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Alfalfa Silage Effect of Storage Methods on Feeding Value and on Preservation of Nutrients

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alfalfa silage

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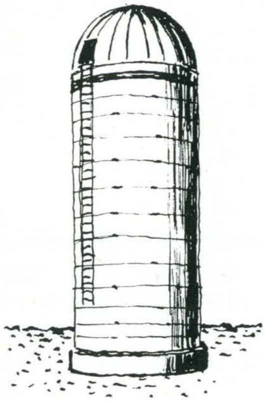

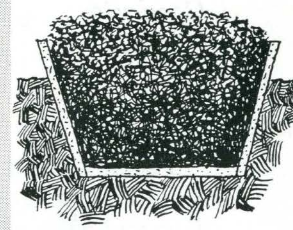

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Great spoilage and fermentation losses occur where open-type storage of alfalfa silage is practiced, unless the silage is fed soon after it is put up. Properly filled upright silos in good repair have considerably less spoilage because less air reaches the silage. Spoilage and fermentation losses cannot be measured by observation, and the feeder seldom realizes how great his loss has been. Dry matter losses of 35 to 50% with open-type storage are not uncommon.

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SUMMARY

Feeding trials using beef cattle were conducted with baled alfalfa hay and with alfalfa silage stored in the stack, trench, and upright silo.

Based upon feed costs at the time of storage, the average feed costs per 100 pounds of gain for the several experiments were as follows: baled hay, $18.70; upright silo, $22.35; trench silo, $30.58; and stack silo, $33.58. The greatly increased costs in the case of the trench and stack were the result of excessive fermentation and spoilage losses because air was not properly excluded.

The chemical composition of the dry matter of the various silages was quite similar. However, the spoilage was considerably different in its composition from the edible silage. This was especially true where chemical determinations of digestibility were made, the values for the spoiled silage being very low.

Dry matter and nutrient losses were determined on hay and the various silages for 1 year's work. The amount of loss was largest when air was not properly excluded (stack and trench).

This work emphasizes the need to provide storage for alfalfa silage of a type which will prevent exposure to air for satisfactory preservation of nutrients. In deciding what type of storage to use, the operator should consider this as well as the many other factors related to cost and convenience.

Alfalfa Silage

EFFECT OF STORAGE METHODS ON FEEDING VALUE AND ON PRESERVATION OF NUTRIENTS[1]

W. C. McCone and O. E. Olson[2]

The South Dakota farmer is often unable to get his first crop of alfalfa up as good quality hay because of the frequent June rains. Storing the crop as silage offers one answer to this problem. The storage method often used in recent years has been the stack or pile of silage—a method that requires little or no cash outlay for a structure.

In 1952, a stack of alfalfa-brome silage was put up at this experiment station. Observation indicated that the results were quite satisfactory. However, information on the extent of nutrient loss was needed before this storage method could be satisfactorily evaluated. The work described in this bulletin was undertaken to obtain this information. Alfalfa was used in the studies.

To allow for comparisons, the studies included several storage methods: (1) baled hay, (2) stacked silage (uncovered), (3) trench silo, and (4) upright silo. Two methods of assessing nutrient losses were used. The first method involved feeding trials with beef cattle, the second chemical analysis.

METHODS

Preparation of silage and hay. Three years of experimental work were conducted to evaluate the different methods of storing alfalfa. Feeding value was compared through beef feeding trials. Each year the first cutting of alfalfa was swathed and allowed to wilt. Then a field chopper was used to prepare the crop for ensiling.

Silage was stored in an upright cement block silo, a stack on the ground, and a trench silo. The stack of silage was prepared by using cribbing to start the stack and to form it during filling. The center was topped off to allow run-off of rains. No packing was used other

[1]This work was conducted as part of North Central Regional Project 23 and was in part supported by grants therefrom.

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than men working continuously on the stack during filling. The cribbing was removed after the stack was well set.

In order to locate a trench silo with adequate drainage, it was necessary to store only part of the silage below ground level; the remainder was supported by planks above ground. Here, except for the first year, the forage was packed by driving a heavy truck over the silage after each load was dumped and spread. For the first year, packing was accomplished by manpower.

The upright silo was filled in the conventional manner and was leveled and packed by tramping near the completion of filling.

Another supply of feed was stored as alfalfa hay baled from a field similar in size and yield to that used as the source of forage for the upright silo. Thus an equal acreage was used for hay and for silage stored in the upright. Light rain fell on the hay before baling in the first 2 years of work.

All forage was weighed into storage. During 1953-54 and 1954-55, the weight of silage fed and the weights of spoilage for each method of storage were determined. During the 1955-56 season, only the weights of silage stored and fed and of the hay fed were determined.

Feeding procedures with cattle. For each of 3 years, 40 long-yearling Hereford feeder steers were divided into four lots of 10 animals each. These were placed on experiment during October. The intention was to feed at a rate to allow for their sale at slaughter grades of Good or Choice at the conclusion of the feeding period.

The cattle were fed a ration of cracked shelled corn, alfalfa silage or hay, and a free-choice mixture of salt, bonemeal, and limestone. They were started at 3 pounds of corn per head daily and this was slowly increased to 7 pounds per head daily. The average rations for the three experiments are indicated in table 1. The steers were continued on experiment until all of the hay or silage for the lot was consumed.

Collection and analysis of samples. Samples were taken at the time the alfalfa used in the feeding trials for 1954-55 and 1955-56 was ensiled. The samples were immediately dried at 75° C. for 72 hours in a forced draft oven to determine moisture content. The dried samples were ground for analysis, using a Wiley mill and a 0.5 millimeter screen. Hay samples were taken from the windrow just before baling and treated in a similar manner.

During the feeding period, samples of spoiled and edible silage were collected weekly, and samples of hay were collected biweekly. These were analyzed for moisture and ground for analysis as already described. Equal weights of the ground samples were composited to give monthly samples for analysis.

The samples were analyzed for ether extract, crude fiber, crude protein (N x 6.25), ash, and nitrogen-free extract by A. O. A. C. methods or slight modifications thereof. Moisture determinations were also made on the ground samples to allow for correction for moisture picked up during grinding and compositing.

RESULTS AND DISCUSSION

Feeding studies. The results of the feeding trials with cattle are given in table 1. Data in these tables reveal that the average daily gains for the different lots varied, but no one lot was consistently high or low. In fact, it appears that there was little effect on average daily gain by storage method. Feed efficiency data were also quite variable. Here again it seems unlikely that the unspoiled silage from either storage facility can be considered best, and correcting for moisture makes it appear that hay is about equal to the silages in this respect.

The most obvious and consistent differences found in these experiments were in terms of percent of stored material fed and of feed costs per hundred pounds of gain, the latter based upon feed purchased for storage. In these cases, the hay was best for the 2 years for which data are available. Silage from the upright silo was considerably better than from either the stack or the trench.

The data for feed costs per hundred pounds of gain have been calculated in two ways, and the results indicate what is happening in these experiments. Assuming comparable costs for the hay or silage as it is fed gives data that are quite similar for the four storage methods. This indicates that feeding values of the hay and various silages offered to the cattle are similar.

However, calculating costs per hundred pounds of gain from the cost of feed placed in storage gives a much different picture. This method of calculating takes into account losses during storage. With this method of calculation, the alfalfa hay was a somewhat cheaper feed than the silage from the upright, which in turn was considerably cheaper than that of either of the other two storage methods. In short, it appears that there is much more reason for concern over how much edible dry matter is preserved by a storage method than over the effect of the storage method on feeding value per pound of edible dry matter.

Chemical composition. Results of the analyses made on samples of alfalfa silage and hay used in the 1954-55 and 1955-56 feeding trials are shown in table 2.

It is apparent that the moisture content is generally higher for the silages than for alfalfa at the time it is ensiled. This has been observed in other work with silage at this station and is the result of the production of water by the fermentation process as well as of the loss of some volatile organic compounds from the silage during the moisture determination.

In comparing the composition of the dry matter, the ether extract content was higher for the edible silage than for the alfalfa as ensiled. The same is true for the crude fiber content and for the ash. Crude protein content increased in some cases, but this was not consistent. Decreases in nitrogen-free extract were found in all cases. These

Table 1. Results of Feeding Trials with Cattle

	1953-54				1954-55				1955-56			
	Upright	Stack	Trench	Hay	Upright	Stack	Trench	Hay	Upright	Stack	Trench	Hay
No steers per lot	10	10	10	10	10	10	10	10	10	10	10	10
No. days fed	92	64	54	92	188	99	121	187	233	123	157	260
Av. initial wt., lbs.	741	740	741	740	705	706	701	702	750	752	752	749
Av. gain per head, lbs.	188	120	99	183	316	164	215	332	409	192	273	465
Av. daily gain, lbs.	2.05	1.88	1.83	1.99	1.68	1.66	1.78	1.77	1.75	1.56	1.74	1.79
Av. daily ration, lbs.												
Silage or hay	44.6	46.3	47.5	15.9	45.7	56.8	50.0	18.2	43.8	45.9	41.4	17.9
Corn	6.3	6.0	5.8	6.3	5.8	4.7	5.1	5.8	6.5	6.0	6.2	6.5
Feed per cwt. of gain, lbs.												
Silage or hay	2178	2459	2591	795	2718	3422	2812	1028	2495	2942	2380	1003
Corn	306	316	314	314	343	281	286	325	367	381	355	364
Silage or hay stored, tons	34.6	33.4	35.1	8.5	61.4	62.3	63.7	22.2	68.6	61.8	60.6	*
Silage or hay fed, tons	20.5	14.8	12.8	7.3	43.0	28.1	30.3	17.0	51.0	28.2	32.5	23.3
Spoilage, tons	9.7	8.3	10.5	0.0	6.8	12.4	14.3	0.3	*	*	*	*
Loss in wt. during storage, tons	4.4	10.3	11.8	1.2	11.6	21.8	19.1	4.9	*	*	*	*
Feed costs per cwt. of gain, $†												
Based on feed fed	15.76	17.10	17.57	15.18	18.76	20.16	17.84	17.77	18.43	20.54	17.69	18.40
Based on feed stored	21.77	29.44	35.54	16.52	23.42	36.79	30.25	20.88	21.86	34.50	25.94	*

*Not measured.
†Feed prices used are as follows: Corn, $1.29 per bushel; alfalfa hay as stored or as fed, $20 per ton; alfalfa forage as stored or alfalfa silage as fed, $8 per ton.

Table 2. Chemical Composition of Edible and Spoiled Portions of Alfalfa Stored in Various Ways

Method of storage	Material analyzed	1954-55 Results: Moisture content %	1954-55 Analysis of dry matter (%): Ether extract	Crude fiber	Protein (Nx6.25)	Ash	Nitrogen-free extract	1955-56 Results: Moisture content %	1955-56 Analysis of dry matter (%): Ether extract	Crude fiber	Protein (Nx6.25)	Ash	Nitrogen-free extract
Upright silo	Alfalfa as ensiled	69.60	2.49	27.27	18.97	9.09	42.18	64.0	2.72	21.89	18.69	8.16	48.54
	Edible silage	72.85	2.91	31.78	17.67	11.20	36.43	66.9	3.99	23.84	20.60	11.05	40.52
	Spoilage	76.80	1.70	30.25	23.05	19.84	25.16	68.2	1.62	24.89	24.49	19.52	29.48
Trench silo	Alfalfa as ensiled	70.6	2.78	26.58	19.65	9.09	41.90	65.3	2.56	21.57	17.75	8.91	49.21
	Edible silage	76.2	2.93	31.54	18.32	11.07	36.14	65.2	3.04	21.77	20.45	11.02	43.72
	Spoilage	72.9	1.08	30.59	23.47	21.15	23.71	61.0	2.21	25.57	24.54	19.11	28.57
Stack silo	Alfalfa as ensiled	69.2	2.68	27.81	19.75	8.92	40.84	70.7	2.67	25.32	19.28	8.53	44.20
	Edible silage	72.1	2.92	28.47	19.38	9.81	39.42	69.2	3.54	27.01	19.08	9.20	41.17
	Spoilage	59.8	1.17	32.63	21.74	16.22	28.24	54.3	1.45	31.57	19.91	13.09	33.98
Hay	Alfalfa as stored	18.4	1.63	27.77	18.42	9.26	42.91	15.3	3.70	24.10	18.26	8.22	45.72
	Hay as fed	14.0	1.45	32.52	17.23	9.08	39.73	13.1	2.69	29.18	16.97	8.23	42.93

changes in composition are what might be expected in a silage-type fermentation where the carbohydrate portion of the nitrogen-free extract is rapidly used by the microorganisms.

Increases in the percentage of ether extract, crude fiber, protein, or ash content of the dry matter during the storage period do not mean that these components have not decreased in total amount. A part of all components may be lost during storage, but since the rate of loss of the nitrogen-free extract was highest, the other components increased percentagewise in the dry matter.

Changes in composition of the alfalfa hay from the time it was stored until it was fed may have been due in part to respiration of the plant tissue, but leaf loss during handling no doubt had the major effect. Compositionwise, the hay as fed compares favorably with the edible portions of the various silages.

Data on spoilage are shown here because they indicate the effect of the presence of air on the loss of organic nutrients. The large increase in ash content of the spoilage over that of the alfalfa as ensiled indicates that a large portion of the dry matter has been lost. This loss is mostly the result of microbial activity, promoted and prolonged by the presence of oxygen.

The amount of dry matter loss in the area of spoilage can be estimated from the ash values. To illustrate this the following example is given, using the data from the stack silo for 1954-55:

Ash content of dry matter ensiled . 8.92%
Ash content of dry matter in spoilage 16.22%

$$\frac{16.22}{8.92} \times 100 = 181.84$$ lb. dry matter in material ensiled to give 100 lb. dry matter in spoilage

$$\frac{181.84-100}{181.84} \times 100 = 45.0\%$$ dry matter loss

This method of calculating has certain inherent errors, the largest possibly resulting through assuming that no ash is lost through leaching or juice run-off. However, correction of ash values for this would increase the dry matter loss values obtained, so the estimates arrived at are probably on the conservative side.

The same type of calculation can be made for the edible portion. For the same stack, the data indicate that each 100 pounds of dry matter in the edible silage represents about 110 pounds of dry matter in the material ensiled and that 9.1% of the dry matter was lost. That dry matter losses calculated by this method are fairly reliable, though conservative, is indicated by the data obtained on a number of stacks by the

Table 3. Average Dry Matter Losses from Various Points Within Stacks of Alfalfa Silage as Obtained by the Bag Technique*

Location of bag in stack	Av. dry matter loss
Top, 6-12 in. from surface	46
Side, 12-24 in. from surface and 40 in. from bottom	37
Center, 40 in. from bottom	15
Center, 6-12 in. from bottom	15

*Taken from *South Dakota Farm and Home Research* 7:52-56, 1956 bag technique (table 3). Some further evidence along this line can be obtained from table 4, where recovery of over 90% of the ash in the edible and spoiled portions again indicates fairly good reliability for the method with values on the conservative side.

Losses in nutrients. Evidence concerning the actual loss of various nutrients was gained during the 1954-55 season when both weights and analyses of the fresh material, spoilage, and edible silage and the hay were obtained. The data are summarized in table 4.

Only 61% of the dry matter originally put into the upright silo was fed. This is, perhaps, surprisingly low. It should be pointed out that this silo was not filled to capacity so that the surface-volume ratio was somewhat larger than it would normally be. This would mean somewhat increased losses over normal conditions. There was also some spoilage around the doors which could have been prevented by better sealing. Finally, some volatile organic matter is lost during the moisture analysis, which increases the dry matter loss.

The recovery of edible silage from the upright might be considerably increased, not only by filling the silo to capacity, but also by certain practices not followed here, such as covering the top surface of the silage, better distribution and packing during filling, and possibly the use of preservatives.

Dry matter recovery in edible sil-

Table 4. Loss of Dry Matter and Various Nutrients in Alfalfa Silages and Hay (1954-55)

		% dry matter and various nutrients fed, lost in spoilage, or not accounted for					
Type of storage		Dry matter	Ether extract	Crude fiber	Protein (Nx6.25)	Ash	Nitrogen-free extract
Upright silo	Silage fed	61	71	71	56	75	52
	Spoilage	8	6	9	10	18	5
	Not accounted for*	31	23	20	34	7	43
Trench silo	Silage fed	38	41	46	36	47	33
	Spoilage	21	8	24	25	48	12
	Not accounted for*	41	51	30	39	5	55
Stack silo	Silage fed	41	45	42	40	45	40
	Spoilage	26	11	30	29	47	18
	Not accounted for*	33	44	28	31	8	42
Hay	Hay fed	81	72	95	76	80	75
	Spoilage	2	1	2	1	2	1
	Not accounted for*	17	27	3	23	18	24

*Represents losses due to fermentation, juice runoff, handling, and loss of volatile matter during drying of samples.

age from the trench was only 38% and from the stack, 41%. The trench used in this work was of such dimensions that its surface-volume ratio was similar to that for the stack, so similar losses should be expected. These two storage methods yielded only about two-thirds as much edible dry matter as the upright.

The data for the various components of the silage dry matter indicated that nitrogen-free extract and protein are lost to the greatest degree. The same is true for hay, although here the ether extract is also lost at about the same rate. In general, the recovery of edible nutrients was much better from the hay than from the silages under the conditions of these experiments.

Some other considerations. Increasing the size of the stack would, of course, decrease the surface-volume ratio, and this should reduce losses percentagewise. Dry matter loss from a large (133 ton) stack of silage fed to sheep during 1955-56 was 19% in the spoilage and 26% in the material not accounted for. From this stack, 55% of the dry matter ensiled was actually fed.

Grass silage is usually considered a good source of carotene. For types of storage where the surface-volume ratio is small so that air is quite effectively excluded, this is no doubt generally true. However, previously reported work (*South Dakota Farm and Home Research* 4:66-71, No. 3, 1953) illustrates the danger in considering stack silage a good source of the carotene. Trenches of the type used in studies previously described here can also be expected to yield low-carotene silage.

The losses in nutrients in the silo occur over a period of time. The shorter the storage period, the less the loss. This has been discussed in an earlier publication (*South Dakota Farm and Home Research* 7:52-56, No. 2, 1956).

The same publication illustrates the futility of attempting to hold stacked alfalfa over from one season to the next. The data in table 5 further illustrate this. Here, feeding actually began during the winter but was extended through June. Only one-fifth of the dry matter put into the stack was recovered as edible silage. The addition of sodium metabisulfite at the time of ensiling had no beneficial effect. Other experimental work with this and other preservatives has shown none of them to have any measurable effect in preventing losses in the stack type silo. Covers have also been used in some studies here, but they require further investigation before they can be properly evaluated.

It is often said, especially in connection with stack silage, that since the spoilage is eaten it represents no loss. It is true that some of the spoilage will be eaten, especially when it is mixed with unspoiled material. However, spoiled material is not palatable and will generally be refused. Attempts to feed it alone or mixed with good silage in sufficient amount to allow for measuring its digestibility have been unsuccessful at this station. Therefore, chemical methods have been resorted to.

Table 5. Dry Matter Losses from Two Alfalfa Stacks Fed during Winter and Spring Months*

	Stacks with no preservative	Stacks with 10 lb. sodium metabisulfite per ton
Date ensiled	June 16, 1955	June 17, 1955
Date feeding started	January 6, 1956	January 6, 1956
Date feeding completed	July 1, 1956	July 1, 1956
Tons ensiled	51.4	52.0
% of dry matter fed	22.3	19.7
% of dry matter in spoilage	47.1	49.4
% of dry matter not accounted for	30.6	30.9

*Data collected with help of L. B. Embry, Animal Husbandry Department.

These methods have not been adequately tested to establish them as highly accurate, but they must be used where a material cannot be fed in reasonable amounts. Comparison of the fresh alfalfa, edible silage, and spoilage and of alfalfa hay, based on these methods is reported in table 6.

The TDN and digestible protein for the fresh alfalfa and edible silage or hay are similar. On the other hand, the values for spoilage are considerably lower. There is much doubt that spoilage should ever be considered to have any real feeding value because of its low palatability and apparent low digestibility.

Table 6. Digestible Nutrient and Digestible Protein Values Obtained on Various Samples by Chemical Methods*

Sample		Crude protein content (Nx6.25), %	Digestible protein content, %	Digestion coefficient (protein), %	Digestible nutrients, %
Alfalfa hay	As stored	17.7	15.0	81	67
	As fed	15.7	12.7	85	64
Upright silo	Alfalfa as ensiled	19.3	16.1	83	68
	Edible silage	18.6	14.4	77	67
	Spoiled silage	22.1	8.9	40	54
Trench silo	Alfalfa as ensiled	18.0	15.1	84	70
	Edible silage	17.5	13.6	78	66
	Spoiled silage	22.3	9.0	40	54
Stack silo	Alfalfa as ensiled	18.2	13.9	76	63
	Edible silage	18.7	13.3	71	62
	Spoiled silage	20.0	8.7	44	52

*The samples used in this study were taken during the early stage of the 1955-56 feeding season. Digestible protein was determine as described in *Silage Fermentation,* A. J. G. Barnett, Academic Press, Inc., 1954 (p. 135). Digestible nutrients is the DLN of Thurman and Wehunt, *Agronomy Journal* 47:302 (1955).

CONCLUSIONS

While observations on stacked alfalfa-brome silage made prior to these studies indicated that this method of storage was probably satisfactory, the experimental data obtained here contradict this opinion. Nutrient losses through spoilage and excessive fermentation measured chemically and by feeding trials, are excessive.

It is true that in the circumstance where frequent rains will not allow for storing an alfalfa crop as hay and where feeding is started shortly after ensiling and completed in a matter of weeks (to supplement or substitute for pasture), the stack may be satisfactory. It is also known that when it becomes necessary to put up hundreds of tons of silage, the stack may be the only possible form of storage. However, the results of the experiments presented here show it to be a very wasteful method. In spite of the small cash outlay it requires, as well as some of its other apparent advantages, stacking the crop as silage cannot be considered a satisfactory method for handling alfalfa except perhaps as indicated above.

The large spoilage and fermentation losses occurring in the stack are, of course, the results of the failure of this storage method to exclude oxygen. Whenever silage is made, the exclusion of oxygen is of utmost importance. Any storage method that fails to do this will result in large nutrient losses. Thus the trench used in this work gave low yields of edible silage, since it was not constructed to give a minimum surface of silage exposed to the atmosphere per ton of material stored. Trench silos should be as deep as practicable, should have only enough slant in their walls to allow for good packing, and in addition should probably be covered with an inexpensive material that will exclude air.

The conventional upright silo gave fairly good results in these experiments. When properly used it can be expected to do so regularly, provided the wall of the silo is kept impervious to air and the doors are kept tight and in good repair. Proper distribution of the silage during filling, packing at the top, and covering the surface with a material impervious to air can all be expected to give some increased returns.

Spoilage and fermentation losses cannot be measured by observation and are seldom given the importance they should have. The data presented here demonstrate how serious they can be. While such factors as low cost of construction, ease of filling, and convenience must certainly be taken into account in planning storage for alfalfa silage, the exclusion of oxygen should also be given adequate consideration. Otherwise, our results indicate that storage of the crop as hay will be most satisfactory in the long run.

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