THE FEEDING OF FIELD CURED ALFALFA HAY

as compared with

STACK BROWNED ALFALFA HAY FOR MILK AND BUTTER-FAT PRODUCTION

by

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INTRODUCTION

Alfalfa (Medicago sativa) is the leading hay crop in the United States. The Yearbook of Agriculture (1927) reports the total acreage for the United States to be estimated at 11,377,000 acres. The State of Kansas ranks third in the United States in total acreage and fourth in production of alfalfa hay.

Several varieties are grown throughout the middle west, the two varieties best adapted being Kansas Common and Grimm. Grimm is a Minnesota variety, and is known for its winter hardiness. It is not as well adapted to Kansas conditions as the Kansas Common.

Throckmorton and Salmon (1927) state that in Kansas there has been a marked decline in alfalfa production in the last eight years. Some of this decline may be attributed to the general loss in curing the product in unfavorable years, to soil conditions, to winter killing and to plant diseases.

Alfalfa is grown over a very wide range of territory where all variations in curing are liable to be encountered. The green cut alfalfa does not cure well unless favorable weather conditions prevail. The quality and yield of alfalfa hay depends very materially upon the time the crop is cut and the way it is cured.

In making alfalfa hay it is especially important to guard against loss of leaves which are the most valuable part of the crop. If possible, alfalfa should be cut, cured, and stacked or put up under shelter without being rained on. A rain on a field of curing alfalfa hay will cause a great loss in nutrients, for this reason alfalfa hay is frequently baled or stacked before properly cured in order to avoid a loss from unfavorable weather conditions.

Shuey (1914) states, "The diastatic activity of alfalfa is greater in the morning or after a period of darkness than otherwise. There is much more diastase present during the summer than during the spring and fall.

Young plants contain more than older ones. The diastatic activity is decreased by drying at elevated temperatures, in humid autumn, while the reverse is true in drying in a current of air with gradually increasing temperature. Light, weathering in the field, and rain during curing have a destructive tendency. The loss of digestible constituents during handling and curing in the field may vary from 20 per cent under favorable conditions to 50 per cent under adverse weather conditions."

Feeders have observed that cattle relish stack browned alfalfa hay, and in some cases even prefer it to normally cured alfalfa hay. This, together with the fact that cows seem to produce well on this feed, has brought up the question as to the relative feeding value of these two hays.

REVIEW OF LITERATURE

The difficulty in field curing of alfalfa hay in some of the most productive alfalfa areas has caused investigation to be made relative to artificial means of curing alfalfa.

Kiefer (1927) shows that alfalfa yields a large amount of nutrients per acre. "This being the case, the question arises, Why is it not more extensively grown?

There are several reasons:

1. The long life of the stand does not fit in well with the rotation of crops.

2. The second and third cuttings interfere with the labor program of other crops.

3. It is difficult to cure.

The first and second objections might be easily overcome, but it is well known that in the humid regions, where alfalfa thrives best, it is most difficult to cure. Many eastern farmers who succeeded well with alfalfa in small acreages became ambitious and put out larger acreages, only to find out that the difficulty of curing in the sun made the saving of the entire crop impossible."

"If a practical method could be devised for artificially curing alfalfa, the third objective would be attained. Arthur J. Maison reasoned that if brick, selling for about three dollars per ton, or salt requiring a great deal of evaporation, could be artificially dried and sold for three dollars per ton, hay worth about five times that amount would warrant the same artificial treatment. This view was further strengthened by the fact that all kinds of hay cured in the sun are subject to wide variations in feeding value depending upon the kind of weather encountered at hay making time. A further objective would be to

make hay, rain or shine, at the most desirable stage of growth, thereby obtaining a uniform hay of superior feeding value."

Kiefer (1927) discusses a process of curing which allows the green cut hay to be taken directly from the mower and placed in the curing machine. The hay passes through a drying tunnel on a traveling conveyor of wire mesh. Dry gas enters the tunnel and dries out the hay. The temperature of the gas is 275° F. at which temperature all of the weed seeds are sterilized. The hay comes from the machine in excellent condition and is well cured.

Kiefer (1927) states, "It is apparent from chemical analysis that artificially cured alfalfa should give better results pound per pound than the sun-cured, as shown in the table below.

Chemical Analysis of Sun-cured and Artificially Cured Alfalfa

Kind of hay	Water	Ash	Protein	Fiber	Nitrogen-free extract	Fat
Sun-cured	8.60	8.60	14.90	28.30	37.30	2.30
Artificially cured	8.29	8.87	19.25	21.43	39.20	2.86

Actual feeding tests at the Walker-Gordon milk farms, where one of the Mason plants has been in operation all this season, showed that with cows changed from a ration containing the best western alfalfa to the same weight of artificially cured hay, there was a decided increase in milk flow. A preliminary report on the vitamin content as shown in comparative tests on white rats at Columbia University shows the superiority of the artificially cured alfalfa (meal). This is also shown in preliminary reports on young pigs at the New Jersey Experiment Station."

"Artificial curing of alfalfa is an accomplished fact. Its superior feeding value has been demonstrated. The recovery of a great tonnage per acre is verified, as shown in table below."

Total Nutrients in Pounds Per Acre of
Sun Cured and Masonized Alfalfa

Kind of hay	Total weight	Protein	Fiber	Nitrogen free extract	Fat	Total nutrients
Sun-cured:	5220	773	1577	1947	120	4222
Masonized:	6500	1251	1392	2554	186	5383

Headden in Colorado Experiment Station Bulletin 110, states, "The general custom in this part of Colorado is

to rake the alfalfa into windrows as soon after cutting as is at all advisable, and complete the necessary curing in windrow or cock as the case may be. This practice is the result of the observed loss of leaves and breaking off of small stems in raking and handling, if allowed to overcure in the swath. The loss of leaves and stems which fall or are broken, amounts, under favorable circumstances, to about one-fifth of the crop, and can if it is necessary to repeatedly handle the hay, amount to as much as two-thirds of the crop."

Bainer (1928, unpublished) set up a hay drying apparatus and worked on the amount of moisture that could be removed from alfalfa hay per minute. He found that by curing the hay in the sun for three hours and placing in the dryer that one per cent of moisture could be removed per minute. The leaves were all retained and the hay cured out in nice shape.

Biron (1904) stated, "A little heating will do the hay no damage. Cattle will eat with a relish hay that is brown from heating."

Swanson, Call and Salmon (1919) have reported that large losses in alfalfa hay are due to improper curing of the hay before stacking or baling. They also state that the degree of color depends upon the conditions which

control the nature and extent of fermentation. Some of these conditions are moisture content of the alfalfa when stacked, size and shape of the stack, the temperature and amount of rainfall during the time of curing. When fermentation occurs there is a loss in nutritive value. The great weight excludes the air and the fermentation (somewhat similar to that which occurs in the silo) is probably responsible for the color development.

Their results also show that good quality brown alfalfa hay contained more crude protein and less crude fiber, than field cured alfalfa hay of the same cutting. The dark brown hay has a higher crude protein content than the tobacco brown or field cured hay. It appears that the crude protein content varied with the color and as the color became darker the protein content increased. The following table shows the results obtained by Swanson, Call and Salmon (1919).

Sample Number	Date of Sampling	Description of sample	Moisture	Protein	Crude Fiber
600	3-26-27	Charred dry	15.70	16.64	23.29
601	3-26-27	Charred moldy but moist, 2nd grade	48.54	10.53	12.83
602	3-26-27	Black alfalfa good quality	62.45	9.06	10.62
603	3-26-27	From bottom of stack, bad odor	66.80	4.62	11.39
604	3-26-27	Alfalfa hay, color and odor good	58.17	8.84	14.66
605	3-26-27	Dark brown next to charred	5.73	17.63	21.47
606	3-26-27	Moldy mostly charred	32.99	17.81	12.84
607	3-26-27	Light brown hay	3.80	16.39	28.20
608	3-26-27	Green from outside stack good	5.02	13.65	31.99

The feeding value of black alfalfa and brown alfalfa as compared with alfalfa cured in the usual way was determined in feeding trials with steers. The ration consisted of shelled corn and oil meal in addition to the hay. The data secured in this feeding test were furnished by Dr. C. W. McCampbell of the Department of Animal Husbandry.

Dr. C. W. McCampbell* shows that the profits from feeding the ordinary brown alfalfa hay and the first quality green alfalfa hay were nearly the same, the difference being only thirty-one cents per steer. There was no essential difference in the daily gain made by the two lots. The steers fed black alfalfa made unsatisfactory gains. There was a loss of $3.51 per head on this feed in spite of the fact that the alfalfa was valued at only one-third as much as brown hay or ordinary green alfalfa hay.

"Alfalfa which has become black as a result of fermentation is very inferior as a feed for steers in comparison with both brown alfalfa hay and alfalfa hay of good color and quality."

The writer has had some experience in feeding brown alfalfa hay to dairy animals. The hay was made from the last cutting (1927) and put up in small round cocks about eight feet across at the bottom and built about ten feet high. The hay cured in excellent shape. It was of good quality, sweet aroma, and a nice tobacco brown color. The weather conditions were favorable for production of field cured hay. This hay was fed to dairy cows at the same

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*Dr. C. W. McCampbell - published in article written by Swanson, Call and Salmon (1919).

time some field cured alfalfa hay was fed. The cows relished the brown alfalfa hay, as well as the field cured hay.

After three attempts to make stack browned hay by using small stacks, it was found very difficult under conditions existing at the Kansas Experiment Station farm.

Fletcher (1928) states that stack browned alfalfa hay is not an adequate source of vitamin A. If the alfalfa hay is field cured correctly it remains rich in vitamin A.

Krittner (1920) indicates that dairy cows do better on browned alfalfa hay, showing an increase in milk production.

Hay that has been damaged by rains in the period of curing will lose the green color associated with properly cured hay. Alfalfa that has been stacked before being properly dried will also be browned or charred in the stack, depending upon the amount of moisture in the alfalfa and the pressure exerted in the stack. Stack browned alfalfa hay as used in this thesis will refer to the last mentioned care of browned hay.

PLAN OF EXPERIMENT

Object of the Experiment

The object of this experiment was to determine the relative feeding value of field cured alfalfa hay as compared with stack browned alfalfa hay for milk and butterfat production.

Duration of the Experiment

The experiment was conducted for sixty days, February 12, 1928 to April 11, 1928, inclusive. The time was divided into two thirty-day periods using the first ten days of each period as a preliminary period. The preliminary period was used to get the cows on feed and make any necessary changes.

Animals Used

Eight cows from the college dairy herd were used in this experiment. The cows were divided into two lots of four cows each. One Jersey, two Holsteins, and five Ayrshires were used. The lots were balanced as evenly as possible, considering the following factors: breed, age, weight, stage of lactation, gestation, condition of animal,

milk production and per cent of butter-fat. The data on the cows in the two lots are shown in Table I.

TABLE I. PARTIAL DESCRIPTION OF COWS USED IN EXPERIMENT

Lot number	Head number	Breed	Age (a)* years	Fresh days (a)*	Dry Days (a)*	Previous lactations
I	154	Hol	5½	45	0	3
I	254	Ayr	7	117	0	4
I	337	Jer	5	210	0	3
I	281	Ayr	3	114	0	0
II	161	Hol	5	83	0	1
II	277	Ayr	3	206	15	0
II	276	Ayr	3	214	82	0
II	278	Ayr	3	182	101	0

*At the beginning of the experiment.

Methods of Securing Body Weights

The cows were weighed at eight o'clock in the morning on the first three days and last three days of each experimental feeding period. The average of the last three weights of each period was taken as the weight of the animal for that period. The weights used for calculating the feed requirements were taken on three days prior to the beginning of the experiment.

Feeds Used in the Experiment

Sufficient feed of uniform quality was set aside to conduct the experiment. All feeds were analyzed by the Kansas State Agricultural Experiment Station. Composite samples of the hays were secured by taking a small portion from each grinding. Three analyses were made of each kind of hay by analyzing the composite samples at the beginning, middle and close of the experiment. The grain mixture was thoroughly mixed and a sample taken for analysis at the beginning of the trial and at each time a new mix was made. The silage was analyzed at ten-day intervals.

The grain mixture was composed of five parts ground corn, two parts of wheat bran and one part of linseed oil meal (old process). All ingredients of the grain mix were of good quality. To the mix there was added one per cent of special steamed bone meal, and one per cent of salt.

The silage fed was made from Kansas Orange Sorgo. It was of good quality throughout the experiment.

The experimental animals received alfalfa hay, silage, and a grain mixture in proportion to their weight and milk production as determined by Morrison's feeding standard. The reversal feeding method was used in which all cows received a basal ration of Kansas Orange Sorgo silage and

a grain mixture. Lot I was fed the basal ration plus field cured alfalfa hay during period one, and stack browned alfalfa hay during period two. Lot II received the basal ration of silage and grain plus stack browned alfalfa hay during period one, and field cured alfalfa hay during period two. If an animal persistently refused to consume the amount of feed calculated for her, the amount was reduced to meet the demand of the animal. All unused feed was weighed back.

Experimental Hay Used

All the alfalfa hay used in this experiment was secured from the same field on the college farm. It was cut at the same time and cured especially for this experiment.

The brown alfalfa hay was prepared by cutting the hay in the evening and allowing it to cure overnight. The next morning it was placed in a stack which was about twenty-four feet long, twelve feet wide and about eight feet high. The weather conditions were fair. At the time of stacking the moisture content was 51.75 per cent. A metal cover was placed over the stack for protection. After remaining in the stack for three months it was baled and placed in the barn. The hay was of dark brown color. The hay was selected so as to secure as nearly as possible

a uniform color of brown hay, but even then it lacked uniformity.

The field cured alfalfa was cured in the windrow then placed in a hay shed. After several weeks it was baled and stored in the hay shed. The moisture content of the field cured hay as it came from the field was 42.82 per cent.

TABLE II. AVERAGE NUTRIENTS IN 100 POUNDS OF EACH FEED USED

Kind of feed	Total dry matter	Crude protein	Fat	Crude fiber	Ash	Carbo-hydrates	True pro-tein	No. analyses
Grain mix	89.09	14.85	4.33	4.22	4.38	65.30		3
Silage	30.09	1.34	.66	7.35	1.68	23.46		7
Stack browned alfalfa	88.83	16.02	1.61	29.15	8.52	62.63	11.05	3
Field cured alfalfa	91.05	15.59	1.60	31.36	7.74	65.75	11.4	3
Alfalfa*	91.40	14.9	2.3	28.3	8.6	65.60		250

*All analyses taken from Henry and Morrison, Table 1, appendix, page 719. Eighteenth Edition.

The field cured alfalfa hay used in this experiment was slightly lower in fat and higher in crude protein than analyses for alfalfa given by Henry and Morrison (1923). The brown alfalfa hay used in the experiment was lower in true protein than the field cured alfalfa hay used, according to analysis made by the Kansas State Agricultural Experiment Station, as shown in Table II. The quality of the field cured alfalfa hay used in this experiment was good. It had a good color and retained the leaves well.

Records of Milk and Butter-fat Production.

The cows were milked and fed twice daily. A complete record of all milk produced during the experiment was tabulated at each milking. The milk was tested for butter-fat during three consecutive days, at the middle of each period. The total production of butter-fat was calculated for each cow by multiplying the total pounds of milk produced during the period by the average butter-fat percentage. The average butter-fat percentage for the entire group was calculated by dividing the total pounds of milk into the total pounds of butter-fat produced.

TABLE III. FEED CONSUMPTION AND MILK AND BUTTER-FAT PRODUCTION OF COWS USED IN THE EXPERIMENT

Ration	Cow number	Total Feed Fed: Hay	Silage	Grain	Total Production: Milk	Fat
Field Cured Alfalfa Hay Lot I, Period 1	154	240	700	135.5	418.9	14.535
	254	239	652	128.0	736.3	26.506
	337	160	500	110.0	234.4	16.150
	281	207	600	110.0	347.6	13.208
Total		846	2452	481.5	1737.2	70.399
Brown Alfalfa Hay, Lot II, Period 1	161	249½	880	207.0	563.7	19.165
	277	192⅛	640	110.0	312.7	12.820
	276	180	600	147.0	359.7	15.826
	278	130½	502	118.5	347.1	12.044
Total		752¼	2622	582.5	1583.2	59.855
Brown Alfalfa Hay, Lot I, Period 2	154	230	700	140.0	369.1	13.472
	254	260	700	140.0	567.8	21.065
	337	162¾	480	90.0	188.8	13.499
	281	200	600	100.0	290.5	10.922
Total		852¾	2480	470.0	1416.2	58.958
Field Cured Alfalfa Hay, Lot II, Period 2	161	238	800	190.0	254.5	17.675
	277	200	600	90.0	278.1	12.013
	276	190	600	110.0	350.0	13.650
	278	70	500	120.0	351.4	14.899
Total		698	2500	510.0	1504.0	58.237
Average on Stack Browned Alfalfa		802.5	2551.0	526.2	1499.7	59.406
Field Cured Alfalfa		772.0	2476.0	495.7	1620.6	64.318
Difference		-30.5	-75.0	-30.5	-120.9	-4.912

EXPERIMENTAL RESULTS

Milk and Butter-fat Production

The production of milk and butter-fat is shown in Tables III and IV. While on the field cured alfalfa hay ration the two lots produced a total of 3241.2 pounds of milk, and 128.636 pounds of butter-fat. They consumed 2313.82 pounds of total digestible nutrients on the field cured ration as shown in Table V. The same lots on a stack browned alfalfa hay ration produced 2999.4 pounds of milk, and 118.813 pounds of butter-fat. They consumed 2392.61 pounds of total digestible nutrients. This is a difference of 241.8 pounds of milk and 9.823 pounds of butter-fat in favor of the field cured hay.

Each 100 pounds of total digestible nutrients in the field cured alfalfa hay ration produced 140.12 pounds of milk and 5.56 pounds of butter-fat while on the stack browned alfalfa hay for each 100 pounds of total digestible nutrients 125.36 pounds of milk and 4.965 pounds of butter-fat were produced. This is a difference of 14.76 pounds of milk and .595 pounds of butter-fat produced per 100 pounds of total digestible nutrients, in favor of the field cured alfalfa hay as compared with the stack browned alfalfa hay.

TABLE IV. COMPARATIVE SUMMARY

	Field cured alfalfa	Stack browned alfalfa
Total digestible nutrients consumed	2313.22	2392.61
Hay consumed	1544.00	1605.00
Milk produced	3241.20	2999.40
Butter-fat production	128.636	118.813
Per cent butter-fat	3.968	3.962
Grain required to produce 100 pounds of milk	30.59	35.09
Hay required to produce one pound of butter-fat	120.028	135.086
Hay required to produce 100 pounds of milk	47.636	53.510
Hay consumed per 100 pounds body weight	17.619	18.495
Amount of milk produced with 100 pounds of digestible nutrients	140.12	125.36
Amount of butter-fat produced with 100 pounds of total digestible nutrients	5.560	4.965

TABLE V. DIGESTIBLE CRUDE PROTEIN AND TOTAL DIGESTIBLE NUTRIENTS CONSUMED

Period One Field Cured Alfalfa Hay Lot One				Period Two Stack Browned Alfalfa Ration Lot One			
Feed	Total pounds feed	D.C.P.* pounds	T.D.N.' pounds	Feed	Total pounds feed	D.C.P.* pounds	T.D.N.' pounds
Hay	846	93.06	428.07	Hay	752.25	85.00	370.85
Silage	2452	166.73	392.32	Silage	2622	178.29	419.52
Grain	481.5	54.89	359.19	Grain	582.5	66.40	434.54
Total			1179.58				1224.91
Lot Two Stack Browned Alfalfa				**Lot Two Field Cured Alfalfa Hay**			
Hay	852.75	96.36	420.40	Hay	698.0	76.78	353.18
Silage	2480	168.64	396.68	Silage	2500	170.00	400.00
Grain	470	53.58	350.62	Grain	510	58.14	380.46
Total			1167.70				1133.64

Total Digestible Nutrients on Field Cured Alfalfa	2313.22
Total Digestible Nutrients on Stack Browned Alfalfa	2392.61
Difference in Favor of Stack Browned Alfalfa	79.39

*Digestible Crude Protein

'Total Digestible Nutrients

The amount of field cured alfalfa hay required to produce 100 pounds of milk was 47.636 pounds as compared to 53.010 pounds of stack browned alfalfa hay. Lots I and II consumed 120.028 pounds of field cured alfalfa hay for the production of one pound of butter-fat, against a consumption of 136.036 pounds of brown alfalfa hay to produce the one pound of fat.

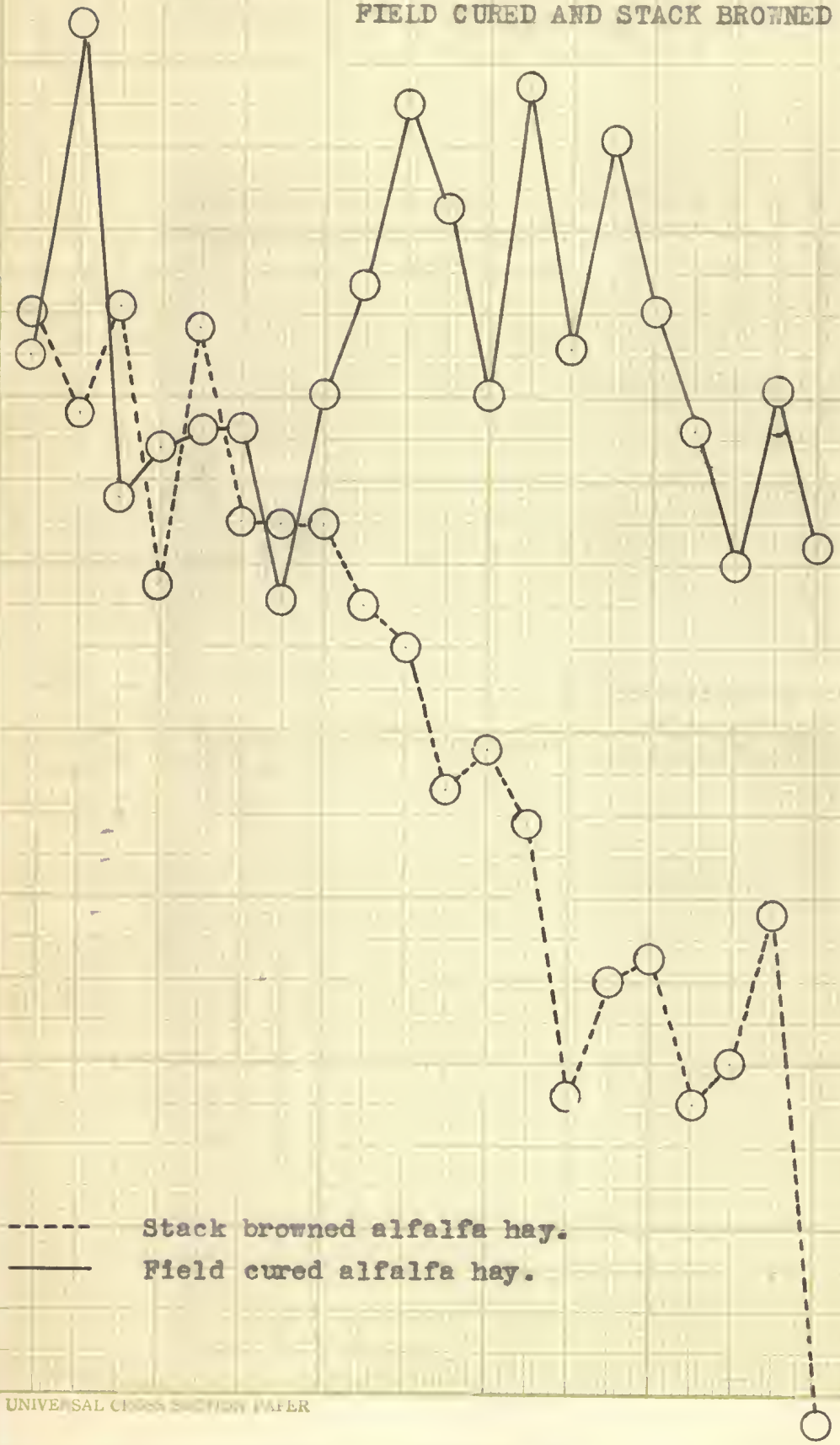
The cows produced 7.46 per cent less milk, and 7.63 per cent less butter-fat on the stack browned alfalfa hay ration than on the ration containing field cured alfalfa hay.

The behavior of the two lots for milk production are shown in Graph I. Graph II indicates the total production of milk for Lots I and II on field cured alfalfa hay and stack browned alfalfa hay. Each graph shows a marked difference in production in favor of the field cured alfalfa hay.

Body Weights

Table VI gives a summary of body weights on field cured alfalfa as compared with stack browned alfalfa. Lot 1 weighed 4429 pounds at the beginning of the experiment and after receiving the field cured alfalfa ration for 30

TABLE VII. GRAPH SHOWING TOTAL MILK PRODUCTION ON FIELD CURED AND STACK BROWNED ALFALFA HAY.



----- Stack browned alfalfa hay.

——— Field cured alfalfa hay.

TABLE VIII. GRAPH SHOWING PRODUCTION OF EACH LOT ON FIELD CURED ALFALFA HAY AND STACK BROWNED ALFALFA HAY.

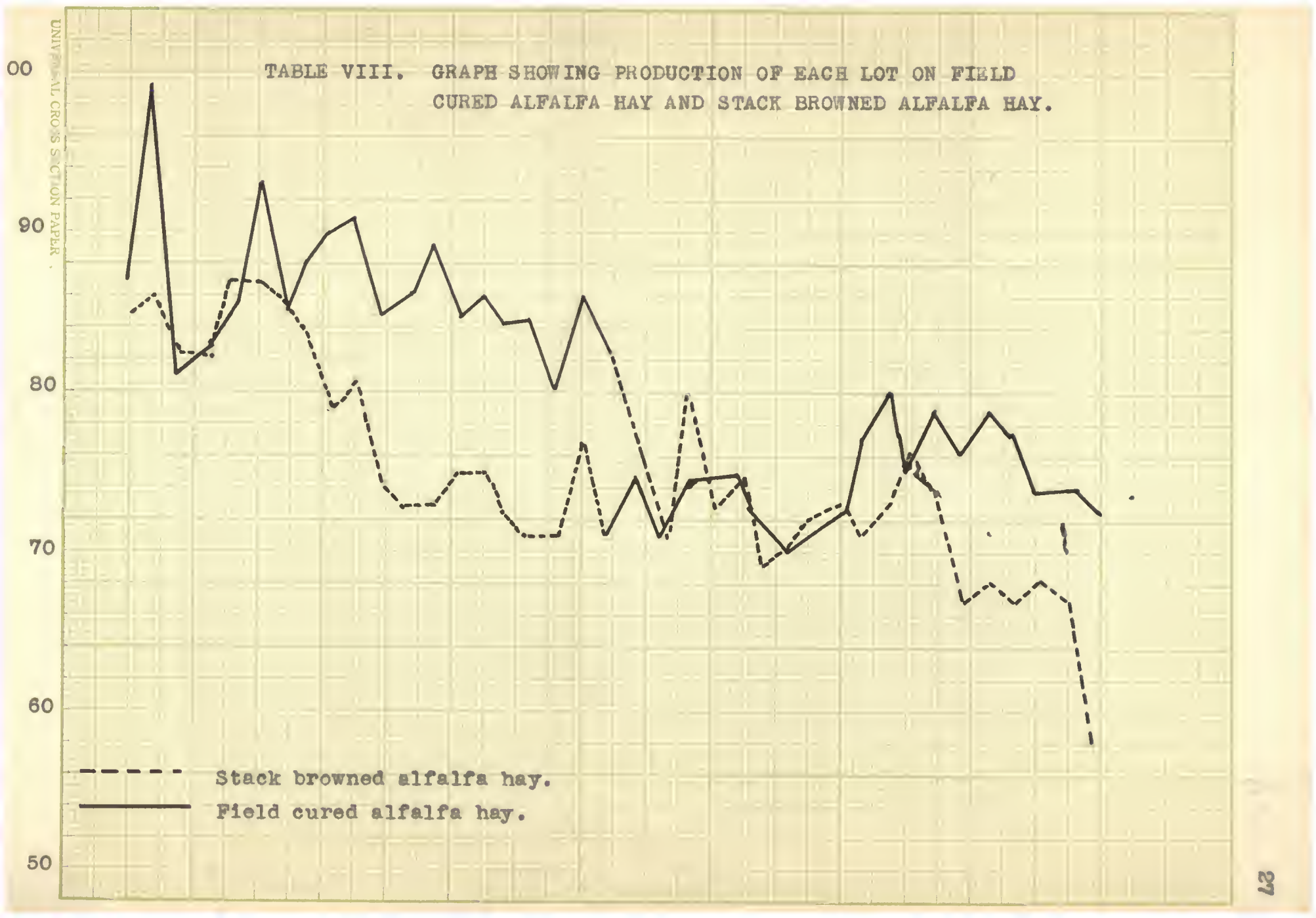


TABLE VI. SUMMARY OF BODY WEIGHTS

Group One Lot No. 1	Field Cured Alfalfa: Beginning Pounds	Field Cured Alfalfa: Termination Pounds	Stack Browned Alfalfa: Beginning Pounds	Stack Browned Alfalfa: Termination Pounds
Cow No. 154	1387	1377	1379	1371
254	1143	1113	1109	1090
337	808	802	806	805
281	1091	1086	1093	1079
Total	4429	4378	4387	4345
Gain or loss	51 loss		42 loss	

Group Two Lot No. 2	Stack Browned Alfalfa: Pounds	Stack Browned Alfalfa: Pounds	Field Cured Alfalfa: Pounds	Field Cured Alfalfa: Pounds
Cow No. 161	1400	1378	1380	1378
277	1014	979	998	1028
276	926	910	929	957
278	1028	989	1016	1034
Total	4368	4256	4323	4397
Gain or loss	112 pounds loss		74 pounds gain	

Total gain on field cured alfalfa - 23 pounds

Total loss on stack browned alfalfa - 154 pounds

days they weighed 4378 pounds which is a loss of 31 pounds. In the second period Lot I was placed on the stack browned alfalfa ration. The weight at the beginning was 4387 and 4345 at the close of the second period. The difference is a loss of 42 pounds.

Lot II during the first period received the stack browned alfalfa hay ration and they weighed 4368 pounds at the beginning and 4256 pounds at the termination of the period. This is a loss of 112 pounds. The same lot during the second period while on field cured hay made a gain of 74 pounds, weighing 4323 pounds at the beginning and 4397 at the close of the period.

It will be noticed from Table VI that all the cows lost weight during the first period. During the second period those that received the field cured alfalfa hay made a gain and those on the stack browned alfalfa hay made a loss. In summing up the gain and loss on the two kinds of hays fed, we find that the groups gained 23 pounds on the field cured alfalfa hay ration and lost 154 pounds on the stack browned alfalfa hay.

Summary of Hay Consumed

Group I and II consumed 1644 pounds of field cured alfalfa hay and 1605 pounds of brown alfalfa hay. They consumed 3.31 per cent more stack browned alfalfa hay and 3.3 per cent more pounds of total digestible nutrients when on the stack browned alfalfa hay ration.

CONCLUSIONS

In this experiment the cows on the field cured alfalfa hay ration produced 7.46 per cent less milk and 7.63 per cent less butter-fat than on stack browned alfalfa hay.

This experiment indicated that when feeding a liberal ration of grain, silage, and alfalfa hay that the substitution of stack browned alfalfa for field cured alfalfa hay does not have any appreciable effect on the per cent of butter-fat.

Stack browned alfalfa hay proved less valuable than the field cured alfalfa hay in maintaining the body weight of the cows, although they consumed 3.81 per cent more of the stack browned alfalfa hay during the experiment.

Stack browned alfalfa hay contains somewhat more crude protein than does the same material when field cured. In true protein, field cured alfalfa is somewhat higher than stack browned alfalfa hay.

In palatability, stack browned alfalfa hay compares favorably with field cured hay.

ACKNOWLEDGMENTS

The writer is deeply indebted to his major instructor Professor J. B. Fitch for his advice and able assistance in preparing this thesis and to Professor H. W. Cave for his helpful instruction in carrying out the feeding test. The writer also wishes to express appreciation to Assistant T. R. Warren for his helpful suggestions and Mr. C. W. Burch who took care of the cows during the experiment.

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