means and that first-cutting hay should be stored in the mow if possible. Then, if mow

storage is short, second- and third-cutting hay may be stored in well-made stacks for reasonable periods of time without excessive loss.

Hay can be stored in well-made stacks for a reasonable length of time, one season, without excessive loss of nutritive value. If hay is stored in stacks, care should be exercised in feeding so that excessive amounts of the hay are not wasted.

SUMMARY AND CONCLUSIONS

Hay cut and cured at the same time and in the same way was stored in stacks and in a mow for 3 haying seasons. The stacked hay and the mow hay were fed to 2 comparable groups of 20 lambs each during the winter following the haying season. The lambs were fed equal amounts of dry matter from the hay stored in the stacks and in the mow. Weighed samples in net bags were buried in the stacks and in the mow to determine the loss in dry matter due to oxidation during the storage period.

An average of 87.7 percent of the mow hay and 88.6 percent of the stacked hay for second-cutting hay, and 82.1 percent of the mow hay and 75 percent of the stacked hay for first-cutting hay, put in storage, was available for feeding. The amount of hay discarded from the stacks varied from 1 to 4 percent of the hay stored in the stack, representing losses in excess of that stored in a mow.

The lambs receiving the mow hay gained an average of 2 lb. per lamb more than the lambs which were fed stacked hay. This small difference in gain was not statistically significant and was of little practical value.

Hay can be stored in well-made stacks for one season without appreciably greater losses than that stored in a mow if the hay is fed under the same conditions so as to prevent excessive waste during feeding.

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