SOY BEAN HAY VERSUS ALFALFA HAY FOR MILK AND BUTTER FAT PRODUCTION

by

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TABLE OF CONTENTS

INTRODUCTION

Alfalfa is one of the most important crops grown in Kansas, the state ranking second in the United States in total acreage used for the growing of this crop. Since 1920, according to Throckmorton and Salmon (1927, p.6), there has been a marked decline in alfalfa production due in part at least to insects, plant diseases and unfavorable seasons. Legume hays are of primary importance in the dairy industry in furnishing cheap roughage of the highest quality. If the supply of alfalfa hay is to be permanently decreased an attempt should be made to find a crop to take its place. The soy bean crop has been increasing in use tremendously in the past 10 years and in many sections of Kansas it might be grown to supplement alfalfa.

Morse (1926, p.671) reports that in 1917, less than 500,000 acres in the United States were devoted to soy beans for all purposes. In 1924, there were 2,500,000 acres, of which 1,000,000 acres were grown for hay, 1,000,000 acres for pasture and silage and more than 500,000 for seed production. About 2,283,000 bushels of seed were produced in 1917, while in 1924 nearly 10,000,000 bushels of seed and 1,360,000 tons of hay were produced.

Soy bean hay has been reported to be equal in feeding value to alfalfa and red clover hay for dairy cows. Soy beans do well on light sandy soils and are noted for their drouth resistance. They are well adapted for use as an emergency crop. If they compare favorably with alfalfa hay in feeding value it is possible that they should be used more extensively in eastern Kansas. This would make a legume hay available on some farms that do not raise legumes at the present time.

With the above thoughts in mind, the experiment presented in this thesis was conducted. It was hoped to obtain some information that would aid in determining the relative feeding value of alfalfa and soy bean hay for milk and butter fat production under Kansas conditions.

Soy Beans in Kansas

The soy bean (Glycine hispida, Glycine max or Soja max) is commonly known as soy pea, soja bean and soya bean. It is a native of China, according to the United States Department of Agriculture Yearbook (1917, pp.101-102), and has been cultivated in China, Japan, Korea and Manchuria for over 5,000 years. It was mentioned in the United States as early as 1804. However, it did not receive much attention, according to Herman (1919, p.1) until 1888, when the variety

now known as the Mammoth Yellow was introduced. Since that time over 1,000 varieties have been introduced.

According to Piper and Morse (1923, p.41) one of the first varieties introduced into the United States was the Ito San in 1889. Prof. C. C. Georgeson, of the Kansas Agricultural Experiment Station, grew some of this variety in 1890, and in subsequent years. The soja bean, grown by Professor Georgeson in 1889 and 1890, was very likely of the Mammoth Yellow variety. The Eda, introduced from Japan, was grown at the Kansas station in 1890.

Laude and Zahnley (1924, p.3) state that soy beans were not entirely successful when first grown in Kansas, chiefly because of poorly adapted varieties and lack of inoculation.

The crop has been grown continuously since its first introduction into Kansas. However, its increased use has been unusually rapid during the past few years due primarily to added information and appreciation of its value as a feed and its value in the rotation system.

Probably the reports of the Kansas State Board of Agriculture (1923-1924, p.502; 1925-1926, pp.534-537; 1928, personal letter) will reveal the most complete information on the value and amount of soy beans grown in Kansas. The results for 1924 are given as the total acreage grown without reference to the proportion grown for hay and grain. These

results indicate that 11,240 acres were grown for all purposes. The total yield was 20,249 tons and had a value of $177,338. The following tabulation, showing the yield of soy beans in Kansas for the years 1925 to 1927, inclusive, was taken from the reports of the State Board of Agriculture for those years.

	1925	1926	1927
Grain:			
Acreage	8,470	7,782	5,404
Bushels produced	89,566	79,451	64,098
Value of crop	$209,807	$156,537	$124,991
Hay:			
Acreage	2,531	3,854	3,332
Tons produced	4,384	6,465	5,799
Value of crop	$35,009	$77,600	$48,711
Per cent acreage increase over preceding year	-----	52.3	13.5
Average acre yield in tons,	1.73	1.70	1.74

The total acreage of soy beans in Kansas in 1926 increased 6 per cent over 1925; while the acreage for soy bean hay increased 52.2 per cent and the acreage for seed decreased 8.1 per cent. In 1927 the total acreage was 24.9 per cent lower, the acreage for hay was 13.5 per cent lower and the acreage for seed was 30.6 per cent lower than in 1926. This shows quite a marked tendency toward the increased use of soy beans for hay during 1926, which increase was not maintained during 1927. However, the acreage for hay in 1927 was 31.6 per cent greater than in 1925. The

average yield for the state during the years 1925 to 1927, inclusive, was 1.72 tons on 3,239 acres.

The production of alfalfa hay as given in the report of the State Board of Agriculture (1925-1926, pp.576-579 and personal letter, 1928) during the same period may be of comparative interest here. The average yield of alfalfa for the state in 1925 to 1927 was 2.44 tons on 906,440 acres. This shows that the acreage used for soy bean hay is relatively small and that the average yield is approximately 0.7 of a ton lower than for alfalfa.

The Variety of Soy Beans for Kansas

Laude and Grandfield (1927) report that A.K. was the largest yielding variety during 1927, and during a six-year period from 1922 to 1927, inclusive, was exceeded only by Peking. For general planting A.K. is to be recommended since it makes high yields of both hay and grain and is a satisfactory variety for pasture.

Quality of Soy Bean Hay

The quality of soy bean hay has much to do with its value as a feed. When the crop is allowed to mature the stems become coarse and woody, making the hay very unpalatable to the cows. The rate of seeding also affects the

fineness of the stems. Hay grown from heavy seeding is to be much preferred over that grown in cultivated rows. Investigations tend to show that hay grown from fields sown at the rate of 60 to 75 pounds per acre and cut at about the time the pods are well formed, but before the seeds have developed very much, makes the best quality of hay.

The amount of hay refused by the animals when fed in ordinary quantities is a measure of its lack of palatability. Several investigators have reported the amount of soy bean hay refused. The amount varies from none to 31.6 per cent depending almost entirely upon the quality of the hay. Cutting increases the per cent of soy bean hay consumed more than it does alfalfa hay. In nearly every case a larger per cent of soy bean hay was refused than of alfalfa. Among the investigators reporting on this subject are: Metzger, Holmes and Bierman (1925, p.93); Morrison, Humphrey and Rupel (1926, pp.130-131); Bechdel (1926, pp.7, 11, 15); Moore and Cowsert (1922, p.7); The Dairy Farmer (Jan. 1, 1926, p.6); and South Carolina Agricultural Experiment Station (1927, pp.57-60).

REVIEW OF OTHER EXPERIMENTS ON SOY BEAN HAY VERSUS ALFALFA HAY FOR MILK AND BUTTER FAT PRODUCTION

Price (1908, pp.35-40) compared alfalfa and soy bean hay for milk production. When on the alfalfa ration the cows, on the average, consumed 21.9 per cent more total digestible nutrients per 100 pounds of milk produced and 33.2 per cent more total digestible nutrients per pound of butter fat produced than when on the soy bean hay ration.

Hunziker and Caldwell (1917, pp.5-6) experimented with cottonseed oil meal, linseed oil meal and gluten feed using soy bean hay and alfalfa hay as the roughage. Careful analysis of the results tends to show that the two hays are about equal in feeding value with possibly a slight advantage in favor of alfalfa hay.

Anthony and Henderson (1923, p.10) conducted two trials in 1919 and 1922, and concluded that the results obtained indicated that good soy bean hay is superior to alfalfa hay as a feed for milk and butter fat production and for the maintenance of body weights of milk cows.

Olson (1925, p.15) reports that soy bean hay is 6 per cent more efficient for milk production and 7.8 per cent more efficient for butter fat production than good-quality alfalfa hay.

Weaver, Shaw and Ely (1926, p.1) state that soy bean hay is 97 per cent as efficient for milk production and 98 per cent as efficient for butter fat production as alfalfa hay.

Eechdel (1926, p.15) concludes that soy bean hay of good quality is slightly superior to alfalfa hay for milk and butter fat production.

Hart and others (1926, pp.130-131) found that soy bean and alfalfa hay produced approximately the same amount of milk and butter fat. However, because of the large quantity of soy bean hay wasted and because of the body weight lost it was concluded that soy bean hay was 73 per cent as efficient as alfalfa hay.

Moore and Cowsert (1926, p.2) state that soy bean hay produced 0.6 per cent less milk and 4.89 per cent more butter fat than did alfalfa hay. The cows lost body weight on soy bean hay and gained somewhat on alfalfa.

Nutritive Value of Soy Beans

Piper and Morse (1923, p.119) state that, "With the possible exception of flax and millet, the soy bean so far as is known at the present time is the only seed containing sufficient amounts of both fat soluble and water soluble vitamins for the promotion of proper growth in rats."

Piper and Morse (1923, p.109) also state that Osborne and Mendel found glycinin, the protein of soy beans, to be a complete protein and was adequate for promoting normal growth of rats. The amino acids, lysine, cystine and tryptophane, which are essential for growth, are absent in corn. Soy beans proved to be an adequate supplement for corn.

A study of the mineral content of alfalfa and soy bean hay (Piper and Morse, 1923, pp.104-105, and Henry and Morrison, 1923, p.722) shows that soy bean hay is considerably higher in phosphoric acid, calcium and magnesium than alfalfa.

This information indicates that soy bean hay has a high nutritive value, being complete in essential vitamins and amino acids and relatively rich in the minerals most likely to be lacking in the dairy cow's ration.

EXPERIMENTAL PLAN

Object of the Experiment

The object of this feeding trial was to determine the relative value of soy bean hay and alfalfa hay for milk and butter fat production under Kansas conditions.

Method of Computing Rations

The rations fed were computed according to the Henry and Morrison feeding standards, using the maximum limit of digestible crude protein and the minimum amount of total digestible nutrients for milk production in order that the largest amount of hay possible could be used. An effort was made to keep the amount of variation from these limits less than 0.1 of a pound of digestible crude protein and less than 0.5 of a pound of total digestible nutrients per cow per day. The nutrient requirements for the first feeding period were determined by using the average milk production for the 10 days previous to the beginning of the experiment, the average butter fat test of the three previous months (except in the case of cow No. 445 when only two tests were available) and the average of the body weights taken during the first three days of the preliminary period. During the second and third periods the average milk production for the last five days of the previous period, the average test of the previous period and the average body weight of the last three days of the previous period were used in determining the nutrient requirements.

The feed necessary to supply these requirements was approximately three-fourths of a pound of hay and three

pounds of silage per 100 pounds of live weight plus one pound of grain for each three pounds of milk produced.

Duration

The experiment was conducted for 90 days, from December 31, 1927, to March 29, 1928, inclusive. The time was divided into three 30-day periods, the first 10 days of each being considered preliminary and not included in the experimental results.

Cows Used

Eight cows, three Holsteins, four Ayrshires and one Guernsey, of the college herd were selected for use in the experiment. They were divided into two groups as evenly as possible. The following factors were considered in making the division: Breed, age, weight, days in lactation, days in gestation, milk produced daily, per cent of butter fat and the coefficient of variability of milk production. The coefficient of variability was computed from the 10 days production previous to the beginning of the experiment. Table I presents a somewhat detailed description of these cows at the beginning of the experiment. It will be noted that the cows were very evenly divided. However, the facts

that cow No. 241 had to be removed because of marked decline in production apparently due to advanced stage of gestation and that No. 152 and No. 152 went down in milk production caused the balance to be displaced somewhat.

Method of Feeding

The cows stood in ordinary stanchions and were fed each morning and evening in regular experimental feeding stalls. All feeds were weighed to each individual and refused material was weighed back and deducted from the total.

Water

The stalls were equipped with individual drinking cups which supplied each cow with an abundance of clean, fresh water.

Housing and Exercise

The cows were housed in the north side of the college dairy barn and on pleasant days were allowed to exercise in a dry lot. The time that they were out was approximately six hours a day for about one-third of the time.

Body Weights of Cows

Weights of the cows were taken between 8 and 9 o'clock a.m., on the first and last three days of each experimental feeding period. The average of the last three weights was taken as the true weight of the individual for that period, the average of the first weights being used for comparative purposes only.

Composition of Feeds

Samples of feed were analyzed in the feed analysis laboratory of the Kansas Agricultural Experiment Station. Composite samples of the hay and grain mixture were made up at the time of grinding and mixing. They were thoroughly mixed and a portion as representative as possible used. The silage samples were taken directly from the silo. The feeds were sampled and analyzed twice each period except during the first period when only one sample of each feed was analyzed. Two extra samples of silage were taken during the second period for moisture and acidity. Table IV shows the average analysis of the samples of feeds for the various periods. Table V gives the coefficients of digestibility used.

Determination of Digestible Nutrients

The digestible matter of any constituent of a feed was determined by multiplying the per cent composition of that constituent by its coefficient of digestibility reported by Henry and Morrison (1923, App., Table II). One variation from the usual method, however, was made. The acidity of the silage was added to the nitrogen free extract in determining the amount of digestible carbohydrates. W. L. Latshaw (unpublished) states that undoubtedly a portion of these acids are digestible and should not be disregarded. Table VI gives the per cent of digestible nutrients in the feeds used in the various periods. The amount of nutrients supplied during any particular period was calculated from the average analysis of the feeds for that period.

Table VII gives the average per cent composition of all feeds used in the experiment.

Feeds Used

Soy bean hay of the A.K. variety was used. It was grown on the college agronomy farm, planted in rows 20 inches apart and was cured under favorable weather conditions. It was raked and turned with a side-delivery rake

until it was cured. The leaves were well retained and the beans were about one-half developed. They made up approximately 20 per cent of the total weight of the hay. The hay was quite high in fiber and low in crude protein, indicating that it was probably too near maturity to be of the highest quality.

The alfalfa hay was also grown on the college agronomy farm. It was cured under favorable conditions, was bright green in color, a little high in crude protein and slightly high in crude fiber. Henry and Morrison's (1923, App., Table I) figures for composition of hays were used for comparison. The grain mixture was composed of four parts of white corn, two parts of wheat bran and one part of linseed oil meal. Sufficient amounts of all feeds were set aside at the beginning to complete the experiment. A supply of cut hay was prepared daily. Kansas Orange Sorgo silage was used. The silage contained approximately 0.1 per cent more digestible crude protein and 7 per cent more total digestible nutrients than average silage as quoted by Henry and Morrison (1923, App., Table III). The acidity of the silage was included with the nitrogen free extract (authority, W. L. Latshaw, unpublished) in determining the carbohydrates. This would account for a small part of the increase in total digestible nutrients. The silage was normal except that a few of the sorgo heads had been removed before ensiling.

Rations Fed

Group I, consisting of three cows, received soy bean hay during the first and third periods and alfalfa hay during the second period supplemented in each case by the basal ration of sorgo silage and the grain mixture. Group II, consisting of four cows, was managed in the same way except that alfalfa hay was fed during the first and third periods and soy bean hay during the second period.

EXPERIMENTAL RESULTS

Feed Consumed

Table IX shows that Group I consumed an average of 1,974 pounds of silage, 405 pounds of grain and 590.8 pounds of soy bean hay during Periods I and III. This feed contained 113.97 pounds of digestible crude protein and 1,004.97 pounds of total digestible nutrients. During Period II they consumed 2,080 pounds of silage, 394 pounds of grain and 688 pounds of alfalfa hay which furnished 144.9 pounds of digestible crude protein and 1,086.29 pounds of total digestible nutrients. This shows that on alfalfa the group consumed 30.93 pounds more digestible

crude protein and 81.32 pounds more digestible nutrients than the average of that consumed during the soy bean periods.

Similarly, Group II consumed an average of 2,937.5 pounds of silage, 477 pounds of grain and 800 pounds of alfalfa hay during Periods I and III. This feed contained 156.73 pounds of digestible crude protein and 1,330.03 pounds of total digestible nutrients. During Period II they consumed 2,887.5 pounds of silage, 416 pounds of grain and 709 pounds of soy bean hay containing 127.51 pounds of digestible crude protein and 1,289.49 pounds of total digestible nutrients. This shows that the group when on alfalfa consumed on the average 29.22 pounds of digestible crude protein and 40.54 pounds of total digestible nutrients more than when on the soy bean hay ration.

Body Weights of Cows

The average total weight of Group I on soy bean hay was 3,683 pounds. Their weight on alfalfa hay was 3,712 pounds or a difference of 29 pounds for the group in favor of alfalfa hay.

The average weight of Group II on alfalfa hay was 5,037 pounds. Their weight on soy bean hay was 4,903 or a difference of 134 pounds for the group in favor of alfalfa.

Both groups tended to gain in body weight more rapidly on alfalfa hay than on soy bean hay. Group II actually lost weight when fed the soy bean ration.

Milk and Butter Fat Produced

Group I, as shown in Table IX, produced an average of 991.6 pounds of milk and 43.137 pounds of butter fat during Periods I and III. During Period II on alfalfa hay they produced 1,035.5 pounds of milk and 43.337 pounds of butter fat, making a difference of 43.9 pounds of milk and 0.199 of a pound of butter fat in favor of alfalfa hay. Figure 1 shows these results graphically. While on soy bean hay the average test of the milk of Group I was 4.35 per cent while on alfalfa it was 4.19 per cent. Similarly, Group II produced an average of 1,136.8 pounds of milk and 47.188 pounds of butter fat during Periods I and III. During Period II on soy bean hay they produced 1,017.6 pounds of milk and 46.486 pounds of butter fat, making a difference of 119.2 pounds of milk and 0.703 of a pound of butter fat in favor of alfalfa hay. These results are also shown graphically in figure 1. While on soy bean hay the average test of the milk of Group II was 4.57 per cent while on alfalfa it was 4.15 per cent. Table VIII contains a summary of the milk and butter fat production and the body weights of the individual cows.

Nutrients Consumed per Unit Production

Due to the wide variation in composition of the feedingstuffs it seemed advisable to compute the nutrients consumed per unit of milk and butter fat produced. Table X shows the results of this comparison. It will be noticed that Group I when on soy bean hay required only 82.1 per cent as much digestible crude protein and 96.6 per cent as much total digestible nutrients to produce 100 pounds of milk as when on alfalfa. In producing one pound of butter fat the cows on soy bean hay required only 79 per cent as much digestible crude protein and 92.9 per cent as much total digestible nutrients as when fed alfalfa hay.

Group II when on soy bean hay required 93.3 per cent as much digestible crude protein and 108.3 per cent as much total digestible nutrients to produce 100 pounds of milk as when fed alfalfa hay. On soy bean hay they required 82.6 per cent as much digestible crude protein and 98.4 per cent as much total digestible nutrients per pound of butter fat produced as when on alfalfa hay.

After encountering the conflicting results of Tables IX and X an attempt should be made to find a solution. Recalling the analysis of the soy bean hay it will be remembered that the protein content was approximately 3 per

cent below the figure used in computing the rations. As a result, the lots fed soy bean hay actually received 20 to 25 pounds less digestible crude protein than was intended when the rations were calculated. Because of this difference in amount of protein supplied, results such as those above might be expected. For two reasons these figures on nutrients supplied are more useful in determining the relative feeding value of the two hays than the figures on direct production; first, the nutrients supplied are expressed in two common units instead of three as is the case when feeds are used directly; and second, feeds are not of uniform composition and ultimately it is the pounds of nutrients supplied rather than the pounds of feed supplied that determines the feeding value.

Per Cent of Butter Fat in Milk

From the total pounds of milk and butter fat produced the true average butter fat test of the milk was calculated. It was found that the average butter fat test on soy bean hay was 4.424 per cent and the average butter fat test on alfalfa was 4.161 per cent, making a difference of 0.263 per cent in favor of soy bean hay. These results are in harmony with other investigations. They indicate that soy bean hay tends, for a short period of time at least, to increase the per cent of butter fat in milk.

EXPERIMENTAL NOTES

For the most part, the experiment progressed very nicely, but a few things seem to be worthy of note. During the early days of the experiment one cow, No. 445, developed the habit of playing with her drinking cup and allowing it to overflow. When her feed became wet she would not eat it. Consequently, the cup had to be removed, returning it for only short times during the day.

On January 29, cow No. 152 began to refuse some of her feed. She was given very little feed for a few days and on February 7, she was eating heartily again. However, her milk flow did not return to the point where it was before she went off feed.

On February 3, cow No. 152 injured one leg. She did not eat well for the next few days and her milk flow diminished rapidly until February 7, when it started to increase. During the experimental period proper she maintained a very consistent level of production.

The alfalfa and the soy bean hay fed in the experiment was cut. Both kinds of hay were eaten with practically no waste. However, due to the coarseness of the soy bean hay, it was thought advisable to determine the per cent of the two hays the cows would eat if fed uncut. Therefore, a 10-

day feeding period was conducted immediately following the third period. All conditions were kept the same except that the hay was fed uncut. The cows fed alfalfa ate all of the hay given them. The cows fed 270 pounds of soy bean hay refused 95 pounds or 35.2 per cent. However, this figure probably is not exact because there is little doubt that a portion of the weigh-back was saliva or water slopped from the drinking fountains. One day 10 pounds of hay was weighed back from a cow that had been fed only nine pounds.

CONCLUSIONS

1. From the data at hand soy bean hay of good quality probably is equal to or slightly better than alfalfa hay for milk and butter fat production.

2. Considered on a digestible nutrient basis, in all but one case less nutrients were required per unit of product when soy bean hay was fed.

3. When total production is considered the alfalfa hay used in this experiment produced 2.6 per cent more milk and 0.3 per cent more butter fat than did the soy bean hay. However, this difference is so small that it is of relatively little significance.

4. Soy bean hay was less valuable than alfalfa hay in maintaining the body weights of the cows. This was possibly due, in part, to the fact that they received less nutrients when fed soy bean hay.

5. Soy bean hay appears to slightly increase the per cent of butter fat in the milk over a short period of time, but the increase is accompanied by a corresponding decrease in milk production.

6. The soy bean hay used in this experiment was relatively coarse and apparently unpalatable. It was of less than average nutrient quality as shown by the chemical analysis.

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Table I.-- Descriptive Summary of Cows Used

Cow No.	Breed	Age		Weight	Days in lactation	Days in gestation	Pounds milk	Per cent of fat	Coefficient of variation	
		Yrs.	Mos.	Pounds						
Group I										
151	Holstein	5	9	1,365	150	45	30.63	3.5	11.8	2.85
270	Ayrshire	3	9	1,196	138	49	17.22	4.1	2.25	0.54
241	Ayrshire	8	4	1,228	234	161	23.59	4.5	7.44	1.54
445	Guernsey	6	3	1,156	60	Open	20.54	4.3	1.75	0.42
Average		6	0	1,236	145	64	22.99	---	5.21	1.25
Group II										
152	Holstein	5	3	1,598	225	46	22.41	4.8	9.83	2.36
132	Holstein	8	6	1,247	198	50	27.66	3.5	6.67	1.59
275	Ayrshire	4	0	1,070	303	35	17.85	4.0	1.64	0.39
272	Ayrshire	3	8	1,045	109	47	20.58	3.8	8.19	2.98
Average		5	4	1,240	209	44	22.12	---	4.03	0.96

Table II.-- Summary of Weights of Cows

Cow No.	Period I (Soy bean)		Period II (Alfalfa)		Period III (Soy bean)	
	Weight at beginning	Weight at end	Weight at beginning	Weight at end	Weight at beginning	Weight at end
Group I	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
151	1,355	1,364	1,372	1,383	1,370	1,367
270	1,184	1,206	1,208	1,210	1,202	1,203
445	1,128	1,106	1,121	1,119	1,127	1,120
Total. .	3,667	3,676	3,701	3,712	3,699	3,690
Group II	(Alfalfa)		(Soy bean)		(Alfalfa)	
152	1,612	1,628	1,542	1,523	1,549	1,557
132	1,245	1,248	1,190	1,183	1,202	1,211
275	1,086	1,105	1,119	1,105	1,108	1,114
272	1,069	1,086	1,097	1,092	1,107	1,126
Total. .	5,012	5,067	4,948	4,903	4,966	5,008

Table III.-- Summary of Feeds and Digestible Nutrients Consumed.

Feed	Feed Pounds	DCP* Pounds	TDN** Pounds	Feed	Feed Pounds	DCP Pounds	TDN Pounds
	Group I				Group II		
Period I							
Silage	1828.0	11.33	367.42	Silage	2900.0	17.98	582.9
Grain	470.0	56.40	345.45	Grain	580.0	69.60	426.3
Hay (soy)	607.0	54.50	314.00	Hay (alf.)	920.0	89.24	430.6
Total.	---	122.23	1027.67	Total.	---	176.82	1439.8
Period II							
Silage	2080.0	14.97	433.05	Silage	2887.5	20.79	601.2
Grain	394.0	46.01	289.98	Grain	416.0	48.59	306.2
Hay (alf.)	688.0	83.93	363.26	Hay (soy)	709.0	58.13	382.2
Total.	---	144.91	1086.29	Total.	---	127.51	1289.6
Period III							
Silage	2120.0	15.05	421.88	Silage	2975.0	21.12	592.0
Grain	340.0	40.12	247.86	Grain	374.0	44.13	272.6
Hay (soy)	574.5	50.55	312.53	Hay (alf.)	680.0	71.40	355.6
Total.	---	105.72	982.27	Total.	---	136.65	1220.2

*DCP - Digestible Crude Protein.
**TDN - Total Digestible Nutrients.

Table IV.-- Average Per cent Composition of Feeds

Feed	Moisture	Acidity	Ash	Crude Protein	Fiber	NFE*	Fat
Period I							
Grain mixture	10.50	---	5.28	15.50	5.46	58.81	4.45
Silage (sorgo)	69.64	2.76	1.73	1.21	8.36	15.82	0.48
Soy bean hay	14.01	---	6.64	11.89	29.33	35.16	2.96
Alfalfa hay	15.99	---	7.52	13.72	28.75	32.35	1.67
Period II							
Grain mixture	11.25	---	4.66	15.12	4.90	59.55	4.50
Silage (sorgo)	69.59	2.66	1.69	1.41	7.94	16.41	0.75
Soy bean hay	8.64	---	6.84	11.19	33.49	36.97	2.88
Alfalfa hay	8.22	---	7.57	17.16	27.69	37.18	2.18
Period III							
Grain mixture	11.24	---	5.17	15.32	4.90	59.06	4.33
Silage (sorgo)	70.23	2.98	1.66	1.39	7.38	15.87	0.52
Soy bean hay	7.94	---	6.78	12.03	33.53	36.83	2.90
Alfalfa hay	7.33	---	7.95	14.86	30.39	37.29	2.21

*NFE - Nitrogen Free Extract.

Table V.-- Average Per cent Digestibility of Feeds Used

Feed	Dry Matter	Crude protein	Carbohydrates: Fiber	Carbohydrates: NFE**	Fat
Grain mixture*	81.3	77.3	49.6	85.4	85.3
Silage (sorgo)	66.0	51.0	65.0	71.0	82.0
Soy bean hay	60.0	73.0	57.0	64.0	44.0
Alfalfa hay	60.0	71.0	43.0	72.0	38.0

**NFE - Nitrogen Free Extract.

*Calculated by taking four times the coefficient of digestibility of corn plus two times the coefficient of digestibility of bran plus the coefficient of digestibility of linseed oil meal divided by seven. (Taken from Henry and Morrison, 1923, Appendix II.)

Table VI.-- Summary of Per cent Digestible Nutrients in Feeds.

Feed	Total dry matter	Crude protein	Carbohydrates	Fat	Total
Period I					
Grain mixture	89.50	12.00	52.9	3.80	73.50
Silage	27.60	0.62	18.6	0.39	20.10
Soy bean hay	86.00	8.70	39.2	1.30	50.82
Alfalfa hay	84.00	9.70	35.7	0.63	46.80
Period II					
Grain mixture	88.75	11.68	53.3	3.84	73.60
Silage (sorgo)	27.75	0.72	18.7	0.62	20.82
Soy bean hay	91.36	8.20	42.8	1.27	53.90
Alfalfa hay	91.78	12.20	38.7	0.83	52.80
Period III					
Grain mixture	88.76	11.80	52.8	3.70	72.9
Silage(sorgo)	26.79	0.71	18.2	0.43	19.9
Soy bean hay	92.06	8.80	42.7	1.28	54.4
Alfalfa hay	92.67	10.50	39.9	0.84	52.3

Table VII.-- Average Per cent Digestible Nutrients in Feeds Used.

Feed	Total dry matter	Crude protein	Carbohydrates	Fat	Total
Grain mixture	89.00	11.0	53.0	3.80	73.3
Silage(sorgo)	27.37	0.7	18.5	0.50	20.3
Soy bean hay	89.71	8.5	42.1	1.28	53.6
Alfalfa hay	89.49	11.0	38.6	0.80	51.4

Table VIII.-- Summary of Weights and Production of Individual Cows

Cow No.	Period I (Soy bean) Milk	Fat	Body weight	Period II (Alfalfa) Milk	Fat	Body weight	Period III (Soy bean) Milk	Fat	Body weight
Group I	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
151	509.5	19.768	1,364	483.4	17.692	1,383	411.2	16.365	1,367
270	293.4	12.880	1,206	268.1	11.984	1,210	229.0	11.289	1,203
445	323.8	14.312	1,106	284.0	13.660	1,119	216.3	11.658	1,120
Total .	1126.7	46.960	3,676	1035.5	43.336	3,712	856.5	39.312	3,690
Group II									
	(Alfalfa)			(Soy bean)			(Alfalfa)		
152	316.9	12.929	1,628	252.0	13.860	1 523	255.6	12.856	1,557
132	414.8	13.895	1,248	294.8	10.435	1,183	214.2	7.625	1,211
275	295.6	13.597	1,105	241.4	13.059	1,105	246.8	13.179	1,114
272	316.5	11.615	1,086	229.4	9.130	1,092	213.2	8.677	1,126
Total .	1343.8	52.037	5,067	1017.6	46.484	4,903	929.8	42.337	5,008

Table IX.-- Summary of Feeds, Digestible Nutrients, Production, and Body Weights.

	Silage	Grain	Hay	Digestible crude protein	Total digestible nutrients	Milk	Fat	Fat	Body Weight
Group I									
	Pounds	Pounds	Pounds			Pounds	Pounds	Per cent	Pounds
Av. Periods I and III (soy bean)	1974.0	405	590.8	113.97	1004.97	991.6	43.137	4.35	3683
Period II (alfalfa)	2080.0	394	668.0	144.90	1086.29	1035.5	43.336	4.19	3712
Difference	106.0	11	97.2	30.93	81.32	43.9	0.199	0.16	29
Group II									
Av. Periods I and III (alfalfa)	2937.5	477	800.0	156.73	1330.03	1156.8	47.138	4.15	5037
Period II (soy bean)	2887.5	416	709.0	127.51	1289.49	1017.6	46.486	4.57	4903
Difference	50.0	61	91.0	29.22	40.54	119.2	0.703	0.42	134

Table X.-- Pounds of Nutrients Required to Produce 100 Pounds of Milk and a Pound of Butter Fat.

	Alfalfa hay	Soy bean hay	Per cent efficiency of alfalfa
Group I			
Protein per 100 pounds milk...	14.00	11.60	82.10
Total digestible nutrients per 100 pounds milk.....	104.90	101.30	96.60
Protein per pound butter fat..	3.34	2.64	79.00
Total digestible nutrients per pound butter fat.....	25.07	23.29	92.90
Group II			
Protein per 100 pounds milk...	13.60	12.60	93.30
Total digestible nutrients per 100 pounds milk.....	117.00	126.70	108.30
Protein per pound butter fat..	3.32	2.74	82.60
Total digestible nutrients per pound butter fat.....	28.18	27.74	98.40

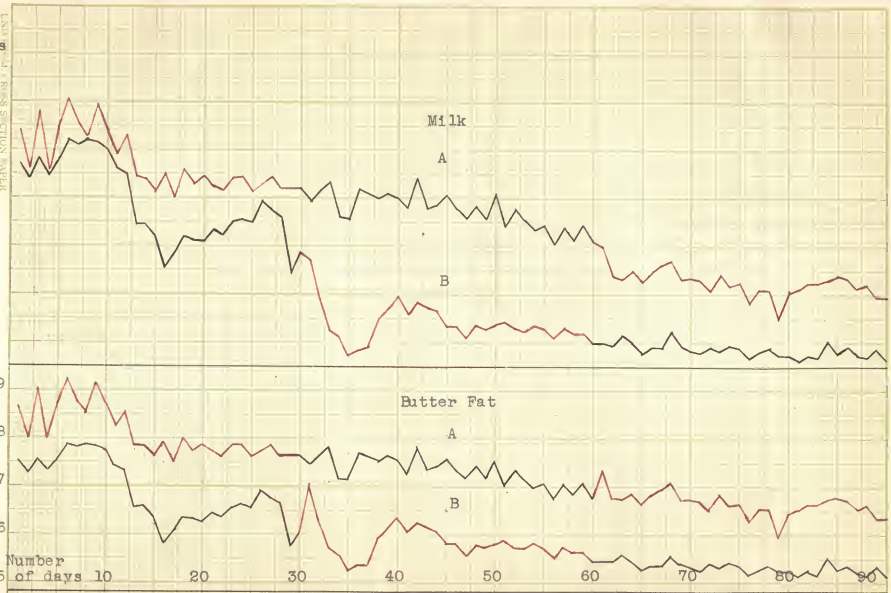

Fig. 1.-- Graph showing milk and butter fat produced daily

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