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An Experimental Comparison of the Feeding Value of Soy Bean with Alfalfa Hay for Feeding Dairy Cows

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AN EXPERIMENTAL COMPARISON OF THE FEEDING VALUE OF SOY BEAN WITH ALFALFA HAY FOR FEEDING DAIRY COWS

by

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Introduction

The tendency during the last few years has been to use more and more of the legumes for feeding dairy cows. Just a few years ago (1) "Dairymen near the Yakima Valley, Washington state, fed their cows nothing but alfalfa hay during the winter. The cows received 40 to 50 pounds of alfalfa per cow per day and produced from 6,000 to 7,000 pounds of milk per year. A Guernsey cow gave 20 pounds of milk per day, four and one-half months after calving, and had received no feed but alfalfa hay for two months previous to that time. The Todd herd of Holsteins, said by many to be the best producing herd in the state of Washington, is fed on corn silage and 25 to 30 pounds of alfalfa hay per cow per day. Mr. Price, formerly dairy specialist for Washington State Agricultural College, and who is familiar with dairy conditions, said that cows had produced as high as 10,000 pounds of milk in a year on alfalfa hay alone."

Although alfalfa is used more widely than any other of the legumes as dry roughage for feeding dairy cows, soy bean hay is rapidly coming to the front in the southeastern and central states. This increase in the use of soy bean hay seems to be a natural and healthy condition, for legume hays are our cheapest sources of protein for winter feeding.

Furthermore, soy bean hay is better adapted to those sections of the country where it is more difficult to grow the maximum yields of alfalfa hay.

The average percentage composition of American feeding stuffs, table (2) shows soy bean hay to be 1.1 percent higher in protein, 3.3 percent lower in crude fibre, 2.2 percent higher in nitrogen-free extract, and 0.5 percent higher in fat than alfalfa. The table for digestible nutrients shows soy bean hay to have 1.1 pounds more crude digestible protein, 0.2 of a pound more carbohydrates, 0.3 of a pound more fat and 2 pounds more total digestible nutrients per hundred pounds than does alfalfa hay.

It is probable therefore, that soy bean hay may prove to be a desirable and profitable legume hay for feeding dairy cows. With this probability in mind, the experiment discussed in this thesis was planned, carried out, and the data tabulated for use in determining the feeding value of soy bean hay as a legume roughage for dairy cows.

Resume of Previous Experimental Work

In two experiments at the West Virginia station (4) soy bean hay was compared with alfalfa hay for milk production. In each experiment 2 lots of 5 cows each were fed by the double reversal method for three week periods with preliminary periods of one week each when the ration changes were made. A basal ration consisting of 30 pounds of silage to each 1,000 pounds of live weight was fed throughout the experiments and a grain mixture was fed at the rate of 1 pound of grain for each 3.5 pounds of milk produced. In addition, 10 pounds of alfalfa or soy bean hay were fed each animal daily. In each trial the cattle designated as lot 1 were fed alfalfa hay in the first period and soy bean hay in the second period, whereas lot 2 was fed soy bean hay in the first period and alfalfa hay in the second.

In the first experiment lot 1 produced 2,685 pounds of milk and 102 pounds of butterfat on the alfalfa ration and 2,696 pounds of milk and 104 pounds of butterfat when soy bean hay was fed. Lot 2 produced 3,015 pounds of milk and 106 pounds of butterfat when soy bean hay was fed and 2,888 pounds of milk and 106 pounds of butterfat during the alfalfa hay period.

Lot 1 gained an average of 12 pounds in live weight on alfalfa hay and 85 pounds on soy bean hay, whereas lot 2 lost 95 pounds on soy bean and 17 pounds on alfalfa hay.

In the second experiment, during the first period lot 1 produced 2,900 pounds of milk and 102 pounds of fat whereas lot 2 produced 3,302 pounds of milk and 116 pounds of fat. In the second feeding period lot 1 produced 2,803 pounds of milk and 99 pounds of fat, whereas lot 2 produced 3,179 pounds of milk and 110 pounds of fat. Lot 1 lost 57 pounds in live weight during the alfalfa period, but gained 115 pounds during the soy bean period, whereas lot 2 gained 45 pounds during the soy bean period and 40 pounds during the alfalfa period.

The combined results of the two experiments indicate that soy bean hay is slightly superior to alfalfa hay for milk and fat production and maintenance of weight. The milk production was 64 pounds greater and the fat production 5 pounds greater for all animals in all trials while soy bean hay was fed. The net gain in live weight for all cows in all trials while fed soy bean hay was 150 pounds, while the total net loss in live weight for all cows in all trials while fed alfalfa hay was 22 pounds.

In 1908, at the Ohio station (5), two lots of five and six cows, producing approximately the same amount of milk were fed during a 31-day preliminary period, a 60-day experimental period, and a subsequent 30-day period as follows: Lot 1, corn silage, soy bean hay, and a grain mixture of corn meal and cotton-seed meal in the ratio of 6:1; lot 2, corn silage, corn stover, and a grain mixture of corn meal, wheat bran, and cotton-seed meal in equal parts.

Lot 2 gave slightly more milk and fat daily per cow than lot 1, but this difference did not change with the change of ration indicating that the two rations were practically equal in feeding value so far as milk and fat production were concerned. The gain in live weight in both lots was practically the same. A comparison of the amount of dry matter consumed per unit of product, milk or milk fat indicates that the difference is very small.

The average daily cost of feed for lot 1 was 15.5 cents per cow; the average cost per pound of milk produced, 0.86 of one cent, and per pound of fat produced, 17.9 cents. The average daily value of the product was 25 cents per cow. For lot 2 the average costs were 16.4, 0.86 of one cent, and 18.5 cents respectively, and the value of product, 25.6 cents per cow.

In 1909 a similar test to the above was conducted and in general confirmed the results obtained in the first test. It appears that 5 percent more dry matter was required to produce a unit of product with the grain ration than with the soy bean ration, but the difference is small and indicates that the two rations were practically equally efficient. These tests indicate that a large share of the protein can be supplied in soy bean hay instead of concentrates with equal efficiency.

Two lots of six cows each were fed during a 28-day preliminary period, a 56-day experimental period, and a 28-day subsequent period as follows: Lot 1, corn meal,

corn silage, and alfalfa hay; lot 2, corn meal, wheat bran, cotton-seed meal, corn silage and corn stover. The nutritive ratio of the two rations was practically the same. Lot 1 consumed less protein and more crude fibre than lot 2. Lot 1 produced slightly more milk than lot 2, but slightly less butterfat. The difference in fat was thought to be due to the difference in the origin l percentage of milk fat between the two lots of cows. The difference remained quite constant throughout the three periods, indicating that the two rations were practically equal in efficiency.

Lot 1 made an average gain in weight per cow of 36.5 pounds and lot 2 of 1 pound. Every cow gained in live weight on the alfalfa ration while three cows gained and three lost on the other ration. Lot 1 consumed 16.6 percent more dry matter per 100 pounds of milk and 19.3 percent more per pound of fat. It was thought that more carbohydrates and fat were given than were required for milk production.

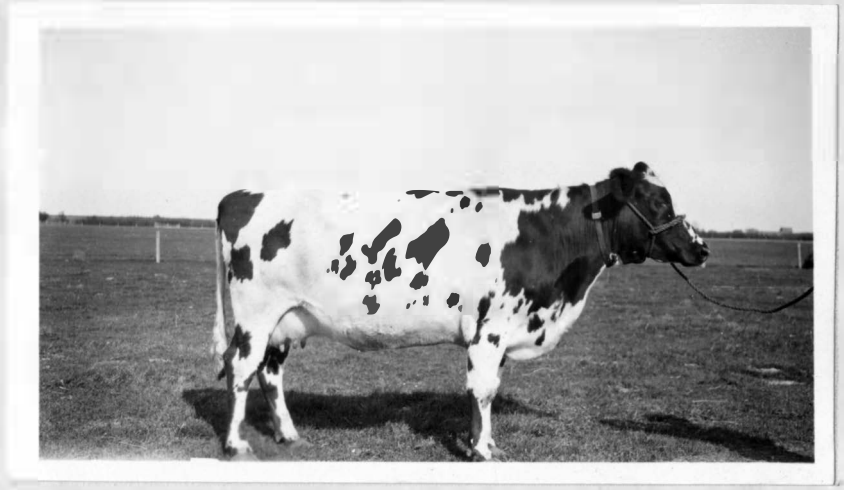
The average daily cost of feed for lot 1 was 16 cents, the cost to produce 1 pound of milk, 0.81 of one cent, and 1 pound of milk fat, 18 cents. For lot 2, the costs were 17, 0.85 of one cent and 19 cents, respectively. From this test it is seen that alfalfa as well as soy bean hay can replace most of the high-priced protein concentrates.

Plan of Experiment

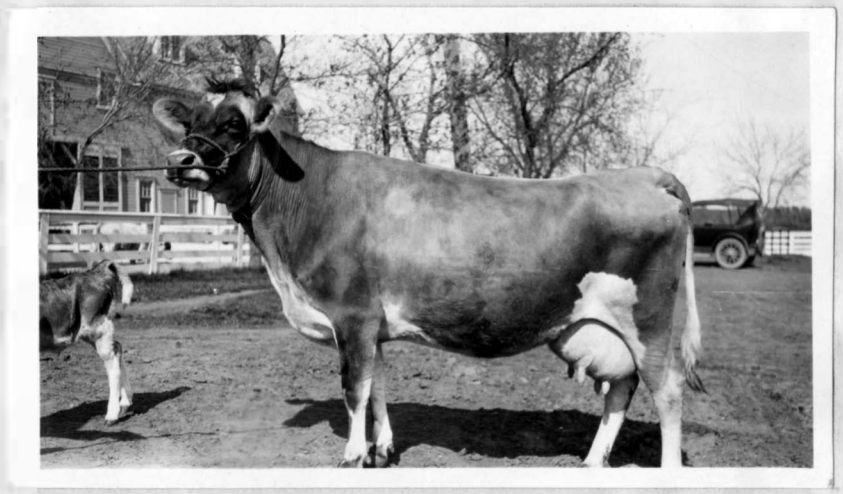
The purpose of this experiment was to collect data for comparing soy bean hay with alfalfa hay as a protein roughage for milk and fat production with dairy cows.

In order to minimize the effects of the abrupt change from pasture to barn feeding, the cows were taken off pasture October 1, 1923. The experiment, beginning October ninth and ending February 6, 1924, was divided into three periods of forty days. Each forty-day period was divided into ten-day subperiods, the first of which in each forty-day period was considered only as a transition period. Alflafa hay was fed during the first and third forty-day periods so the data for these two periods might be averaged for comparison with the second forty-day or soy bean period data, thus eliminating the possibility of error due to the stage of lactation.

The animals used in the trials were all purebred cows of Jersey, Ayrshire, Guernsey, and Holstein breeds. In the discussion of this experiment the cows will be referred to by their herd numbers which correspond to the names as given on the next page.

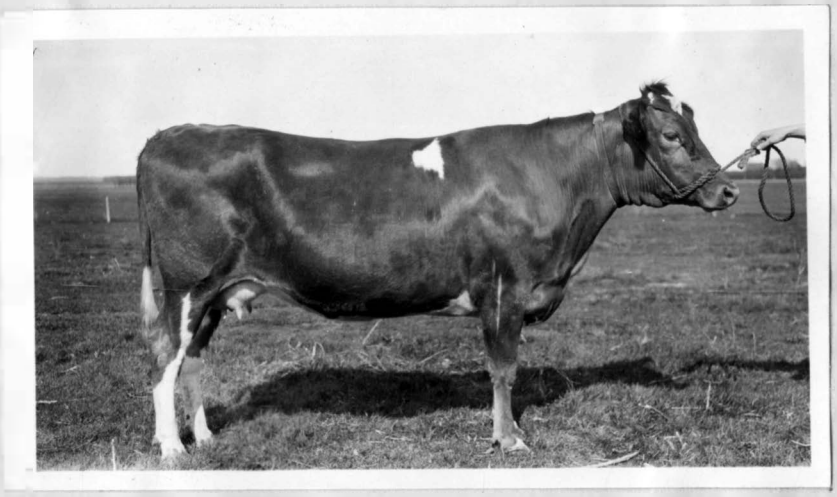


Number 209 - Bessie of Radnor 2nd



Number 82 - College Fern Belle

Number 306 - College Ormsby Belle Wayne



Number 258 - Lady Blanche of Dassel

Number 82 - Jersey - College Fern Belle.

Number 209 - Ayrshire - Bessie of Radnor 2nd.

Number 258 - Guernsey - Lady Blanche of Dassel.

Number 306 - Holstein - College Ormsby Belle Wayne.

Table of Information Concerning the Cows

Number	82	209	258	306
Breed	Jersey	Ayrshire	Guernsey	Holstein
Age, trial began. yr-mo-days	4-9-24	2-6-5	2-8-24	2-9-26
Days fresh trial began	211	78	139	83
Lactation period	2nd	1st	1st	1st
Record: Fat	432.5			
Milk	7299.2	0	0	0
Fat%	5.88			
Days bred, trial close	193	0	0	0

Number 82.

This Jersey cow was close to five years of age when the experiment began. She was a mature cow weighing close to 930 pounds, with a keen appetite and ate as much roughage as the Holstein 306 which was nearly 200 pounds heavier. As would be expected with such a large feed consumption, cow number 82 produced very consistently during the trial, dropping only about six pounds in daily production of milk from the 25.5 pounds production with which she started when 211 days along in her lactation period.

This cow was in good condition and ate very well except for three days in the middle of the last forty-day period when she was off feed for some reason or other, and decreased in milk production for a period of five days.

Number 209.

The Ayrshire cow was easy to keep in condition. She was about two and one-half years of age and 78 days along in her first lactation period when the experiment began. She weighed 1,086 pounds when the trial began; ate less feed than the Jersey but produced consistently during the experiment losing only about 3 pounds on her daily milk production during the trial. She was thrifty and in good condition throughout the experiment.

Number 258.

This Guernsey was past two and one-half years old, 139 days along in her first lactation period, and weighed 1065 pounds when the trial began. She went off feed very easily causing her milk production to be low. With careful feeding she finished the trial without going off feed and increased her daily production from fifteen pounds of milk at the beginning of the trial to nineteen pounds for the first ten days of the last forty-day, or the second alfalfa period.

Number 306.

The Holstein weighed 1211 pounds, was nearly three

years old, in her first lactation period, and not bred when the trial began. She had been milking only 83 days when the experiment began and was not bred during the entire trial. Her barrel was rather small and she ate only a fair ration for a cow of her size, being thin the entire time while on experiment. It was necessary to cut her ration somewhat during the second forty-day or the soy bean period. Her daily milk production decreased from 29.5 pounds at the beginning of the experiment to 26 pounds at the end.

Feeds.

The grain used consisted of ground corn, ground oats, and linseed oil meal. The succulent and dry roughages were supplied as corn silage and as hay, respectively.

The oil meal, corn, and oats which were of fair quality, were purchased at the local Farmers' Cooperative Elevator. The corn, as local corn runs, was consistently from one to nearly two percent lower in ether extract than that given for average (6) dent corn.

The silage which was grown on the college farm, was good in quality but somewhat low in moisture content as the corn was fairly well matured when ensiled.

Discussion of Results

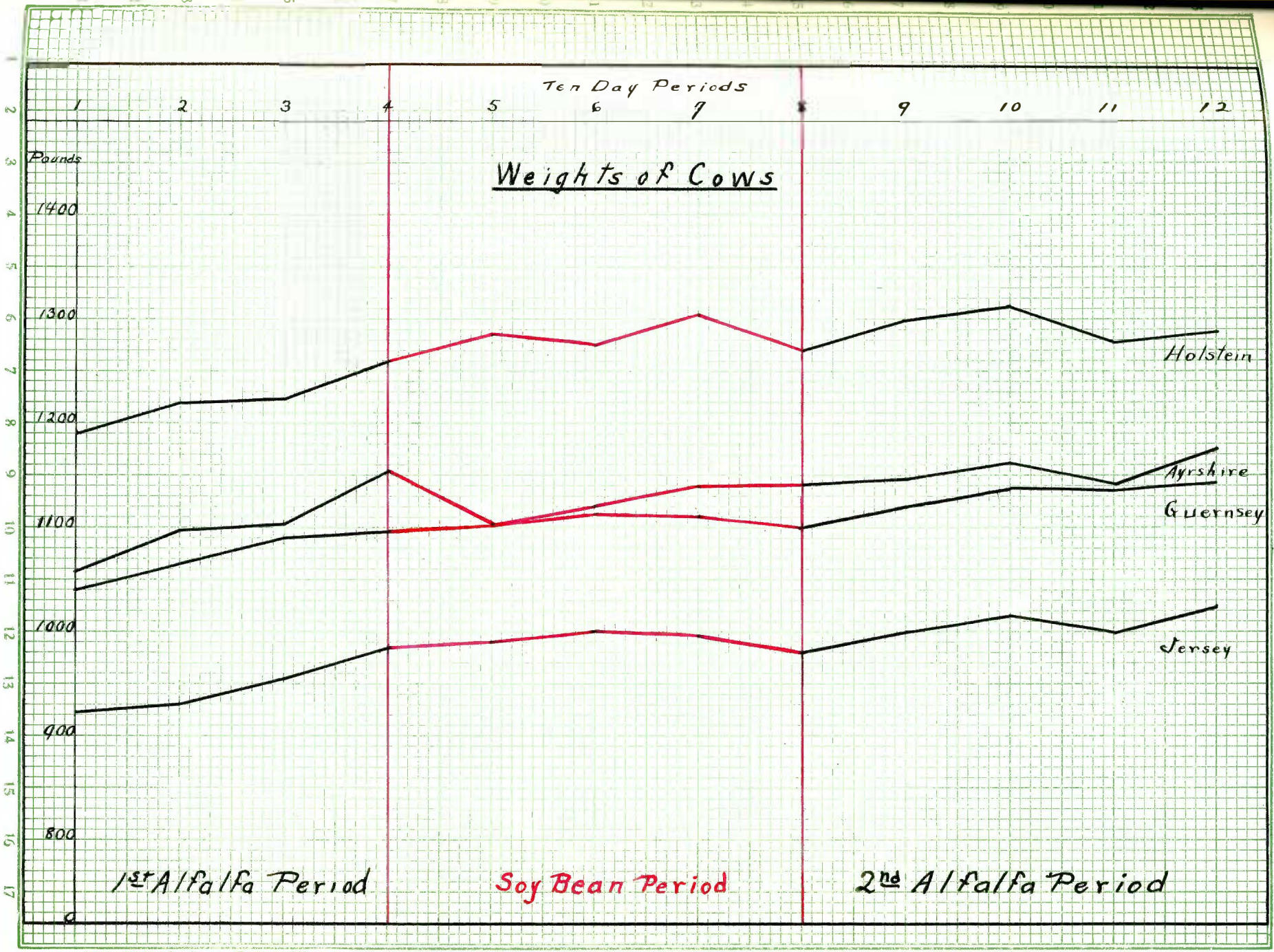
Weights of Cows.

Each of the cows showed more or less steady increases in weight throughout the trial, which in the case of the Jersey was undoubtedly due to the fact that she carried a calf during the entire experiment.

The increases for the other three cows may have been due to growth as all of them were immature. Furthermore, at the beginning of the experiment it was found necessary to increase the amounts of some parts of the rations for all the cows in order to supply them with all they would consume. In the case of the hay for 82 and 306, and corn for 82, the increase was considerable in amount. The differences in average weights for the first and second forty-day periods exclusive of the change periods, ranged between 19 and 52 pounds and the increases for the third over the second, ranged between 4 and 56 pounds.

Table of Average 30-day Weights for Periods

Cow number	82	209	258	306
First period	956	1118	1084	1237
Second period	992	1137	1109	1289
Third Period	1048	1161	1140	1293



No. 01333—W. M. Welch Manufacturing Company, Chicago

Everything considered it seems that the increases in weight showed a healthy condition and do not indicate overfeeding.

Feeds.

A. Roughages.

The alfalfa hay was of very good quality and relished by the cows so there was very little refuse during the two alfalfa periods. Number 82, the smallest of the four cows ate 14 pounds of the hay while cow number 258, eating only 10 pounds of hay, refused a few of the leaves early in the experiment.

The soy bean hay was very poor in quality, having considerable wild grass in it. The cows would not eat the coarser soy bean stems so there was considerable hay refuse during the soy bean period.

The silage was of good quality but low in moisture content as the corn was well matured when ensiled. Twenty-five to thirty pounds were eaten daily by each of the cows but cows 306 and 209 would not eat all the cobs in the silage so there was some silage refuse.

B. Concentrates.

After the change made at the end of the first ten days in the first 30-day period, no changes were made in the grain rations for the cows during the experiment.

Physical Condition.

With the exception of number 258, the cows were in fair condition at the beginning and all were in very good con-

dition at the end of the experiment. At the beginning of the experiment, cow number 256 was inclined to go off feed very easily. In fact she did not consume at any time while on experiment, as much corn as any one of the other cows. In the middle of the last or the second alfalfa period, cow number 82 was off feed but she regained her appetite after three days' time. So far as could be observed the soy bean hay had no extraordinary effect on the cows except for a laxative effect, noticed on cow number 306 and to some extent on the other three cows when the change to soy bean hay was made. This may have been due to weed seeds of the wild grasses rather than to the soy bean hay itself.

Digestion Trials.

The conditions for conducting the two trials were ideal. The help for catching the excreta was reliable; the analyses were made promptly; and the amount of feeds, fed in both trials were exactly the same except for four pounds of hay for cow number 306. Furthermore, the feed refuse, which was mostly silage cobs and hay stems, was small for both trials although somewhat greater for the soy bean trial. The only difference in quality and kind of feeds for the two trials was the use of the soy bean hay in the first and the alfalfa hay in the second trial.

Feeding.

The rations were weighed out separately for each cow

daily. The hay was weighed into large canvas bags. Each part of the grain ration was weighed separately into the pail for each cow. The pails were numbered and the bags marked. The grain was mixed thoroughly and half of the grain and hay ration was fed in the evening and half in the morning while a half ration of silage was weighed from the silage cart at feeding time. The silage and grain were fed about 5 P. M. and 6 A. M., and the hay about an hour later both morning and evening. The hay was sufficient in amount to provide just about all the cows would clean up in a day.

Feed Refuse:

The refused feeds were collected from the manger and feed boxes and placed in labeled bags, care being taken to keep the silage and hay refuse separate. There was no grain refuse. At the end of each forty-day period the refuse collected during the period, exclusive of that for the ten day change periods, was run through the feed chopper and the entire lot of chopped feed mixed thoroughly, after which an adequate sample was delivered to the chemist. The sample was delivered before the moisture content changed, from evaporation.

Rations.

The rations were calculated to meet the requirements of each cow as found by the "Modified Wolff-Lehman Standards (7).

The ether extract and crude fibre coefficients for all four cows and the nitrogen-free extract coefficient for cow number 306 were higher during the soy bean than during the alfalfa trial, while the ash or mineral coefficients were higher in the alfalfa trial. The coefficients for total dry matter was uniform for all four cows in both trials, the highest total dry matter coefficient being 78.32 percent for cow number 258 in the alfalfa trial and the lowest, 73.53 percent for cow number 82, in the soy bean hay trial.

The urine weights were uniform for both trials, but the amount of urine for cows, numbers 82 and 209, was considerably higher than that for cows, numbers 258 and 306. The percents of ash and solids were about equal for both trials, while the protein percentage was three times as high in the alfalfa as in the soy bean trial. This disparity in protein may have been caused by the shortage of digestible crude protein in the ration during the soy bean trial.

The protein supplied was in every case, in excess of the requirements during both alfalfa periods. The nutritive ratios for the alfalfa periods ranged from 1:5.44 to 1:6.65. Unfortunately the soy bean hay was of such very poor quality that during the soy bean period the average requirements for protein were not supplied, although the same amounts of grain and hay were

fed throughout the entire experiment and the cows received all the soy bean hay they would eat. Had the soy bean hay been of average composition, sufficient protein would have been supplied.

Management.

The cows were allowed to exercise in a dry lot for one-half to two hours a day when the weather permitted. Each of the cows was groomed daily, their stalls kept as clean as possible, and were well bedded down with straw at all times.

The milking and feeding were done regularly and except on a few occasions were not subjected to extremes of temperature or bad weather.

Each evening about 4 P. M. for the last three days of each ten-day period during the experiment the cows were weighed and the weights recorded. Care was taken in balancing the scales before each cow was weighed. The silage was eaten well by the cows except that quite a few of the cobs were refused by cow number 306, and cow number 209.

The alfalfa hay which was fed during both the first and second forty-day alfalfa periods was second cutting hay of the finest quality and grew on the college farm. It was of average moisture content (6), about 0.7 of one percent lower in ether extract, 3.3 percent lower in crude fibre, but 3 percent higher in protein and 2 percent higher in nitrogen-free extract than the average (6)

so that the hay was high in two of its most valuable feed constituents.

The soy bean hay was very poor in quality and had considerable wild grass and some weeds in it. It was low (6) in fat, ash, and ether extract but very high in crude fibre and nitrogen-free extract. It contained only about one-half the usual soy bean hay percentage of protein and was only about half as high in protein percentage as the alfalfa hay.

Water, in tanks holding about 100 pounds, was available for the cows at all times. Salt during the first forty-day period was supplied in the form of pressed cakes which were placed in the feed boxes. During the remainder of the experiment about 0.1 of a pound of salt per day was fed each cow in her grain ration.

Milk and Butterfat Records.

The cows were milked by hand twice a day and all milk weights recorded. Ten-day composite samples of the milk were taken and preserved with corrosive sublimate tablets. These samples were tested for butterfat by the Babcock method at the end of the ten-day periods.

Digestion Trials.

Two five-day digestion trials were conducted, one of them being near the end of the soy bean period and the other one at the close of the second alfalfa period of forty days.

Special analyses of the feeds set aside and fed during the digestion trials were made to eliminate variations in feed composition. The cows remained in their stalls constantly during the trials and care was taken to catch all the excreta and place it in containers from which very little evaporation was possible. Daily, each evening during the trials, the feces and urine were weighed, mixed thoroughly, and proportionate samples taken and placed in air tight containers. At the end of the trials the analysis of the samples was begun immediately.

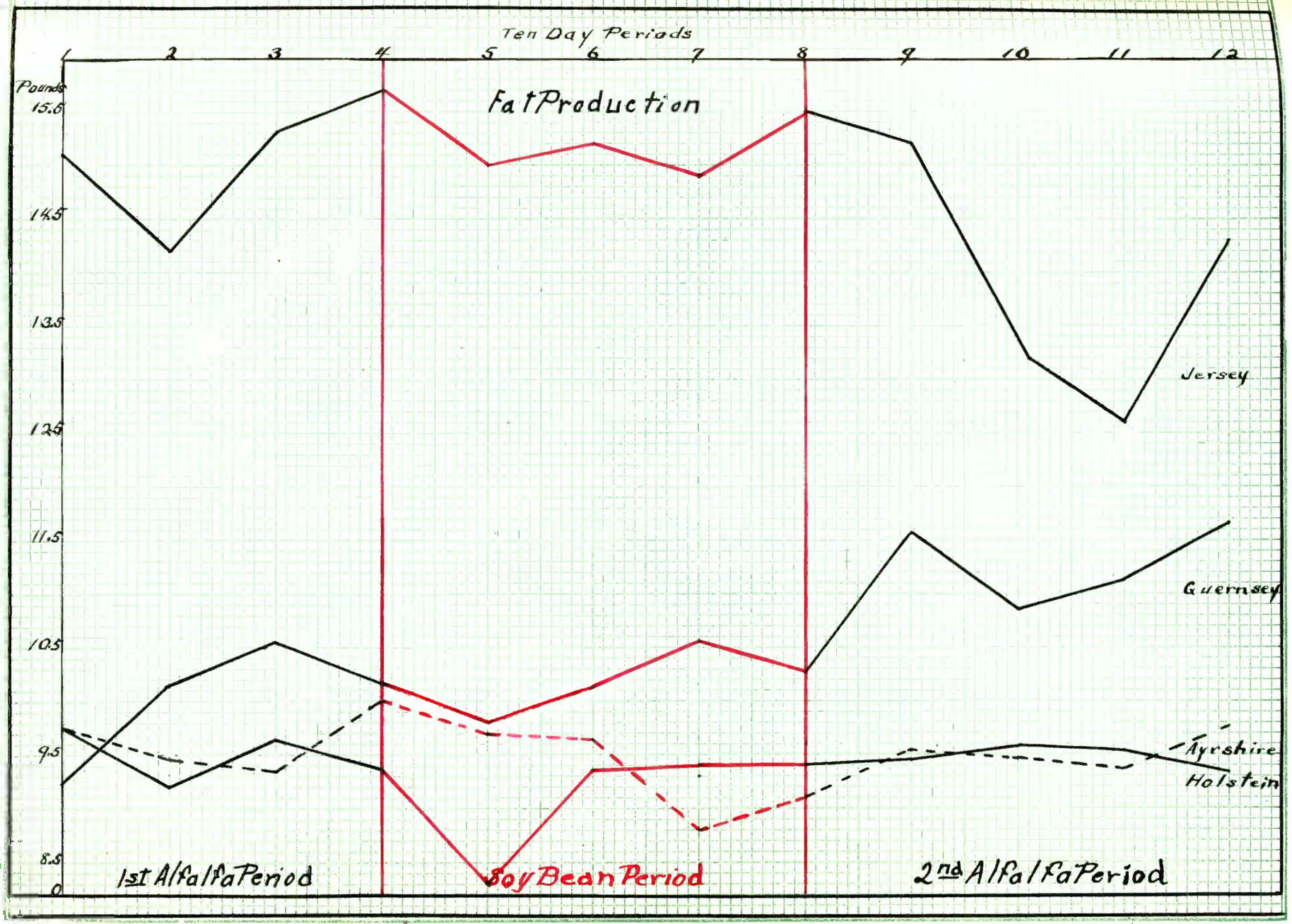
The first-trial digestion coefficients were used in calculations for the soy bean period and the second-trial coefficients used for both the first and second alfalfa periods.

Table of Coefficients for the Two Digestion Trials

Cow No.	82	209	258	306
	Soy Bean Digestion Trial			
E. Ext.	84.75	86.07	84.71	90.24
Ash	36.14	46.59	44.78	48.59
Protein	44.71	58.76	57.88	64.21
C. Fibre	78.69	68.76	67.27	69.74
N.F. Ext.	77.96	83.46	82.57	86.80
Dry Mat.	73.53	75.46	74.37	77.17
	Alfalfa Digestion Trial			
E. Ext.	61.21	66.43	68.10	65.80
Ash	50.08	54.35	59.16	50.02
Protein	64.19	68.17	71.18	68.93
C. Fibre	66.69	64.96	66.50	63.54
N.F. Ext.	84.61	85.62	85.79	83.76
Dry Mat.	75.75	77.34	78.32	75.61

Milk and Butterfat Production.

The total milk production for the soy bean hay period was 2,678.1 pounds as compared with an average milk production for the two alfalfa periods of 2,706.45 pounds or there was a difference of 28.35 pounds of milk in favor of the alfalfa hay. The butterfat production during the soy bean hay period excelled by 1.007 pounds the 132.29 pounds of fat produced during the average of the alfalfa hay periods. According to W. L. Gaines 4 percent milk equivalent method (8) the production of the soy bean hay period was the greatest by 3.76 pounds of 4 percent milk equivalent.



Comparative Results

	Jersey	Ayrshire	Guernsey	Holstein
Nutrients Digested per Pound of Milk Produced				
First Alfalfa Period				
E. Ext.	0.0217	0.0214	0.0277	0.0217
Ash	0.0312	0.0260	0.0415	0.0306
Protein	0.1122	0.1067	0.1453	0.1180
C. Fibre	0.1471	0.1201	0.1636	0.1371
N.F. Ext.	0.5126	0.4677	0.5981	0.4911
Dry Mat.	0.8564	0.7469	0.9759	0.8016
Second Alfalfa Period				
E. Ext.	0.0313	0.0265	0.0316	0.0249
Ash	0.0371	0.0299	0.0386	0.0275
Protein	0.1348	0.1076	0.1347	0.1088
C. Fibre	0.1863	0.1306	0.1641	0.1325
N.F. Ext.	0.6395	0.5064	0.5932	0.4872
Dry Mat.	1.0286	0.7995	0.9615	0.7810
Soy Bean Period				
E. Ext.	0.0298	0.0273	0.0357	0.0281
Ash	0.0239	0.0248	0.0290	0.0276
Protein	0.0628	0.0727	0.0852	0.0669
C. Fibre	0.2259	0.1564	0.1872	0.1741
N.F. Ext.	0.5443	0.5138	0.5987	0.5360
Dry Mat.	0.9055	0.7937	0.9316	0.8324
Average Alfalfa Periods				
E. Ext.	0.02650	0.23950	0.02965	0.02330
Ash	0.03415	0.02750	0.04005	0.02905
Protein	0.12350	0.10715	0.14000	0.11340
C. Fibre	0.16680	0.12535	0.16385	0.13480
N.F. Ext.	0.57605	0.48705	0.59565	0.48915
Dry Mat.	0.94250	0.77320	0.96870	0.79130
Nutrients Digested per Pound of Fat Produced				
1st Alfa.	13.9565	18.9311	16.9738	21.5545
2nd Alfa.	15.0680	19.1871	15.9374	21.1137
Soy Bean	13.8595	19.4339	15.6588	22.4346
Ave. Alfa.	14.51225	19.05910	16.45560	21.33410

Conclusions:

1. Soy bean hay is at least equal in feeding value to alfalfa hay for milk and fat production with dairy cows.

2. Legume hays, including soy bean hay, may be substituted quite largely for concentrates high in protein with cows of average production.

3. More soy bean hay should be used for feeding dairy cows in regions where it is difficult or impossible to grow alfalfa.

4. Soy bean hay may well be used as an emergency crop in case other hay crops have been winter-killed, or do not promise a sufficiently large yield.

ACKNOWLEDGMENTS

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