FORAGE MANAGEMENT STUDIES

I. SILAGE FEEDING BEHAVIOR IN A SELF-FEEDING TRENCH SILO

II. LOSSES DURING STORAGE OF ALFALFA HAY

by

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INTRODUCTION

PART I

The labor saving appeal has stimulated much interest in self-feeding trench silos. Hand-feeding of silage is laborious, expensive and unpleasant. One phase that has not been considered adequately is the compatability between this system of feeding silage and the cows' natural feeding habits and performance.

Questions relative to cows' feeding performance arise mainly from the fact that manger space of common trench silos is limited. This is complicated further by the fact that in order to control silage flavors of milk it is necessary to prevent cows' access to silage 4 to 6 hours previous to milking. When cows have access to silage with only a limited amount of manger space available after milking, the natural "social order" within the herd may prevent some individuals from obtaining sufficient silage. With this question in mind a study was initiated to study cow feeding behavior as related to this system of feeding silage.

PART II

At the present time a large amount of alfalfa hay is baled after field-curing and stored in large stacks in the mows of barns. Dry matter and nutrient losses of hay due to imperfect curing and subsequent spoilage in the mow probably are much greater than is generally realized.

Since the storing of hay baled in the field is relatively new, the extent of dry matter and nutrient losses has not been determined extensively.

It appears that farmers today are buying many tons of baled hay out of the field, only to lose a high percentage of the dry matter and nutrients later in storage. It seems desirable to evaluate the extent of such storage losses more precisely than in the past in order to promote more intelligent hay selection.

The purpose of this investigation was to study the correlation between the dry matter and the nutrient losses of baled alfalfa hay and the moisture content at the time of storage. A second objective was to study the correlation between the moisture content at the time of storage and the mow keeping qualities of baled alfalfa hay.

REVIEW OF LITERATURE

Esmay and Brooker (12) listed the following opinions, obtained by interviews with farmers, as the reasons why many operators do not self-feed silage: (a) as much space must be provided for self-feeding as has always been used when feeding in bunks; (b) "boss" cows will guard the feeding area and keep timid cows from eating; (c) it is just as easy to haul silage out of the silo as it is to haul the manure which is wetter and heavier; (d) cattle will not eat the recommended amount of hay if they have free access to silage; (e) it is impossible to ration the silage when it is self-fed. Farmers who were self-feeding silage, however, had the opinion that none of these were valid reasons.

Hunnicutt (22) reported that when self-feeding on a round-the-clock basis, 2 - 2.5 cows could feed per cross section foot of feeding space. Armstrong (2) believed that 2.5 animals could eat per foot of silo width. Esmay and Brooker (12) stated that interviewed farmers believed 3 animals could feed satisfactorily per foot of feeding space.

Turner (46), during his observations, allowed 14 inches of space per animal. The silage being fed during these observations, however, was long cut grass and the cattle spent considerably more time obtaining their fill than is usually spent under more nearly normal conditions with chopped silage.

Esmay and Brooker (12) recommended that the feeding gate be constructed with the bottom 18 inches solid. They found that cows will pull fresh silage from the pile as long as it is within reach. The silage that falls will not be eaten until last and the gate must hold this accumulation until the cows are forced to eat it. These workers also stated that it is desirable to have the silo pack only 6 ft. deep, but a depth of less than 6 ft. is not recommended. Turner (46) reported a silo depth of 6 ft. was most desirable. He found that a stack of 8 ft. was too high for cows to eat from satisfactorily.

Turner (46) observed the feeding habits of 15 lactating dairy cattle of mixed breeds at a self-feeding trench silo. For roughage, the cows received only a limited amount of hay in addition to their free-choice silage. He found the animals spent an average of 4.2 hours eating daily and varied from 8.0 to 1.8 hours. This worker reported that the observed animals averaged 19.6 entries into the feeding area per day. He found that one individual fed 38 times in one 24-hour period while another animal fed only 3 times. This worker observed that two small Jerseys which were of a timid nature obviously did not have a fair chance against the larger and more aggressive animals. He reported that the herd was very contented, and that he observed no rush to feed, no horning and very little bullying of any kind. It was evident, however, that some of the smaller cows were being kept away from the feed by master cows standing near the silo although not feeding. The general condition of the herd improved and the milk yield was maintained. He reported that the average consumption of the long grass silage was 86 lb. per day.

Lewis and Johnson (28) found that twenty Brown Swiss dry cows in a loose-housing barn with free access to hay and silage averaged 4.2 hours a day at the silo and one hour daily eating hay. Most of the activity was observed between 7 a.m. and 8 p.m., with a peak being between 8 a.m. and 11 a.m. The cows ate 22.5 and 22.4% of their daily hay and silage, respectively, between the hours of 8 p.m. and 3 a.m. Very little roughage was consumed between 3 a.m. and 6 a.m. They summarized that the time spent eating hay was affected markedly by the availability of silage. When silage was available, the cows spent less than an hour daily eating hay, but when no silage was available, the cows spent more than 5 hours daily at the hay feeder.

Porter (35) observed 16 dry cows which had free access to both good alfalfa hay and alfalfa-brome silage, in addition to receiving 4 lb. of mixed concentrate. He observed the cows' activities for one 24-hour period and found that the cows averaged 39 minutes eating hay and 184 minutes eating silage daily. The average time spent eating per entry was 13 and 23 minutes for hay and silage, respectively. Consumption was checked by bunk-feeding on a separate day and he found that the average consumption was 15.0 and 41.7 lb. of hay and silage, respectively. When corn silage was substituted for the grass-legume silage, silage consumption increased 15.3 lb. while hay consumption was lowered 2.0 lb. He observed that 5 animals ate hay only once during the day while one animal ate hay 10 times during the 24-hour period. The number of entries per day to the silage feeding area varied from 5 to 15, with a variation in the total time spent eating from 132 to 300 minutes. He observed 3 periods of silage feeding activity. The first of these came early in the morning followed by two periods of less intensity at 12 noon and about 4 p.m.

Castle <u>et al.</u> (8) noted the striking regularity of eating habits of lactating cows, even under conditions of varying feeding and management practices. They found that throughout the year, regardless of the type of feed available, two peaks of feeding activity prevailed; one in the morning and one in the evening.

Berousek et al. (4) observed the feeding activity of cattle under varying shelter conditions. They found that a group of 4 head which had no protection from summer heat averaged 274, 89 and 100 minutes of grazing, eating hay and eating silage, respectively. Another group that had a loafing shed available for summer shelter spent 312, 83 and 78 minutes, respectively.

Hancock (16) stated that an outstanding feature of the grazing behavior of dairy cattle was its variability due to internal and external conditions. Of the external factors, climate (in a temperate zone) was thought to be relatively unimportant.

Seath and Miller (38) reported that cows on good pasture in warm weather grazed three times as much at night as they did during daylight. These workers and Hancock and Wallace (17) found that hot weather depressed overall grazing time, but did not alter the day and night grazing ratio. Seath and Miller (38) observed that dairy cattle spent about 2.5 hours grazing at night to every daylight hour spent in the pasture. However, Hancock and Wallace (17) reported a ratio of about 1:1.

Castle et al. (8) found that the cow's natural inclination was to divide her total grazing time about equally between the day and night intervals. They reported that no aspect of grazing behavior was found to be strongly related to either current milk-yields or air temperature.

EXPERIMENTAL

A series of six 72-hour observation periods were made at the Oklahoma Agricultural and Mechanical College dairy farm to study silage feeding behavior in a self-feeding trench silo. Observations were made using a concrete trench silo that was 10 ft. wide at the bottom, 12 ft. wide at the top, 8 ft. deep and 35 ft. long. The silo was constructed in a bank in such a way that the floor of the silo was on a ground level. The floor had a slope of one inch per four foot, constructed to drain toward the open end of the silo. A solid bottom A-frame feeding panel with five head-holes was suspended from a pipe resting on the top edges of the silo sides.

The silo was filled with sorghum silage for winter feeding studies and with vetch silage for summer study. The palatability of each was reasonably good, and the dry matter content of the sorghum and vetch silage averaged 29.6 and 18.4%, respectively.

The conditions during the various observation periods were as follows: No. 1, 11 head with 24-hour access to sorghum silage; No. 2, 18 head with 24-hour access to sorghum silage; No. 3, 18 head with 24-hour access to sorghum silage and low quality prairie hay; No. 4, 18 head with access to sorghum silage in alternate 6-hour periods (12 hours per day) and 24-hour access to low quality prairie hay; No. 5, 16 head with 8-hour daylight access to sorghum silage daily and 24-hour access to low quality prairie hay; and No. 6, 25 head with 24-hour access to vetch silage but no hay.

The first five observation periods were conducted under winter feeding conditions, while the last observation was during the summer. The prairie hay was of low quality and was offered free choice in excess of consumption, with weigh backs being made periodically. Limited amounts of dry bermuda and native pasture grasses were available during all periods of observation. When changes were made in the feeding routine, at least seven days were allowed for adjustments of the animals before observations were made. Each 72-hour observation period consisted of three 24-hour continuous watches spread over 3 to 8 days.

Dry cows and 2-year-old bred heifers were used in observing and recording feeding activity. The first winter observation period involved eleven head, including five Holstein heifers, and one Holstein, two Guernsey and three Jersey dry cows. The second, third and fourth observations concerned an additional four Guernsey and three Jersey dry cows. Before the fourth observation, one Holstein heifer was replaced by a dry Holstein cow. The fifth winter observation involved sixteen head, including four Holstein heifers, and two Holstein, five Guernsey and five Jersey dry cows. Twenty-five yearling heifers were observed in the summer study, including one Holstein, seven Guernseys, eight Ayrshires and nine Jerseys.

Each cow was positively identified by color pattern or number painted on the rump and all entries to the silo and the time spent feeding were recorded at minute intervals. Night identification was aided by the use of a battery-powered lantern or automobile lights.

Careful estimates were made with respect to silage consumption. The amount of top spoilage, wastage and refusal was carefully determined by weighing. The silage available was determined by measuring the pack and calculating the weight, using concurrently determined density. The labor requirements for servicing the silo were recorded.

Climatological data from the Stillwater, Oklahoma, station were taken from the records of the United States Department of Commerce with some local conditions reported during observations by the recorder.

RESULTS

The amount of time spent eating was the primary criterion used in evaluating the silage feeding behavior of the individuals observed. The data relative to feeding behavior of the animals offered sorghum silage are shown in Table 1.

When the silo access time was 24 hours the average daily silage eating time per animal was 107 minutes, but the time varied between cows and days from 0 to 253 minutes. Individuals varied from day to day as much as 193 minutes in the time they spent feeding. The animals averaged 5.6 entries into the silo per day and varied from 0 to 19 entries. One individual entered the silo six times during one 24-hour period but fed 19 times on another occasion. During these observations one animal averaged 3 hours eating in 9.6 entries to the silo per day while the other extreme averaged only 36 minutes in 1.5 entries.

The feeding of low quality prairie hay decreased the silage feeding activity about 25%. On the average, two less trips were made by each animal to the silo daily after hay had been made available.

The average feeding time per cow was decreased markedly when the silo access time was decreased. When the silo was opened in alternate 6-hour periods, the animals spent an average of 71 minutes feeding per day. Five individuals spent a half hour or less each day, with one of these eating for only one minute during three days of observation. When the silo was opened for only 8 hours during each 24-hour period, the average eating time per animal was only 68 minutes.

Table 1

Feeding Behavior of Animals on Sorghum Silage in the Winter

		24 hour access without hay Observation 1[a]	24 hour access without hay Observation 2	24 hour access with hay	12 hour access with hay[b]	6 hour access with hay
Total time spent in silo (minutes)						
Av./animal/day		122	117	87	71	68
With 5 most aggressive, av./animal/day		137	178	126	111[c]	127[c]
Range, all animals	min.	27	0	1	0	0
	max.	226	253	187	205	182
Range, 5 most aggressive	min.	60	80	80	84	61
	max.	226	200	184	205	182
Widest individual variation	min.	81	1	61	95	39
	max.	226	193	187	205	155
No. of entries into silo						
Av. times/animal/day		7.5	6.4	4.5	3.4	1.9
With 5 most aggressive, av./animal/day		8.6	9.3	6.3	3.8[c]	2.6[c]
Range, all animals	min.	2	0	1	0	0
	max.	16	19	12	10	6
Range, 5 most aggressive	min.	4	6	2	2	1
	max.	15	15	12	6	4
Widest individual variation	min.	3	6	2	2	2
	max.	13	19	12	10	6
Time spent in silo/entry (minutes)						
Av./animal/entry		16	20	19	21	35
With 5 most aggressive, av./animal/day		17	16	20	30[c]	49[c]
Range, all animals	min.	1	1	1	1	1
	max.	108	97	103	97	151
Range, 5 most aggressive	min.	1	1	1	1	3
	max.	55	65	103	97	151
Widest individual variation	min.	1	1	1	1	7
	max.	108	97	99	97	151

a Observation 1 includes 11 animals, all others include 18 animals.
b Twelve-hour access in alternate 6-hour periods.
c One of the 5 most aggressive individuals was removed from the experiment. The average is based on the 4 most aggressive.

Two individuals, however, failed to feed at all during the three days of observation, while another individual ate for only three minutes.

The data relative to summer feeding are presented in Table 2. With 25 heifers feeding on vetch silage, the time spent in the silo per entry was only 50% as long as that observed with previous groups with 24-hour access, but there was an increase in the number of daily entries into the silo. Seven heifers spent over two hours eating silage daily, while five head ate for less than one hour. One animal spent a total of only 6 minutes eating during 72 hours of observation.

Table 3 presents data relative to the utilization of the silo access time during each of the six observation periods. The size of the silo and arrangement of the feeding panel were such that five animals could feed side by side. Except in the sixth observation, five animals were seldom observed eating at the same time. When the silo was open 24 hours daily and 11 or 18 animals had access to the silo, five animals feeding at once was noted only six times for a total of 68 minutes during 216 hours of watching. With 18 animals the silo was unused about 25% of the time and used by less than 3 animals about 60% of the time. This distribution was about the same whether or not hay was available in addition to the silage. When the access time was decreased to 8 or 12 hours, the silo was still unused for nearly 20% of the access time.

With 25 head feeding during the summer study, the silo was unused for more than 13 hours per day. The silo was filled to capacity 35% of the time that any feeding activity was observed, with three or four head eating during 40% of that time. The average number that fed

Table 2

Feeding Behavior of Animals on Vetch Silage in the Summer

		Total time spent in silo (minutes)	No. of entries into silo	Time spent in silo/ entry (minutes)
Av./animal/ day		95	10.2	9
Range, all animals	min.	0	0	1
	max.	242	27	90
Widest individual variation				
	min.	141	9	1
	max.	242	27	90

Table 3

Utilization of Silo Access Time

No. animals in silo	11 animals 24-hour access No hay	18 animals 24-hour access No hay	18 animals 24-hour access With hay	18 animals 12-hour access[a] With hay	16 animals 8-hour access With hay	25 animals 24-hour access No hay
	(%)	(%)	(%)	(%)	(%)	(%)
0	47.1	23.8	29.2	17.0	18.5	54.6
1	25.5	30.8	43.9	22.2	20.9	6.2
2	16.8	30.2	18.8	37.3	25.1	5.3
3	8.2	10.6	5.6	14.2	18.6	7.2
4	1.6	4.3	2.1	8.5	16.3	10.7
5	0.8	0.3	0.4	0.8	0.6	16.0

a Twelve hour access in alternate 6-hour periods.

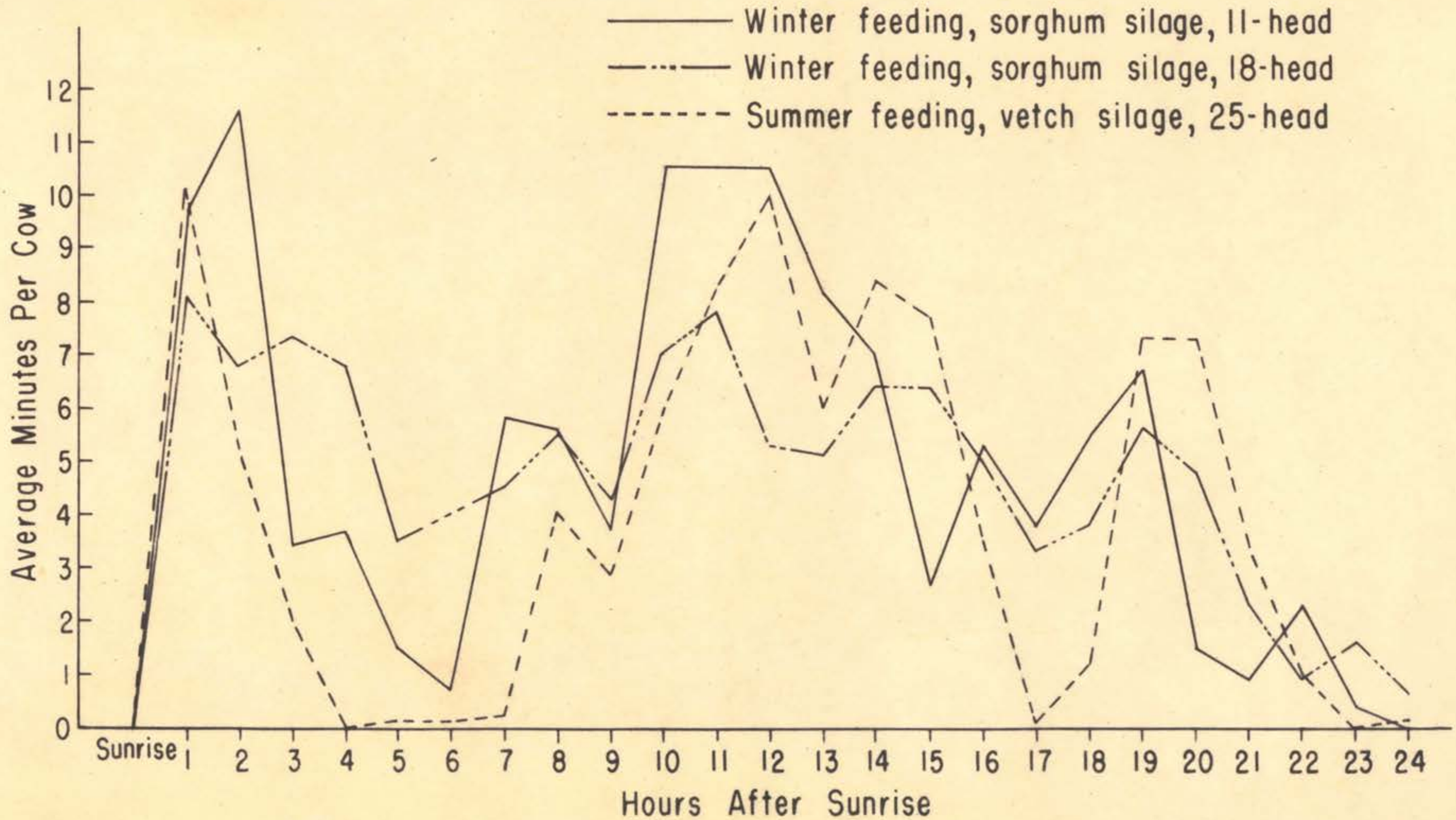
while any animal was feeding was 3.6 animals.

There were three periods of feeding activity, as shown in Figure 1. The first of these, just after sunrise, was usually characterized by heavy feeding by several animals. The result was a greater than average number of entries into the silo, but less time spent eating per entry. The second period of activity began nine hours after sunrise and was usually two or three hours longer than the first. The third period, after midnight, was normally less intensified and was often the result of feeding activity of those animals that had failed to feed in the earlier periods.

In the winter studies with 24-hour access to sorghum silage but no hay, the calculated average daily consumption per animal was 51 lb. An average of about 36 lb. of silage and 4.5 lb. of hay was eaten daily when low quality prairie hay was made available. The calculated dry-matter intake compared favorably under the two feeding conditions. In the summer study, with vetch silage, the calculated average daily consumption per heifer was 53 lb. From these consumption rates and the time spent in the silo it was calculated that the animals consumed about 25 lb. sorghum silage and 33.5 lb. vetch silage per hour of feeding.

Figure 1

Hourly Feeding Activity (Minutes Per Cow)



DISCUSSION

From the observations made in this study it appeared that silage feeding behavior was quite random in nature. These results agree with the findings of Turner (46) and Porter (35). Even during the periods of limited access there were times when no feeding activity was observed. Consequently it was difficult to understand why certain individuals were so seriously curtailed in their rate of silage feeding. It did not appear that any other activity in the feeding area should have commanded more attention than the silage feeding.

The size of the silo and arrangement of the feeding panel were such that 5 animals had ample room to feed side by side, but this was seldom observed. Most often from 1 to 3 animals were in the silo at one time even while others appeared to desire entry.

The social order of the animals apparently affected the silage feeding behavior of the group. In the first five observations the animals were easily ranked in order of dominance. Whenever three or more animals were feeding at the same time the group nearly always consisted of members of a group of five that led in aggressiveness and operated as a clique. These five animals averaged one hour more silage feeding time than the other individuals in the study.

When the silo access time was decreased below 24 hours the group of most aggressive individuals continued to feed at about the same rate as previously while the average daily eating time of the other animals was decreased very markedly.

The intensity of aggressiveness of each animal used in the summer observation was apparently about equal to that of others in the group. There were no alliances formed within the group, and each animal appeared to eat whenever she pleased, provided that a vacant head-hole was available in the feeding panel.

The three periods of feeding activity observed in this study were apparently typical of those observed by Porter (35), but did not agree with the findings of Castle et al. (8). It was possible that the number of peak periods of feeding activity may have been governed by when the animals were allowed to feed. The cattle observed by Castle and co-workers (8) were being milked twice daily and their greatest feeding activity occurred when they were allowed to graze immediately after milking. The cattle observed in this study and by Porter (35) were either dry cows or heifers and had 24-hour access to the feeding panel.

The ratio of day-time to night-time feeding was apparently quite different from the previous findings. At no time during this study did the amount of night-time feeding appreciably exceed day-light feeding, while Seath and Miller (38) found a ratio of about 2.5:1. It may have been, however, that feeding behavior while self-feeding silage was completely unrelated to grazing habits.

These results support the opinion of Hancock (16) that climate is relatively unimportant in affecting the grazing behavior of dairy cattle. Temperatures varied while these observations were being conducted from a low of 28° on March 30, 1954, to a high of 112° on July 13, 1954.

Wastage due to spillage through the feeding panel was negligible with only a small amount being spilled as the cows withdrew from the head-holes. As the animals worked the silage loose from the pack a small amount of silage dropped to the floor, behind the feeding panel. This material accumulated, since the cows appeared to prefer eating the silage from the pack. The accumulated material was removed every week to ten days in order to move the panel forward so that the cows would have easy access to the silage. Estimates of the amount removed varied from 3 to 9% of the total silage available. This silage was fed in bunks to other animals and was readily eaten. There was some evidence of spoilage in this accumulated loose silage during periods of warmer weather.

The exposed end of the silage pack did not appear to suffer any spoilage. There was some drying out, but only on the outer surface and it did not appear to affect palatability. The drying out of the exposed surface during the summer was no greater than during the winter; however, more animals were feeding and the silage contained more moisture during the summer. The average depth of top spoilage was found to be approximately 4 and 8 inches in the vetch and sorghum packs, respectively.

Not over one-half hour of labor per week to ten days was required to clean off the top spoilage and readjust the feeding panel. The floor area of the open end of the silo was cleaned out with a tractor-mounted scraper in a few minutes about once monthly. Little accumulation of manure was observed in this area since very little loitering of the cows was experienced. Considerable droppings accumulated in the vicinity of the silo, however.

Since the silo used in this study was 8 ft. deep, a caving off of the top end of the silage pack after the cows had eaten below was observed occasionally. To prevent the caving about ten minutes every three days was spent breaking the top down after the cows had eaten into the silage pack. This contributed some to the accumulation of loose silage on the floor of the silo behind the feeding panel. The silage pack was only slightly over 5 ft. deep during the summer studies and the difficulties associated with caving were not experienced. This experience supports the opinion of Esmay and Brooker (12) and Turner (46) that a silo depth of about 6 ft. is desirable.

REVIEW OF LITERATURE

According to Shepherd et al. (40) about 90% of the total hay crop is field cured with a good share of this amount being stored in the baled form. There has been only limited work reported relative to dry matter and nutrient losses resulting from the baling of either apparently cured hay or of hay considered too green for baling.

Many workers (1, 20, 32) feel that dry matter and nutrient losses are just as important as losses in quality, although they are not generally recognized. Much of the loss of nutrients in hay results from the mechanical loss of leaves which is the portion of the crop richest in dry matter, protein, vitamins, and minerals (27, 40). LeClerc (27) stated that losses of valuable constituents of the hay may account at times for as much as half the value of the crop. Shepherd et al. (40) indicated that leaf loss averaged 38.5% when the hay had not been exposed to rain, while that which had suffered damage from showers was associated with nearly 75% leaf loss.

Zink (50) found that alfalfa hay leaves shatter when the hay moisture content approaches 30%. When the leaves shattered, the actual moisture content of the leaves themselves was about 10%. Watson (47) found the most suitable moisture level was 20 to 24%. Shepherd et al. (40) indicated that the moisture content should not exceed 25% at the time of storage. Bohstedt (5) reported that baling alfalfa with only 20% moisture retained the fresh green color of the hay and gave it greater nutritional value than hays baled at either higher or lower moisture contents. Bohstedt's (5) table of nutritional value was determined by finding the digestibility of the organic matter. Morrison (33) stated that baled hay should not be over about 22% moisture at the time of storage. Kendall et al. (24) concluded that the moisture content of hay at the time of baling should be no greater than that of cured hay which is to be stored in any other manner. Henson (18) made similar conclusions. He believes that the temperature developed in hay bales corresponds with that of mow stored hay of the same moisture content.

Swanson and co-workers (44) stacked alfalfa containing nearly 60% moisture and found that a 39% loss of organic matter resulted. The loss of nitrogen-free-extract and protein was 45 and 33%, respectively. Truinger (45) found storage losses of nitrogen-free-extract as high as 40%, and found digestible pure protein losses ranging from 50 to 100%. Hoffman and Bradshaw (20) reported losses in organic substances up to 22%. The average loss reported was 13% with variations being due to mow location and air passage. The losses involved chiefly the fats (maximum 47%), the sugars (maximum 94%), and the hemicellulose group (maximum 52%).

Swanson and Latshaw (43) found that alfalfa hay cured in the sun contained 6 to 9% more protein than hay cured in the shade. They concluded that the difference was due to chemical changes which were little known or noticed. Gallup and Briggs (13) in a study of the protein content of prairie hay found that digestibility of dry matter appeared to be roughly proportionate to the protein content of the hay and unrelated to other constituents. However, Archibald et al. (1) reported that nothing has been found, with the possible exception of fiber, that would serve as an indicator of the nutritive value of hay.

Camburn et al. (6) found that sun-cured hays experienced a 6.9% loss of dry matter while in storage, when stored with a 25% moisture content. The same hay was found to have lost 3.3% crude protein, 16.75% nitrogen-free-extract, and 8.9% ether-extract, while ash and crude fiber showed gains of 3.9 and 3.1%, respectively.

Dexter (11) showed there was a pronounced loss of sugar and some loss of starch in slowly dried samples, but these losses were much greater in samples which were dried rapidly. He showed further that ordinary field-cured hay had a much higher sugar content than hay dried in the mow over a 3-week period. Archibald and co-workers (1) found that losses of nitrogen-free-extract, sugars, and carotene during storage were significantly correlated with moisture content of the hays at the time of storage. They reported a 4% loss of protein during storage, but could not associate it with any curing process.

Camburn and Jones (7) found that the dry matter loss of stored alfalfa hay averaging 23.65% moisture at the time of storage was slightly over 6%.

Losses of hay stored in an undercured condition are related to excessive heating, which may result in temperatures which are sufficiently high to produce combustion. Although it may not ignite undercured hay will often suffer serious deterioration and often complete destruction of its feeding value. LeClerc (27) suggested that losses of this nature may be even greater than the losses from fire. Henson (18) and Rothe (36) stated that such losses will be less if the hay does not exceed 30% moisture at the time of storage.

According to Hoffman (21), organic matter in hay is not destroyed until a temperature of 226° F. or greater is reached. McClure (31) determined the ignition point of hay to be at 300° F., and that hay undergoing fermentation did not reach temperatures exceeding 150° F., except when insufficiently cured. He did not indicate the per cent moisture at which the hay would be considered cured sufficiently. McClure (30) found that the sweating of hay usually ceased 3 to 6 weeks after removal from the field.

Henson (18) stated that the degree of heating is not directly proportional to the moisture content when placed in storage. Green color was usually destroyed when heating exceeded 112° F. Clean brown hay was formed at temperatures between 131 and 158° F. and in general, moldy hay resulted when it was heated to between 104 and 122° F. during the storage period. He found that when hay was baled from the field with 23% moisture and was carefully stored there was no detrimental heating.

Black and various shades of brown hay may also result from storing undercured hay. There is apparently some controversy among workers on the comparison of palatability and feeding value of "normal" hay and brown or black hay. Maynard et al. (29) reported brown alfalfa to be more palatable and slightly higher in feeding value for fattening lambs than green alfalfa. Cave (9), Henson (18), and Willard (49) all found that cattle would learn to eat brown hay but the feeding value of such hay was lower than normal hay. Monroe and co-workers (32) believe that an explanation for the lack of agreement on the feeding value of "brown" hay was that there is considerable variation between different lots of "brown" hay and in the processes occurring which result in off-colored hay.

Bohstedt (5) reported that brown hay was characterized by a lower protein digestibility. He found the digestibility of brown and black hay to be 11.4 and 2.6% lower, respectively, than green hay that was 86.5% digestible. Grasoman and Steiner (10) indicated there were losses up to 45% of the digestible true protein when the hay was stored with a high moisture content. Watson (48) found no difference in the protein content or digestibility due to storage losses, but did indicate that early hay retained about 4.5% more protein than did the late season hays.

Aside from conventional proximate analysis, most of the chemical studies have centered on carotene. Bohstedt (5) reported that the carotene content is the best single criterion of hay quality. He found that when the carotene content was high the hay was usually leafy and had been cured quickly. Kon and Thompson (25) stated that the carotene content was a poor measure of hay quality, because baled hay that had lost 75% of its carotene during hay making in the field, lost 33 to 42% of the remainder during 13 months in storage, and yet was still of high quality.

Russell et al. (37) pointed out that strong sunlight and high temperature are particularly detrimental to the carotene content of hay. Kane and co-workers (23) found that in alfalfa hay stored below 45° F. the average carotene loss per month was about 3% and at temperatures between 45 and 66° F. the average loss per month was 6.5%. At temperatures above 66° F. the average loss was 21% per month during the first summer of storage and 11% during the second summer. Guilbert (15) and Smith (41) reported similar results.

Bohstedt (5) said that carotene preservation in hay depends largely on a quick reduction of moisture to 20 to 24% without undue exposure to the bleaching action of the sun. Griffith and Thompson (14) found that carotene is nearly half again as stable in the leaf as it is in the stem and they pointed out the need of feeding hay that had most of the leaves still attached to the stem.

Archibald *et al.* (1) attempted to determine when changes took place in hay during storage. They found, in summarizing their work: (a) a slow, steady rate of increase in fiber; (b) a similar rate of decrease in nitrogen-free-extract; (c) a rapid decrease in protein during the first week of storage, followed by a leveling off to a much slower rate of decrease; (d) a considerable decrease in sugar the first week of storage, followed by a much slower rate of decrease up to the end of a month, after which there was apparently no decrease; (e) a very rapid decline in carotene at first followed by a less rapid but still substantial loss to the end of the storage period. They also stated that the close similarity between the curve for carotene and that for moisture indicated that destruction of carotene proceeds along with the dehydration process.

Lardinois and associates (26) found no apparent loss of thiamine, riboflavin, biotin, nicotinic acid, and pantothenic acid in hay that had been stored in a dark room at 68 - 77° F. for one year.

EXPERIMENTAL

The baled alfalfa hay used in this study was obtained from hay delivered from local sources to the Oklahoma Agricultural and Mechanical College dairy barn.

Six truck loads of baled alfalfa hay from each of three cuttings of hay from three separate fields were to be sampled at random. Because of adverse climatic conditions, only a limited amount of second cutting hay was obtained. Ten per cent of the bales of each truckload was selected at random, tagged for identification, sampled and weighed. All hay was sampled and weighed the day of baling upon arrival at the storage barn.

Each group of bales was stacked in such a manner that the sample bales were not excessively exposed to surface air currents. A layer of old prairie hay was placed on the concrete floor under the experimental hay to eliminate a possible source of error due to a floor sweat. The top tier consisted of new non-experimental alfalfa hay which served to reduce surface exposure. All sample bales were handled with extra care to prevent excessive shattering.

After 128 to 148 days of storage, at which time the sweating process was completed, all bales were again identified, weighed, and sampled. After completion of the storage period, the bales were weighed and sampled on the same day to minimize the possibility of error due to variations in atmospheric conditions.

The sample of hay obtained from each experimental bale weighed approximately 250 grams and was obtained by a sampling device attached to an electric drill. The sampling tube consisted of a 15-inch long, 2-inch inside diameter pipe with a cutting edge on one end.

Moisture determinations were made on all samples immediately after collection. The per cent moisture present was determined by weighing the whole sample obtained and drying it to a constant weight at 115° C. without a vacuum. The samples were then ground to pass the fine mesh screen of a Wiley cutting mill.

All 45 samples were analyzed for their protein content by the Kjeldahl method (3). The first two samples from each group of bales were further analyzed for the percentage of alcohol soluble solids, soluble nitrogen, reducing sugars, sucrose and total sugars.

Soluble nitrogen was determined by the Kjeldahl method on material extracted with 80% alcohol for 36 hours in a Soxhlet extractor. Soluble solids were run on aliquots of 80% alcohol extracts and were dried overnight at 105° C. Reducing sugars were determined by a modification of the Shaffer - Hartmann procedure (34). Sucrose determinations were made by the same method after the sucrose in the sample had been inverted by the use of hydrochloric acid.

RESULTS

The weight losses of bales grouped according to the per cent moisture present at the time of storage are summarized in Table 4. Weight loss during storage of baled alfalfa hay averaged 12.7% and varied from 3.2 to 24.1%. The average bale weight at the time of storage was 84.1 lb. The average moisture content at the time of storage was 19.5% and ranged from 12.0 to 34.7%. Considerable variation was apparent in the relationship between bale weight loss and per cent moisture at the time of storage. The correlation between the original per cent moisture and bale weight loss was +0.63.

The average moisture content at the end of storage was 9.1%, ranging from 7.9 to 11.7%. Only 4 bales varied more than 1% from the mean.

It is generally recommended that alfalfa hay should be baled when the moisture content is between 20 and 25%. Of the 45 samples obtained, only seven were found to contain more than 25% moisture while 26 analyzed less than 20% moisture.

The average dry matter loss for all bales was only 0.84%. The range was from a loss of 11.41% to a negative loss (gain) of 15.40%. Seventeen of the 45 experimental bales appeared to gain in dry matter during storage, and only 9 bales lost more than 5%.

Data relative to the loss of soluble solids, sugars, soluble nitrogen and protein are summarized in Table 5. All figures are expressed on a dry matter basis.

Table 4

Bale Weight Losses of Alfalfa Hay During Storage

Description	Moisture group Low	Medium	High	Average
	15.0% or less	15.1 - 24.9%	25.0% or more	19.5%
No. bales	9	28	8	45
Av. bale weight	78.9	83.5	92.0	84.1
Av. weight loss/bale	6.5	10.1	17.6	10.7
Av. per cent loss	8.2	12.1	19.1	12.7

Table 5

Losses of Various Nutrients During Storage[a]
(computed on dry matter basis)

Description	Soluble solids	Reducing sugars	Sucrose	Total sugars	Soluble nitrogen	Protein
Start of storage						
% nutrient	23.04	1.13	1.52	2.50	0.63	19.97
Lbs. D.M./bale	68.30	68.30	68.30	68.30	68.30	67.50
Lbs. nutrient/bale	15.74	0.77	1.04	1.81	0.43	13.48
End of storage						
% nutrient	20.79	0.78	0.64	1.42	0.65	20.48
Lbs. D.M./bale	68.98	68.98	68.98	68.98	68.98	66.80
Lbs. nutrient/bale	14.34	0.54	0.44	0.98	0.45	13.68
Lbs. nutrient lost/bale	1.40	0.23	0.60	0.83	- 0.02	- 0.20
% loss	8.9	13.0	57.7	45.9	- 4.6	- 1.48

a Protein determined on all 45 samples. Other nutrients determined only on 10 bales selected at random.

Six bales, with less than 24% moisture, lost only 5.5% of their soluble solids during storage, while the remaining four bales with more than 24% moisture, lost 14.0% of their soluble solids.

On the average there was an 0.83 lb. loss of sugars per bale, 72% of which was found to be sucrose. The analyses indicated that a 0.02 lb. increase of soluble nitrogen per bale occurred during storage while the protein content increased 0.20 lb. per bale.

In Figure 2 the per cent bale weight loss has been plotted against per cent moisture at the time of storage. The models used here and subsequently for linear regression and curvilinearity of regression, were of the type $y = a + bx$ and $y = a + bx + cx^2$, respectively. The linear regression line A, of Figure 2 is fitted from the equation $Y = -1.54 + .712X$. Fitting the same data to a curvilinear equation gave $Y = 1.82 + .09528X + .02138X^2$. This equation is fitted to the data as line B, of Figure 2. In these equations, Y is the per cent bale weight loss, "a" is a constant and X is the per cent moisture at the time of storage. The mean square, as found in Table 6, due to linear regression is not statistically significant, while that due to curvilinearity of regression is highly significant at the one per cent level (42).

In Figure 3 the per cent dry matter loss has been plotted against per cent moisture at the time of storage. The linear regression line A is fitted from the equation $Y = 9.22 - 0.430X$. The curvilinear regression line B is fitted from the equation $Y = -4.82 + 0.876X - 0.03X^2$. In these equations, Y is the per cent dry matter loss and X is the per cent moisture at the time of storage. The mean square, as found in Table 7, due to curvilinearity of regression is not statistically

Figure 2

Per Cent Bale Weight Loss Plotted on Per Cent Moisture at the Time of Storage

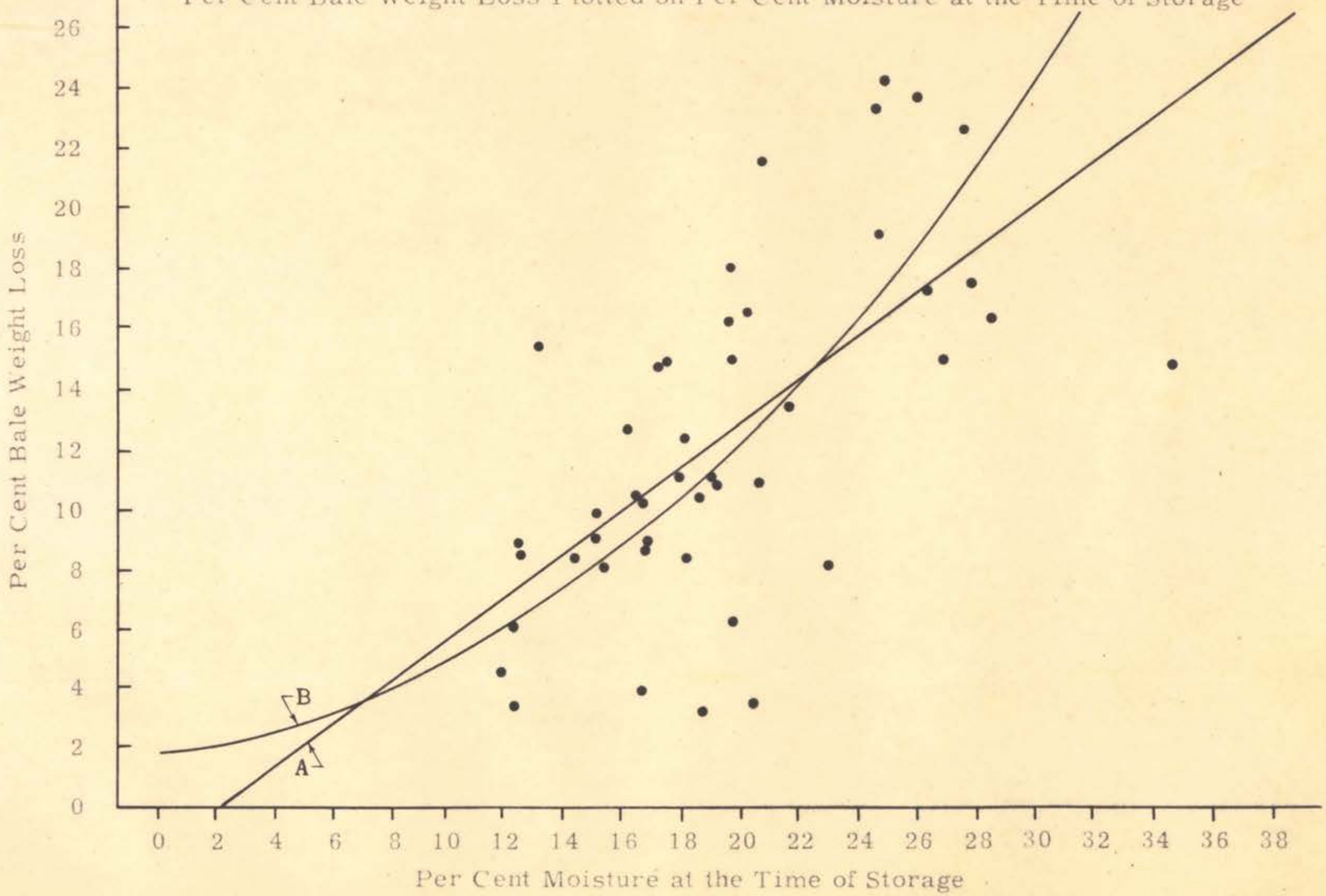


Table 6

Regression of Per Cent Bale Weight Loss on Per Cent Moisture at the Time of Storage

Source	Degrees of freedom	Mean square	F
Total	44		
Due to linear regression	1	34.38	2.23
Due to curvilinear regression	1	726.80	47.19**
Deviation from curvilinearity of regression	42	15.40	

** Confidence limits at the 99% level.

Figure 3

Per Cent Dry Matter Loss Plotted on Per Cent Moisture at the Time of Storage

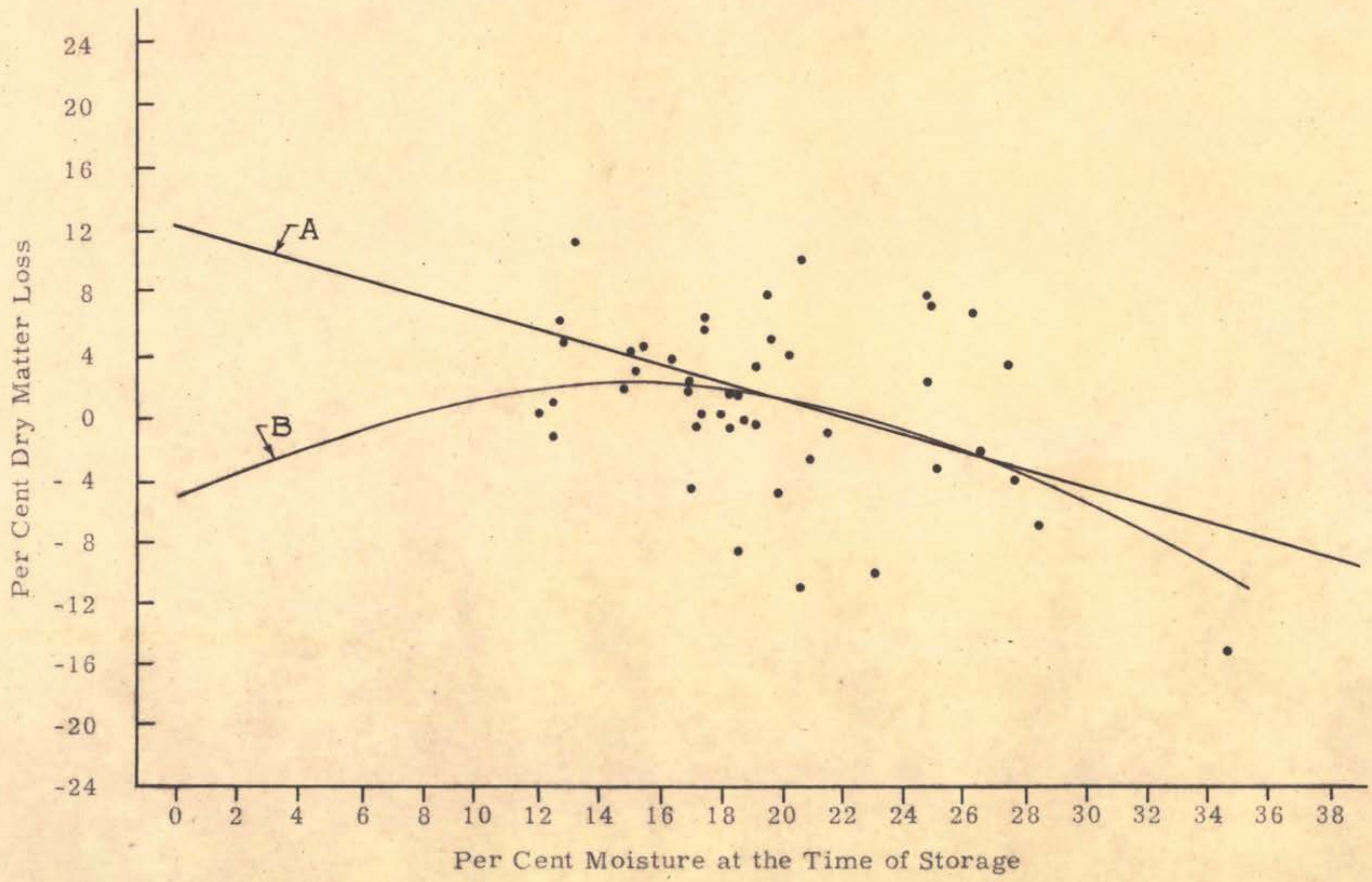


Table 7

Regression of Per Cent Dry Matter Loss
On Per Cent Moisture at the Time of Storage

Source	Degrees of freedom	Mean square	F
Total	44		
Due to linear regression	1	205.53	7.80**
Due to curvilinear regression	1	34.31	1.30
Deviation from curvilinearity of regression	42	26.33	

** Confidence limits at the 99% level.

significant, while that due to linear regression is highly significant at the one per cent level (42).

In Figure 4 the per cent protein loss has been plotted against per cent moisture at the time of storage. The linear regression line A, of Figure 4 is fitted from the equation $Y = 7.66 - .487X$. Fitting the same data to a curvilinear equation gave $Y = 16.09 - 1.286X + .0188X^2$. This equation is fitted to the data as line B, Figure 4. In these equations, Y is the per cent protein lost, and X is the per cent moisture at the time of storage. The mean square, as found in Table 8, due to curvilinearity of regression is not statistically significant, while that due to linear regression is significant at the five per cent level (42).

Linear regression and curvilinear regression lines were fitted from the data concerning the percentage of soluble solids, soluble nitrogen and total sugars lost during storage. The mean square (Tables 9, 10 and 11) of these due to linear regression or curvilinearity of regression, are not statistically significant (42).

In Figure 5, the per cent moisture at the time of storage has been plotted against per cent bale weight loss. The linear regression line A, is fitted from the equation $Y = 12.50 + .562X$. Fitting the same data to a curvilinear equation gave $Y = 13.56 + .3816X + .00673X^2$. In these equations, Y is the per cent moisture present at the time of storage, and X is the per cent bale weight loss. The mean square, as found in Table 12, due to curvilinearity of regression is not statistically significant, while that due to linear regression is highly significant at the one per cent level (42).

Figure 4

Per Cent Protein Loss Plotted on Per Cent Moisture at the Time of Storage

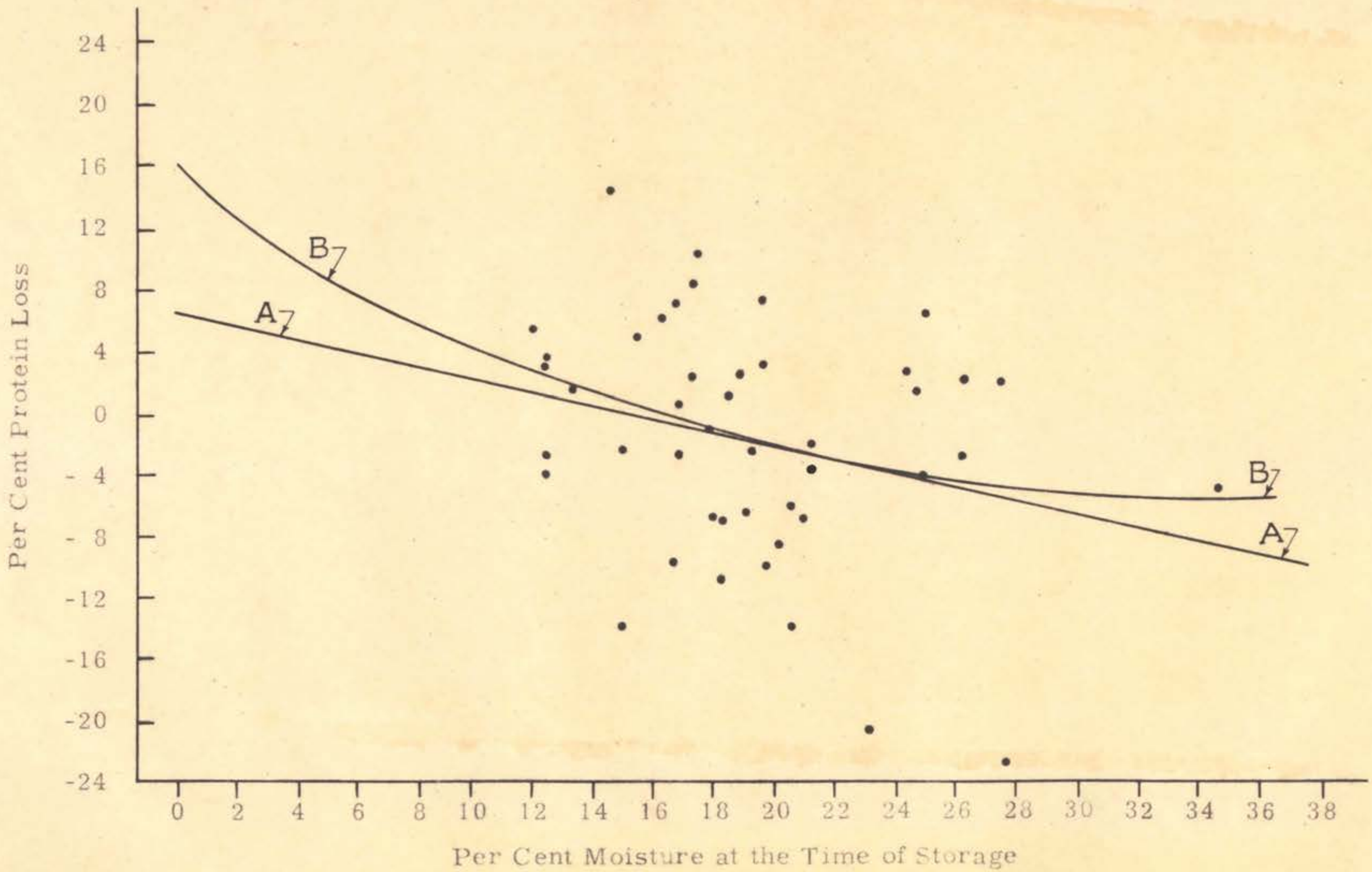


Table 8

Regression of Per Cent Protein Loss on Per Cent Moisture at the Time of Storage

Source	Degrees of freedom	Mean square	F
Total	44		
Due to linear regression	1	262.96	4.38*
Due to curvilinear regression	1	15.77	3.81
Deviation from curvilinearity of regression	42	60.03	

* Confidence limits at the 95% level.

Table 9

Regression of Per Cent Soluble Solids Loss on Per Cent Moisture at the Time of Storage

Source	Degrees of freedom	Mean square	F
Total	9		
Due to linear regression	1	85.58	2.16
Due to curvilinear regression	1	3.71	49.80
Deviation from curvilinearity of regression	7	184.76	

Table 10

Regression of Per Cent Soluble Nitrogen Loss on Per Cent Moisture at the Time of Storage

Source	Degrees of freedom	Mean square	F
Total	9		
Due to linear regression	1	3.30	61.54
Due to curvilinear regression	1	22.77	8.92
Deviation from curvilinearity of regression	7	203.10	

Table 11

Regression of Per Cent Total Sugars Loss on Per Cent Moisture at the Time of Storage

Source	Degrees of freedom	Mean square	F
Total	9		
Due to linear regression	1	546.51	1.89
Due to curvilinear regression	1	6.33	45.75
Deviation from curvilinearity of regression	7	289.61	

Figure 5

Per Cent Moisture at the Time of Storage Plotted on Per Cent Bale Weight Loss

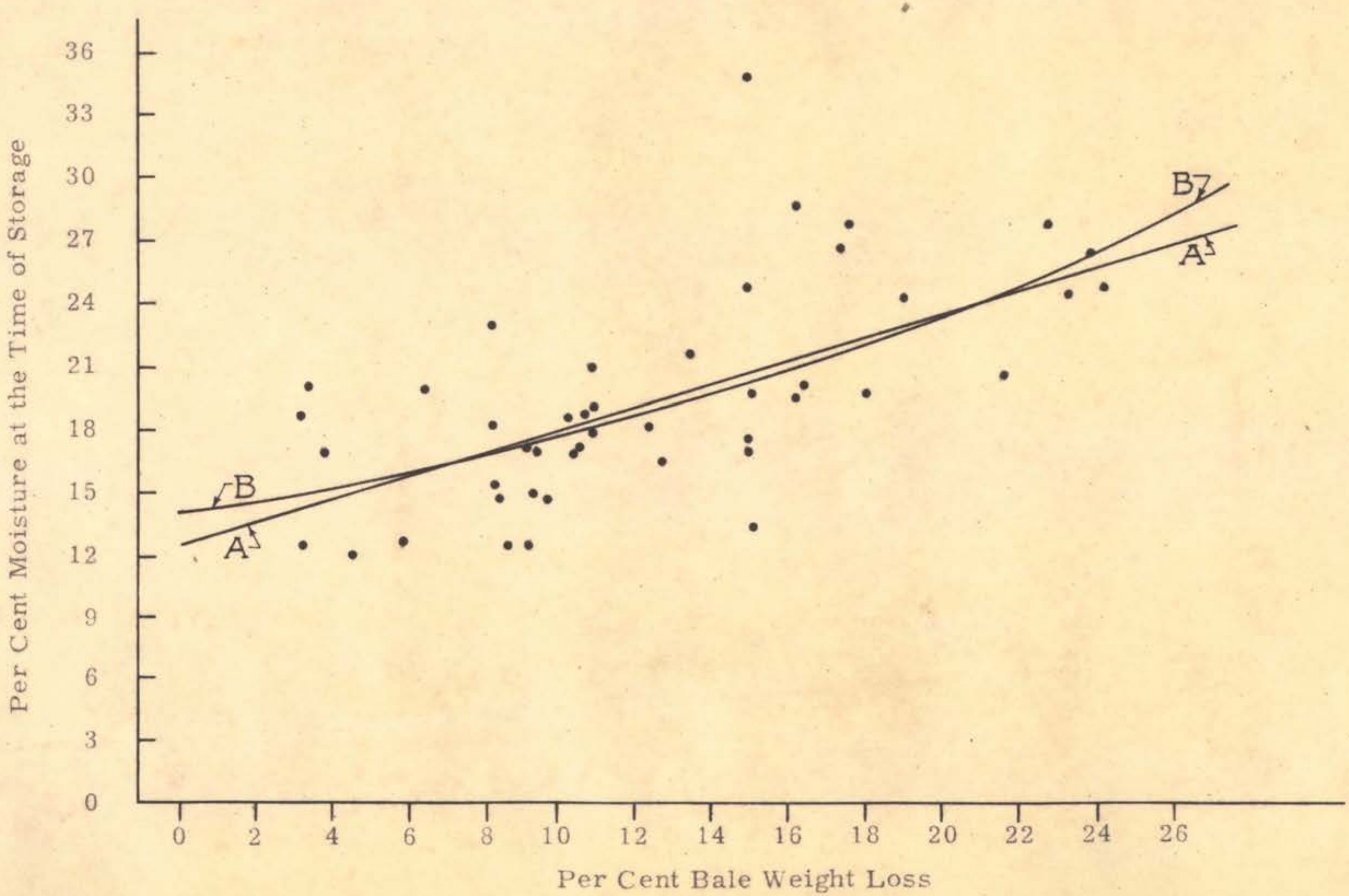


Table 12

Regression of Per Cent Moisture at the Time of Storage on Per Cent Bale Weight Loss

Source	Degrees of freedom	Mean square	F
Total	44		
Due to linear regression	1	444.91	28.2**
Due to curvilinear regression	1	2.63	0.17
Deviation from curvilinearity of regression	42	15.80	

** Confidence limits at the 99% level.

DISCUSSION

Some consideration should be given to the method used in determining the per cent moisture of the experimental bales. The apparent variation in the relationship between bale weight loss and per cent moisture at the time of storage may be indicative of an inadequate sampling procedure.

Fifteen bales lost from 10.0 to 15.0% of their weight. On the basis of data fitted from the linear regression line A of Figure 5, the range in expected per cent moisture at the time of storage for those bales was from 18 to 21%. Only 6 of the 15 bales were found to be within this range at the time of storage as the per cent moisture, as determined, varied from 16.3 to 34.7%.

Since there is considerable variation in the relationship between bale weight loss and per cent moisture at the time of storage, it appears that a much larger number of bales must be sampled and analyzed before definite conclusions can be drawn.

In Figure 5, the per cent moisture at the time of storage has been plotted against per cent bale weight loss. If considerable variation persisted in future work, it may be desirable to use data from Figure 5, or similar data, as a method of determining the per cent moisture at the time of storage when the per cent bale weight loss is known.

Line B of Figure 2 may be used to estimate the probable bale weight loss during storage when the per cent moisture at the time of storage is known. As may be seen in Figure 2, line B is concave upward.

This trend is in agreement with the findings of Hodgson et al. (19). Because of the limited data, it is felt that the limits of line B should be placed at the 12 and 25% moisture levels.

The linear regression line A of Figure 3 may have value in predicting losses of dry matter during storage. If the limits of line A were again placed at the 12 and 25% moisture levels, we could expect dry matter losses to vary from 3.5% to a negative 1.5%, respectively.

However, it is felt that it could be assumed that no appreciable loss of dry matter occurred during the storage period of the hay used in this study. This is not in agreement with the findings of Camburn et al. (6) or Camburn and Jones (7), but does support the opinion of Hodgson and co-workers (19).

In Figure 4 the per cent protein loss has been plotted against the per cent moisture at the time of storage. Line A of Figure 4, concerning expected protein loss, follows a pattern comparable to line A of Figure 3 which is used to predict expected dry matter loss. Again, it is felt that the limits should be placed at the 12 and 25% moisture levels. According to results from line A of Figure 4, any hay containing more than 16.8% moisture at the time of storage should have an increased protein content at the end of storage. As it is impossible for hay to increase in protein content during storage, and because the apparent gain is relatively small, it is felt that probably no change of protein occurred during storage. This does not agree with the work of Archibald et al. (1) who found a 4% loss of protein during storage they could not associate it with any curing process.

The losses of soluble solids, soluble nitrogen and total sugars were not significantly related with the per cent moisture at the time of storage. It is believed that the lack of a significant relationship may be due to the limited amount of data available. These results were not in agreement with Archibald et al. (1) who found a significant correlation between the loss of sugars during storage and the per cent moisture at the time of storage. According to Dexter (11), field cured hay has a higher sugar content than hay dried in the mow over a three-week period. It seems probable that loss of sugars may be completely independent of the moisture content at the time of storage or the method of storage.

As shown in Table 5, an average loss of nearly 9% of the soluble solids occurred. Apparently little is known as to what materials may be involved in the loss of solids. Apparently the sugars represented about 60% of the solids lost. Some plant pigments are probably included in these losses, also, but they would not account for any appreciable amount of solids lost during storage. There is a need for study to determine what is incurred in the loss of soluble solids during storage.

SUMMARY

PART I

A total of 432 hours was spent observing and recording the feeding activity of dry cows and heifers in a self-feeding trench silo. Groups of 11, 16 and 18 animals were observed under winter conditions with sorghum silage and 25 animals were used in summer studies with vetch silage.

Normal cow feeding behavior apparently offers some limiting factors in the use of self-feeding trench silos. The silage consumption during these studies was not uniform among all animals due to the apparent natural animosity between individuals. This situation became more intensified when the silage access time was decreased below 24 hours. Decreased access time seriously curtailed the silage feeding of some animals. Competition for feeding space was decreased when hay was fed in addition to silage. It was apparent that the silage feeding behavior of the animals in these studies was random in nature. Daily silage eating time per animal varied from 0 to 253 minutes, and variations from 0 to 27 entries to the silo were observed among individuals.

There were three characteristic periods of feeding activity during each day, 1-2 hours, 10-12 hours and 19-20 hours after sunrise. Wastage and spoilage did not appear to be serious problems in this system of feeding silage under relatively mild climatic conditions. Labor requirements for servicing the silo were negligible.

The available feeding space was not completely utilized, even during periods when some individuals failed to obtain any silage. More than 3 individuals feeding at one time was seldom observed at the feeding panel which was of the size and arrangement to accommodate 5 animals.

PART II

In a preliminary study, 45 bales of second cutting alfalfa hay were obtained to determine what losses occur during storage.

Considerable variation was apparent in the relationship between bale weight loss and the per cent moisture at the time of storage. The average moisture content at the beginning of storage and at the end of storage was 19.5 and 9.1%, respectively. Weight losses averaged 12.8% and the correlation between the original per cent moisture and bale weight loss was $+ 0.63$. A curve has been fitted to the data from which the expected bale weight loss can be predicted when the per cent moisture at the time of storage is known.

Losses of dry matter, soluble nitrogen and protein were negligible.

Nearly 50% of the sugars were lost during storage, but the loss could not be correlated significantly with the per cent moisture at the time of storage.

A loss of nearly 9% of the soluble solids occurred. About 60% of the soluble solids lost presumably were the sugars. More thorough studies are needed to determine what is incurred in the loss of soluble solids during storage.

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APPENDIX

Table 1

Total Time Spent in Silo and
Number of Entries Into Silo per Day

Observation No. 1

	Minutes in silo per day				Number of entries into silo per day			
No.	Feb. 8	Feb. 9	Feb. 10	Av.	Feb. 8	Feb. 9	Feb. 10	Av.
1	123	144	97	121	4	4	8	5.3
2	226	219	81	175	14	8	8	10.0
3	166	127	60	118	7	6	5	6.0
4	161	119	112	131	15	13	11	13.0
5	179	118	121	139	11	7	8	8.7
6	156	157	73	129	16	8	7	10.3
8	186	147	127	153	3	7	13	7.7
11	174	148	129	150	10	7	11	9.3
13	82	93	29	68	2	5	2	3.0
14	146	51	35	77	6	5	6	5.7
16	126	69	27	74	4	4	4	4.0
Av.	157	127	81	122	8.4	6.7	7.5	7.5

Table II

Total Time Spent in Silo and
Number of Entries Into Silo per Day

Observation No. 2

No.	Minutes in silo per day: Feb. 26	Mar. 1	Mar. 5	Av.	Number of entries into silo per day: Feb. 26	Mar. 1	Mar. 5	Av.
1	129	175	80	128	6	7	7	6.7
2	244	253	132	210	11	15	7	11.0
3	235	143	162	180	7	6	10	7.7
4	233	196	172	200	6	11	13	10.0
5	200	155	154	170	12	13	9	11.3
6	127	194	172	164	10	19	6	11.7
7	128	244	106	159	2	14	13	9.7
8	147	135	109	130	9	15	8	10.7
9	41	1	194	79	2	1	3	2.0
10	106	133	150	130	5	4	6	5.0
11	133	227	142	167	4	10	8	7.3
12	85	133	49	89	7	5	1	4.3
13	71	66	53	63	4	4	4	4.0
14	81	1	60	47	5	1	2	2.7
15	10	51	85	49	1	2	3	2.0
16	124	58	53	78	4	3	4	3.7
17	83	11	19	38	7	1	3	3.7
18	57	0	14	24	2	0	2	1.3
Av.	124	121	106	117	5.8	7.3	6.1	6.4

Table III

Total Time Spent in Silo and
Number of Entries Into Silo per Day

Observation No. 3

	Minutes in silo per day				Number of entries into silo per day			
No.	Mar. 16	Mar. 19	Mar. 23	Av.	Mar. 16	Mar. 19	Mar. 23	Av.
1	138	184	91	138	4	6	4	4.7
2	182	128	154	155	6	11	6	7.7
3	85	103	84	91	4	5	5	4.7
4	83	138	142	121	7	8	11	8.7
5	163	80	131	125	2	12	4	6.0
6	131	84	104	106	6	7	6	6.3
7	187	61	151	133	7	8	3	6.0
8	5	66	29	33	5	2	4	3.7
9	117	57	89	88	5	4	3	4.0
10	91	62	85	79	5	3	4	4.0
11	86	146	114	115	4	5	6	5.0
12	24	68	17	36	2	2	6	3.3
13	77	54	63	65	4	7	6	5.7
14	73	70	135	93	3	4	1	2.7
15	37	15	54	35	3	1	2	2.0
16	66	63	18	49	3	1	3	2.3
17	99	38	13	50	1	2	3	2.0
18	95	48	1	48	1	1	3	1.7
Av.	97	81	82	87	4.0	4.9	4.4	4.5

Table IV

Total Time Spent in Silo and
Number of Entries Into Silo per Day

Observation No. 4

No.	Minutes in silo per day				Number of entries into silo per day			
	Mar. 30	Mar. 31	Apr. 1	Av.	Mar. 30	Mar. 31	Apr. 1	Av.
2	95	205	151	150	2	6	4	4.0
3	135	142	84	120	4	3	2	3.0
4	92	126	102	107	3	5	4	4.0
5	123	97	144	121	4	8	5	5.7
6	91	154	65	103	3	10	2	5.0
7	12	111	134	86	3	5	7	5.0
8	42	114	100	85	2	9	7	6.0
9	38	51	105	65	1	2	6	3.0
10	31	94	78	68	10	4	2	5.3
11	66	117	135	106	6	6	2	4.7
12	43	43	100	62	5	4	6	5.0
13	26	21	5	17	2	0	1	1.0
14	75	0	39	38	4	0	2	2.0
15	0	0	1	0	0	0	1	0.3
16	24	0	44	23	3	0	3	2.0
17	60	36	0	32	2	2	0	1.3
18	74	16	0	30	1	1	0	0.7
19	49	41	78	56	3	3	1	2.3
Av.	60	76	76	71	3.2	3.8	3.1	3.4

Table V

Total Time Spent in Silo and
Number of Entries Into Silo per Day

Observation No. 5

	Minutes in silo per day				Number of entries into silo per day			
No.	Apr. 12	Apr. 13	Apr. 14	Av.	Apr. 12	Apr. 13	Apr. 14	Av.
2	182	174	146	167	4	2	3	3.0
3	81	115	86	94	4	2	2	2.7
4	167	151	132	150	4	1	4	3.0
5	138	95	61	98	2	1	2	1.7
6	135	122	57	105	4	3	3	3.3
8	79	158	65	101	6	2	2	3.3
9	155	39	68	87	3	1	4	2.7
11	74	113	37	75	5	1	2	2.7
12	72	76	0	49	3	1	0	1.3
13	0	0	20	7	0	0	1	0.3
16	2	49	20	24	1	2	2	1.7
17	0	0	3	1	0	0	1	0.3
18	0	0	0	0	0	0	0	0.0
19	72	95	70	79	4	1	3	2.7
20	0	0	0	0	0	0	0	0.0
21	9	70	53	44	1	2	2	1.7
Av.	73	79	51	68	2.6	1.2	1.9	1.9

Table VI

Total Time Spent in Silo and
Number of Entries Into the Silo per Day

Observation No. 6

	Minutes in silo per day				Number of entries into silo per day			
No.	July 13	July 16	July 20	Av.	July 13	July 16	July 20	Av.
22	29	18	52	33	4	5	11	6.7
23	64	48	60	57	6	7	8	7.0
24	146	62	62	90	8	11	16	11.7
25	66	76	85	76	5	11	12	9.3
26	72	103	96	90	6	12	21	13.0
27	35	99	107	80	3	8	17	9.3
28	73	69	100	81	6	11	17	11.3
29	55	50	100	68	5	11	17	11.0
30	17	44	76	46	2	7	15	8.0
31	98	66	76	80	4	8	8	6.7
32	63	55	102	73	9	8	21	12.7
33	51	4	63	39	4	2	12	6.0
34	51	113	85	83	6	17	16	13.0
35	97	85	94	92	6	15	12	11.0
36	131	99	120	117	9	16	27	17.1
37	0	3	3	2	0	1	1	0.7
38	106	127	176	136	6	11	9	8.7
39	141	198	242	194	6	7	6	6.3
40	110	142	191	148	6	12	17	11.7
41	85	94	101	93	4	9	13	8.7
42	78	137	114	110	5	15	9	9.7
43	161	140	125	142	9	17	14	13.3
44	158	201	159	173	9	20	14	14.3
45	154	121	158	144	10	15	16	13.7
46	174	123	101	133	9	14	17	13.3
Av.	89	91	106	95	5.9	10.8	13.8	10.2

Table VII

Climatological Data

Observation	Date		Temperature Max.	Min.	Precipitation	Remarks
1	Feb.	8	73	28	none	
		9	77	42	"	
		10	77	43	"	
2	Feb.	26	70	36	none	(Observed snowfall
	Mar.	1	62	34	"	at silo on Feb. 26
		5	82	47	trace[a]	and Mar. 5)[b]
3	Mar.	16	59	33	none	(Severe local storm
		19	62	40	trace[a]	at Stillwater on
		23	64	45	.02	Mar. 24)[b]
4	Mar.	30	38	28	none	
		31	50	30	"	
	Apr.	1	63	23	"	
5	Apr.	12	60	54	.06	
		13	68	48	.12	
		14	79	58	none	
6	July	13	112	76	none	(July was reported
		16	109	76	"	hottest month on
		20	107	75	"	record in Oklahoma,
						as well as being
						extremely dry)[c]

a Trace indicates precipitation fell but in too small a quantity to be measured.

b Remarks recorded by observer while observing at silo.

c Reported on summary page of U. S. Dept. of Commerce report.

Table VIII

Weight, Dry Matter and Nutrient Determinations at the Beginning of the Storage Period

Sample No.	Bale weight	% Dry matter	% Sol. solids	Sugars: Red.	Sugars: Sucro.	Sugars: Total	Nitrogen: Sol. N	Nitrogen: Protein
1	82.0	80.8	22.33	1.25	2.35	3.60	.51	19.75
2	86.0	78.5	24.84	1.30	2.31	3.61	.58	20.19
3	80.5	81.9						19.81
4	70.5	87.4						18.69
5	71.0	85.0						17.25
6	80.0	84.6						20.25
7	83.5	85.1						18.87
8	72.5	81.4						19.87
9	91.0	86.7						19.31
10	86.0	80.3						19.37
11	93.5	72.2	21.96	1.03	1.19	2.22	.62	20.25
12	93.0	76.9	22.78	1.34	1.26	2.60	.58	21.06
13	78.0	83.2						22.87
14	87.0	83.2						22.12
15	92.5	82.7						22.31
16	98.0	82.4						24.75
17	89.0	79.8						20.62
18	87.0	80.8						20.87
19	94.0	75.4						21.81
20	79.0	83.7						21.37
21	97.5	75.0	21.26	1.34	1.10	2.44	.72	20.56
22	108.5	72.4	21.77	1.34	1.10	2.44	.74	21.00
23	84.0	71.6						22.12
24	94.5	73.6						20.37
25	97.0	79.3						20.00
26	76.5	87.6	23.10	1.19	1.83	3.02	.58	19.81
27	73.0	79.5	24.99	.73	2.37	3.10	.65	19.31
28	78.5	81.4						19.31
29	80.0	83.2						18.19
30	77.0	85.3						20.44
31	84.0	87.5						20.00
32	80.0	83.1						19.56
33	68.5	87.6						18.81
34	73.0	82.0						18.69
35	88.5	88.0						18.87
36	84.5	80.4	24.90	.83	1.40	2.23	.64	18.88
37	87.0	75.4	23.23	.83	0.48	1.33	.70	19.12
38	78.0	73.5						19.44
39	91.5	74.9						20.31
40	88.5	65.3						19.19
41	82.0	82.4						18.75
42	84.5	81.2						18.75
43	78.0	81.8						18.12
44	78.0	79.0						17.62
45	78.0	80.1						17.69

Table IX

Weight, Dry Matter and Nutrient Determinations
at the End of the Storage Period

Sample No.	Bale weight	% Dry matter	% Sol. solids	Sugars Red.	Sugars Sucro.	Sugars Total	Nitrogen Sol. N	Nitrogen Protein
1	73.0	91.2	20.37	1.17	.34	1.51	.53	20.19
2	74.5	91.6	18.27	.83	.45	1.28	.50	20.44
3	70.0	91.7						21.68
4	64.5	91.0						18.89
5	64.5	90.9						20.21
6	73.5	90.3						19.54
7	75.5	90.7						20.06
8	65.0	89.5						19.86
9	77.0	90.8						21.42
10	70.5	90.5						20.33
11	77.0	91.2	19.56	.65	.40	1.05	.70	23.98
12	85.5	91.9	23.41	.65	.40	1.05	.65	23.23
13	70.0	90.8						21.73
14	78.0	91.2						22.39
15	84.0	90.8						21.86
16	83.5	91.9						23.39
17	74.5	91.6						23.28
18	73.0	91.6						23.36
19	72.0	91.0						23.08
20	69.0	92.1						20.92
21	74.0	91.9	19.30	.99	.41	1.40	.80	23.04
22	84.0	90.4	19.34	.77	.19	.96	.70	21.19
23	70.5	91.2						22.92
24	72.0	90.4						22.36
25	76.0	91.0						22.68
26	74.0	91.5	22.96	.61	1.63	2.24	.63	20.16
27	70.5	91.7	24.21	.61	1.75	2.36	.70	19.76
28	76.0	91.3						19.73
29	77.0	90.7						19.04
30	70.5	91.4						17.13
31	76.5	90.1						20.65
32	73.0	91.7						19.89
33	64.5	91.8						19.91
34	65.0	91.8						18.98
35	84.5	91.5						18.01
36	72.0	91.4	21.14	.89	.61	1.50	.59	18.10
37	70.5	90.9	19.22	.65	.30	.95	.74	19.32
38	64.5	91.0						18.62
39	78.0	90.4						18.61
40	75.5	88.3						17.45
41	70.0	90.9						18.21
42	75.5	91.0						18.21
43	71.5	89.7						19.36
44	69.5	91.0						18.36
45	73.0	90.8						18.31

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