SOME ALFALFA HAY SUPPLEMENTS FOR MILK PRODUCTION

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INTRODUCTION

Alfalfa hay is classed above all hays as a milk producing roughage in a balanced ration. In providing low cost nutrients for milk production alfalfa hay ranks next to good pasture. In regions where alfalfa is grown extensively dairy cows have been fed almost entirely on alfalfa hay alone for long periods of time without serious impairment to health or reproduction.

Maximum milk production cannot be obtained, however, when alfalfa hay is fed as the sole ration. The cow cannot consume enough alfalfa hay to meet her energy requirements during the early part of the lactation period, a fact which probably accounts for the comparatively rapid decline in milk flow. In later lactation a cow on alfalfa hay alone lacks the persistency of production of cows on a mixed ration even though the cow receives sufficient nutrients from the hay consumed to meet her requirements as judged by common feeding standards. The lack of persistency suggests some nutrient to be a limiting factor in milk production.

This report deals with experiments designed to determine the comparative value of simple concentrate feeds

in supplementing an alfalfa hay ration.

REVIEW OF LITERATURE

Alfalfa hay experiments

Results of controlled investigations dealing with the feeding of alfalfa as the sole feed for dairy cattle are given in the annual report of the California Agricultural Experiment Station (3). Two groups of heifers and calves were selected, and to one group was fed alfalfa hay and green alfalfa only and to the other group a mixed ration of alfalfa hay, silage, green corn, and an unstated amount of concentrate mixture. Heifers receiving the mixed ration made about a 20 per cent greater gain in weight. Insofar as reproduction was concerned, no great difference was noted in the two rations. Thirty lactations periods were used for comparison. Six each were in first and second lactation periods and three each were in third lactation periods. The average milk production on the alfalfa rations was 6,492 pounds of milk and 259 pounds of butterfat as compared to 7,337 pounds of milk containing 323 pounds of butterfat with the mixed rations. The animals on the all alfalfa ration thus produced 88.4 per cent as much milk and 80.0 per cent as much butterfat as the animals fed the mixed ration.

Records obtained from cow-testing associations in Nevada for the years 1922-23 and including 702 cows in 53 herds was summarized by Headley, Knight, and Cline (15). The average cow in the associations weighing 1,024 pounds produced 7,060 pounds of milk containing 263 pounds of butterfat in a 9.7 month lactation period on alfalfa hay alone. There was much variation reported on production of individual cows.

The economy of raising dairy heifers on different levels of feeding was studied by Reed, Fitch, and Cave, (25). Six Holstein heifers were fed alfalfa hay exclusively from six months of age through two ten month lactations. Later two of the animals completed their third lactation on full feed. The actual average production for the two lactations on alfalfa hay alone was 4,124 pounds of milk and 150 pounds of fat. The two animals on a full feed ration averaged 8,191 pounds of milk and 298 pounds of butterfat.

Headley (13) maintained four Holstein cows continously for four years on alfalfa hay alone. Their actual production for the period averaged 8,644 pounds of milk and 304 pounds of butterfat per cow. Four other cows of the same breed fed alfalfa hay and grain at the rate

of about 1 pound of grain to 5 pounds of milk averaged 10,352 pounds of milk and 359 pounds of butterfat for the four years. The alfalfa hay cows produced 83 per cent as much milk and a little less than 85 per cent as much butterfat.

Holdaway and associates (17) compared alfalfa and timothy hay with the differences in protein content adjusted by the protein content of the supplemental grain mixture fed with the timothy hay. Pound for pound of hay consumed, the alfalfa produced greater quantities of milk and butterfat than timothy hay.

Dickson and Kopland (4) fed ten Holstein cows by three different methods for as many different lactation periods. The three levels of nutrition consisted of a full grain ration with one pound of a standard grain mixture fed to each 3 pounds of milk produced, a limited grain ration in which one pound of grain mixture was fed to every 6 pounds of milk produced, and a roughage ration consisting of all the roughages the cows could clean up and pasture during the summer. The roughages were alfalfa hay, corn silage, sugar beets, and beet pulp. Cows on the full and limited grain ration received the same kind of roughage and pasturage. The cows were fed the 1 to 3 ration for their first lactation because they were being used in an inheritance study. Considering

the records made on a full grain ration calculated to maturity as their maximum, the cows produced 77.1 per cent as much the lactation they were fed the all roughage ration and 94.2 per cent as much the limited grain ration. The actual production of the same ten Holstein cows fed on three different planes of nutrition on three-times-a-day milking was as follows:

	Milk	Fat
Full grain (1 to 3)	15,793.2	544.5
Limited grain (1 to 6)	16,607.3	576.4
Roughage (no grain)	13,295.2	464.1

Milk production of cows fed almost entirely on roughage consisting mostly of alfalfa hay is reported by Jones and coauthors (19). Alfalfa hay was fed long, chopped, and long with grain to three different groups of dairy cows. The 14 cows fed long hay on an average weighed 985 pounds; consumed 9,031 pounds of long alfalfa hay, 126 pounds of long oats and vetch hay, and 189 pounds of concentrates; produced 166.2 pounds of butterfat in 305 days; and calved again in 13 months. The nine cows in the chopped hay group on an average weighed 1,045 pounds; consumed 8,960 pounds of chopped alfalfa hay, 863 pounds of chopped red clover hay and 76 pounds of concentrates; produced 214.0 pounds of fat in 305 days; and calved again in 15 months. Seven cows constituted the long alfalfa hay and grain group which on the average

weighed 888 pounds; consumed 5,664 pounds of long alfalfa hay, 2,060 pounds of ground barley and 1030 pounds of ground oats; produced 277.9 pounds of butterfat in 305 days; and calved again in 14½ months.

Headley (14) reported a study covering a period of 8 years. Records on a sole alfalfa ration were obtained for 52 cow years and 54 cow years for cows receiving a grain mixture at the rate of approximately 1 pound of grain to 5.3 pounds of milk, in addition to the alfalfa hay. The average production for the cows receiving alfalfa hay alone was 283 pounds of fat and 8,090 pounds of milk. The grain fed cows had an average production of 331 pounds of fat and 9,498 pounds of milk. Grain feeding gave an increase of 16.9 per cent in fat and 17.4 per cent in milk production. The average production of the ten highest producers on alfalfa hay alone was 288 pounds of fat and the ten lowest 228 pounds of fat as compared to the ten highest producing cows receiving grain with an average production of 366 pounds of fat and the ten lowest with 240 pounds of fat.

Experimental work conducted at various field stations of the Federal Bureau of Dairy Industry pertaining to the nutritive value of alfalfa hay when fed as a part of or as the entire ration for dairy cattle is discussed by Graves and associates (9). Covering 26 lactation periods 15 cows averaged 11,125 pounds of milk and 398.6

pounds of butterfat on alfalfa hay alone. These same cows had previously made records under full feed conditions. The full feed ration consisted of roughage and grain fed at the rate of 1 pound to each 3 pounds of milk produced and pasture in most cases. All but four of the records were for 365 days and except for two cows receiving alfalfa hay, all records were for three-times-a-day milking. The average production on the hay ration was 57 per cent as much milk and 60 per cent as much butterfat as the cows averaged under full feed conditions. The cows on alfalfa hay alone were in good condition but lighter in body weight when fed alfalfa hay alone.

Hodgson and collaborators (16) reported investigations with cows on roughage alone. Three groups of ten cows each were on pasture in the summer and received either (1) mixed hay, or (2) grass silage, or (3) mixed hay and grass silage in the winter. Salt and iodine were given but no concentrates were fed. The average yearly production on mixed hay and pasture was 254 pounds of fat; on grass silage and pasture, 251 pounds of fat; and on pasture, mixed hay, and grass silage, 258 pounds of fat. Fifteen of the cows had made 30 previous lactation records on alfalfa hay, good pasture, and limited grain. On an all roughage ration they produced about 73 per cent as much butterfat as when grain fed. There were no

breeding troubles, digestive disturbances, or other ailments attributable to the rations fed.

Production of cows on four different planes of nutrition were compared by Graves and associates (8). The same twelve Holstein cows were fed four different rations in as many lactation periods. One lactation the animals were given a so-called full-grain ration consisting of alfalfa hay, corn silage, pasture in season, and a grain mixture made up of 2 parts barley, 1 part oats, and 1 part wheat bran and fed at an average rate of 1 pound of grain to 4.33 pounds of milk. In another lactation period they were fed only alfalfa hay, pasture in season and some alfalfa hay during the periods of pasture shortage. In still another lactation period, barley was fed as the sole grain at the rate of 1 pound to every 6.03 pounds of milk produced. Pasture in season and alfalfa hay were the roughages. During another lactation period the cows were fed all roughage, consisting of alfalfa hay, corn silage, and pasture in season. Compared to their production on the full grain ration, the 12 cows produced 69.75 per cent as much milk and 65.77 per cent as much butterfat on the alfalfa-pasture ration; 86.03 per cent as much milk and 80.24 per cent as much butterfat with the barley, alfalfa, and pasture ration; and 73.57 per cent as much milk and 69.93 per cent as

much butterfat on alfalfa, corn silage, and pasture. All production was calculated to a mature basis.

Two groups of grade Jersey cows were used by Sherwood and Dean (23) in comparing the economy of production on alfalfa hay alone and with concentrates. Average production for the cows on alfalfa hay alone was 4,216 pounds of milk and 236.1 pounds of fat and for the cows receiving 5 pounds of grain daily in addition to alfalfa, 5,575 pounds of milk and 294.1 pounds of fat for the first two lactations when pasture was not available. The last two lactations when pasture was available to both groups, the cows on the alfalfa hay alone produced an average of 4,168 pounds of milk and 240.4 pounds of fat and the cows receiving 4 pounds of grain daily in addition to alfalfa produced 5,141 pounds of milk and 293.6 pounds of fat.

Deficiencies of sole alfalfa hay rations

Alfalfa in common with other roughages is comparatively low in phosphorus. Haag and coworkers (12) called attention to the fact that alfalfa hay may contain less the 0.2 per cent phosphorus. Calcium and phosphorus balance studies by these authors showed that cows in early lactation, fed only on alfalfa hay, were usually in positive calcium balance and always in neg-

ative or slightly positive phosphorus balances. Later metabolism trials by the same investigators (1) showed that cows restricted to alfalfa hay alone containing 0.153 per cent phosphorus were negative in both calcium and phosphorus balances. Positive calcium and phosphorus balances resulted with the supplemental feeding of bone meal.

Analyses reported by Huffman and coworkers (18) indicate that alfalfa containing less than 0.2 per cent phosphorus is common. They studied the phosphorus requirements of dairy cattle when low phosphorus (less than 0.2 per cent) alfalfa hay was fed. Their low phosphorus ration consisted of alfalfa hay, corn silage, yellow corn, and salt. The feeding of this low phosphorus (about 0.2 per cent) ration resulted in low inorganic blood phosphorus and anorexia. Their results indicated that anorexia was a better criterion of phosphorus deficiency than osteophagia. The basal rations furnished insufficient amounts of phosphorus for high milk production but was adequate for low milk production. Individual variations in amounts of phosphorus required were observed. In order to allow for individual variations, the authors recommended 0.75 gram of food phosphorus per pound of milk when ten grams of phosphorus are allowed per 1000 pounds of body weight for main-

tenance. During late gestation and advanced lactation not less than 17 grams daily were recommended.

Rations deficient in phosphorus have been reported to effect the milk flow of lactating cows. Tuff (23) reported decreased milk yields in cows in phosphorus deficient areas and subsequent increased milk yields by feeding bone meal or herring meal. Data presented by Eckles and associates (6) show that cows fed adequate amounts of phosphorus during the dry period and lactation have a much higher annual milk production than the same animals receiving inadequate amounts of phosphorus prior to and during lactation.

Cystine was shown to be a limiting factor in the nutritive value of alfalfa proteins by Haag (10). Feeding experiments were conducted with rats in which ground alfalfa leaves supplied crude protein at a 9 to 15 per cent level. Rats receiving alfalfa leaves plus a cystine supplement demonstrated significant gains over rats receiving the non-supplemented alfalfa leaves. This rather definitely demonstrated a dificiency of cystine in the crude proteins of alfalfa.

Wright and Haag (26) made lactation studies with rats with alfalfa leaf meal as the only source of protein in the ration. Lactation was increased as measured by the rate of growth of suckling young, by supplementing

the ration with l-cystine. There was also a reduction in the loss of body weight of the lactating females with the l-cystine supplement.

Effect of fat level in ration

Maynard and McCay (21) studied the influence of different fat levels on milk secretion. Grain mixtures containing 6 or 7 per cent fat were extracted with ether and all but 1 per cent of the fat was removed. The fat was replaced by an iso-dynamic amount of starch. Removal of the fat resulted in lowered fat and milk yields. Decreases in milk and fat yields also occurred when the fat content of the grain mixture was reduced to 3 per cent.

Allen (1) reported an increase in the fat percentage of milk over a period of five or six days when various oils were added to a ration low in ether extract.

Bratton et al (2) report a measurable increase in fat test with the inclusion of 25 per cent raw soybeans in the grain mixture.

Comparatively recent experiments by Maynard and associates (20) using a double reversal feeding system showed that mixtures with soybeans as a constituents and containing 5.27 per cent fat gave higher milk and fat yields than a mixture containing solvent extracted

soybean meal having 3.35 per cent fat plus starch to replace the fat removed.

Gibson and Huffman (7) observed virtually the same effect when soybean oil meal replaced iso-dynamic amounts of beet pulp in a ration. The addition of soybean oil meal gave a temporary increase in butterfat percentage and milk production.

OBJECT OF THE INVESTIGATION

This study was undertaken to determine the comparative value of various concentrates in efficient supplementing the deficiencies of alfalfa hay for milk production. The primary object was to study the supplementary value of other protein sources but the energy, fat, and phosphorus intake were to be considered.

EXPERIMENTAL PROCEDURE

Animals used

For this study five purebred Holstein-Friesian cows and one purebred Ayrshire cow were fed alfalfa hay alone and with various supplements. Table 1 gives the herd number and history of the experimental animals at the beginning of and during the investigation.

Feeding of animals

The allowance of alfalfa hay for each cow was weighed daily into canvas bags and fed morning and evening. Any refused hay was weighed back daily. Weighed amounts of concentrates were also fed in equal portions morning and evening. The supplements were introduced at various lengths of time after calving depending on the decline in milk production on alfalfa hay only and the occurrence of a feed change. Usually the cows received hay alone for about the first six weeks following parturition. With a few exceptions, all feed changes were made every 28 days. Changes were made similtaneously on all cows. The general plan throughout the lactation was to have two supplemental feeding periods followed by a period in which alfalfa hay alone was fed.

Alfalfa hay was reduced 5 pounds after November 20, 1939 and 10 pounds after June 3, 1940 during the periods when concentrates were fed. The digestible protein and total digestible nutrient intakes were held approximately constant for the alfalfa hay alone, and alfalfa hay and concentrate periods by mixing the protein supplement with starch or sugar and regulating the amount fed. When concentrates lower in digestible protein than al-

Table 1. Data on experimental animals

Cow no.	Born	Calving Date	History of Animals	Breeding Record
322	9-1-33	11-24-35	1st lactation--full feed	Normal
		12- 3-36	2nd lactation--alfalfa hay alone	Normal
		10-29-37	3rd lactation--alfalfa hay and limited concentrates	Normal
		11-25-38	4th lactation--alfalfa hay and limited concentrates	Normal
		12- 2-39	5th lactation--alfalfa hay with various concentrates	Normal
		1- 3-41	6th lactation--alfalfa hay with various concentrates	Normal
334	9-6-34	6-27-36	1st lactation--full feed for four months then on alfalfa hay alone	Normal
		5-23-38	2nd lactation--full feed	Normal
		5-26-39	3rd lactation--full feed for five months then on alfalfa hay and limited concentrates	Normal
		7- 6-40	4th lactation--alfalfa hay with various concentrates	Normal
336	10-2-34	6-15-37	1st lactation--full feed for two months then on alfalfa hay alone	Three services required
		6-23-38	2nd lactation--alfalfa hay alone	Normal
		6-30-39	3rd lactation--alfalfa hay and limited concentrates	Normal
		6-12-40	4th lactation--alfalfa hay with various concentrates	Normal
341	11-6-34	6-23-36	1st lactation--full feed for five months then on alfalfa hay alone	Normal

Table 1. Data on experimental animals--continued

Cow no.	Born	Calving Date	History of Animals	Breeding Record
		8-21-37	2nd lactation--alfalfa hay alone	Normal
		12- 6-38	3rd lactation--alfalfa hay and limited concentrates	Normal
		2-19-40	4th lactation--alfalfa hay with various concentrates	Normal
356	2- 7-36	7-38	1st lactation--full feed	Normal
		5-17-39	2nd lactation--full feed	Normal
		5-14-40	3rd lactation--alfalfa hay with various concentrates	Normal
700	17-11-34	10-15-36	1st lactation--full feed for six weeks then on alfalfa hay alone	Normal
		9-22-37	2nd lactation--alfalfa hay and limited concentrates	Normal
		11- 7-38	3rd lactation--alfalfa hay and limited concentrates	Aborted
		9-13-39	4th lactation--alfalfa hay with various concentrates	Normal
		11- 4-40	5th lactation--alfalfa hay with various concentrates	Normal

falfa hay were used it was impossible to maintain the digestible protein intake at its previous level. The cows had free access to di-sodium phosphate, as well as salt in separate boxes in their feed mangers, and bone meal. The feeding of supplements began November 21, 1939. The 1938 crop of alfalfa hay was fed until November 2, 1939 after which the 1939 crop of alfalfa was fed.

Handling of animals

The animals were kept in stanchions during the entire experimental period except when turned out in a concrete yard about 2 hours daily for exercise. Water was supplied by individual drinking fountains. The manger had concrete bottoms and were walled on either side and in front of each cow to facilitate accurate feed intakes. The cows were milked twice daily by machine.

Record keeping

Beginning June 21, 1941 the cows were weighed daily. Previous to that time they were weighed weekly. Milk was weighed and aliquot samples taken at each milking. The milk samples were preserved with corrosive sublimate tablets and tests were made by the Babcock method weekly. Feed intakes were recorded daily.

Feed analysis

A chemical analysis of feeds used in this investigation are shown in table 2. Samples of each year's crop of alfalfa hay were taken at regular intervals while being fed. Protein analysis were made on each individual hay sample. All samples for a given year's hay crop were then pooled and analyzed for ash, moisture, crude fat and crude fiber. The above described samples are designated as alfalfa hay for the respective years. Samples of wheat middlings, wheat bran, and oat groats were not analyzed the average analyses given by Morrison (22) being used.

Table 2. Analysis of feeds used in experiment

Description of feed	Ash	Moisture	Crude Protein	Crude Fat	Crude Fiber
Alfalfa hay--1938 crop	8.0	6.7	14.7	2.4	30.4
Alfalfa hay--1939 crop	7.8	7.0	14.6	2.6	28.8
Blood meal	6.7	13.8	80.0	0.5	
Beet molasses*	12.8	2.6	5.0		
Beet pulp	2.6	6.8	7.2	0.8	21.1
Fish meal	15.9	9.0	65.9	3.4	
Meat meal	22.1	7.9	55.0	9.7	
Peanut meal	6.4	9.4	43.8	5.8	14.8
Skimmilk powder	7.6	3.6	36.6	0.2	
Soybeans (ground)	7.9	9.4	37.6	20.0	6.5
Soybean oil meal (dehydrated)*	9.5	11.2	43.0	5.3	7.0

Nutritive value of feeds

The average digestion coefficients reported by Morr-

ison (22) were used in calculating the total digestible nutrients and digestible protein of the feeds as shown in table 3. The digestible constituents of the feeds not analyzed are also given.

Table 3. Digestible-nutrient content of feeds used in the experiment

Description of feed	Digestible protein	Total-digestible nutrients
Alfalfa hay--1938 crop	10.6	52.2
Alfalfa hay--1939 crop	10.5	52.2
Blood meal	68.8	69.9
Beet molasses (dehydrated)	2.6	75.0
Beet pulp	4.5	70.0
Fish meal	53.4	66.7
Meat meal	51.2	77.8
Peanut meal	38.9	73.5
Skimmilk powder	34.8	90.1
Soybeans	33.5	77.9
Soybean oil meal	36.5	75.0
Wheat middlings	14.4	78.4
Wheat bran	13.2	69.5
Oat groats	14.7	92.5

RESULTS OF THE INVESTIGATION

The average daily milk yield and percentage of the maximum months yield for cows under ordinary conditions as given by Eckles (5) are shown in table 4.

The table following shows that a cow ordinarily reaches her highest production the second month of lactation. Cows that are fed alfalfa hay alone usually have their highest production the first month of lactation.

In this experiment the highest production occurred during the first 28 day period on alfalfa hay alone in the case of all cows with the exception of 322. The period when the highest average yields were obtained was considered 100 per cent and the milk yields of the other periods were compared to the 100 per cent period.

Table 4. Relation of stage of lactation to milk yield

Month of lactation	Average daily milk yield pounds	In terms of percentage
1	32.9	99.6
2	33.0	100.0
3	30.3	92.0
4	28.4	86.0
5	27.0	82.0
6	24.7	75.0
7	23.4	71.0
8	22.7	69.0
9	21.1	64.0
10	17.1	52.0
11	11.3	34.0
12	3.8	11.5

The lactation curve for cows under ordinary conditions as determined by Eckles (5) is plotted in each figure with other lactation curves of the various animals.

Experimental cow 322

Figure 1 and Table 5 present graphically and numerically the production and feed consumption of cow 322

during the experimental lactation. Production during previous lactations is plotted for comparison. Production was maintained at a fairly constant level for the first two periods on alfalfa hay alone with a slightly higher average yield the second period which was considered 100 per cent. The total digestible nutrients consumed during the feeding of alfalfa hay were insufficient to meet the requirements. A drop in production occurred during the eighth and ninth weeks.

At the beginning of the tenth week, skimmilk powder replaced a part of the alfalfa hay. Milk production declined rather sharply through the twelfth week and then held constant through the thirteenth week. Production was 88% of the high period. The amount of nutrients consumed was in excess of the amount required when milk powder was fed and throughout the remainder of the lactation.

Following the skimmilk powder period cow 322 was again placed on alfalfa hay alone. This resulted in a marked decline through the sixteenth week and a slight increase during the seventeenth week. The average production was 72 per cent of the highest period.

Fish meal was fed for the next five weeks and production increased the first two weeks of the period after

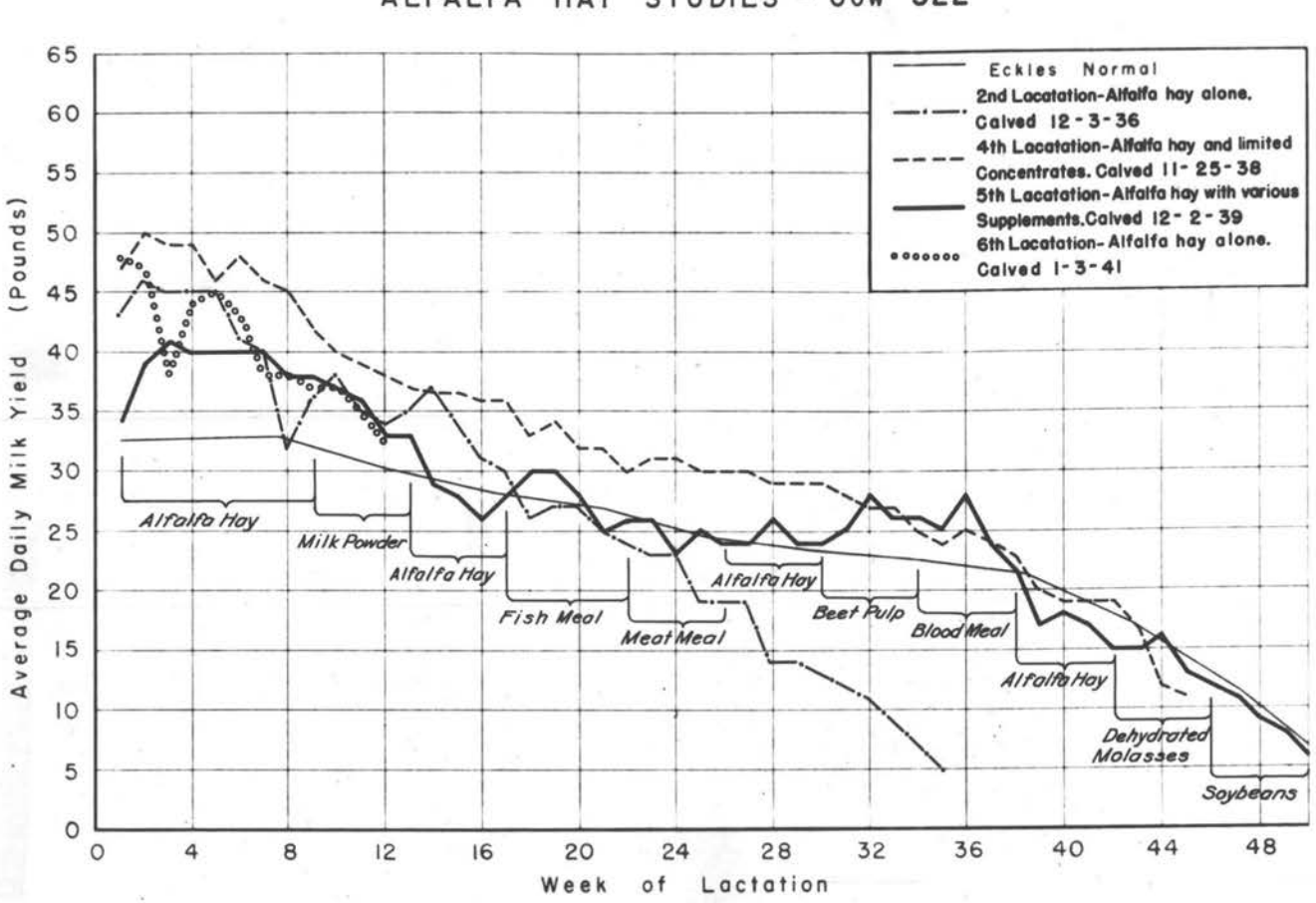

ALFALFA HAY STUDIES - Cow 322
Eckles Normal
2nd Lacatation-Alfalfa hay alone. Calved 12-3-36
4th Lacatation-Alfalfa hay and limited Concentrates. Calved 11-25-38
5th Lacatation-Alfalfa hay with various Supplements. Calved 12-2-39
6th Lacatation-Alfalfa hay alone. Calved 1-3-41
Average Daily Milk Yield (Pounds)
Week of Lactation
Alfalfa Hay
Milk Powder
Alfalfa Hay
Fish Meal
Meat Meal
Alfalfa Hay
Beet Pulp
Blood Meal
Alfalfa Hay
Dehydrated Molasses
Soybeans

Figure 1

which a decrease occurred; however, there was a check in rate of decline as evidenced by a 71 per cent average production of the highest period.

On an average, milk production decreased when meat meal was fed replacing fish meal. Production was only 63 per cent of the high period. A decided reduction occurred during the second week of the period but production increased again the third.

Milk production remained at practically the same level on alfalfa hay alone the period after meat meal was fed.

The feeding of beet pulp after alfalfa increased milk yield from 63 to 67 per cent of the highest period. Less digestible protein and more digestible nutrients were consumed on beet pulp than in previous periods.

Blood meal feeding followed the beet pulp period and milk increased the second week it was used as a supplement. There was a distinct decline the remainder of the period. For the period 64 per cent of production of the highest period was obtained.

Alfalfa hay only was fed after the blood meal periods and production declined to 44 per cent of the high period. Dehydrated molasses and ground soybeans were fed for 4 week periods each near the end of the lactation. Milk production decreased rather uniformly

Table 5. Average daily consumption and production of cow 322

Days in period	Feed: Alfalfa (pounds)	Feed: Concentrate	Digestible Nutrients: Total: Required (pounds)	Digestible Nutrients: Total: Consumed (pounds)	Digestible Nutrients: Protein: Required (pounds)	Digestible Nutrients: Protein: Consumed (pounds)	Milk (pounds)	Milk yield based on highest period (per cent)
35	39		20.93	20.24	2.53	4.06	39.26	99.19
28	40		20.94	20.77	2.53	4.17	39.58	100.00
28	35	1.5# Milk Powder 1.5# Starch	19.46	20.88	2.30	4.19	35.12	88.73
28	39		18.62	20.99	2.15	4.23	28.59	72.23
35	35	1.0# Fish Meal 1.0# Starch	17.28	19.81	1.98	4.20	28.20	71.24
28	35	1.0# Meat Meal 1.0# Starch	16.71	19.80	1.86	4.18	25.06	63.31
28	40		16.79	20.81	1.86	4.18	25.12	63.46
28	30	7.0# Beet Pulp	17.39	21.24	1.96	3.48	26.80	67.71
28	30	1.34# Blood Meal 3.99# Sugar	17.27	20.28	1.92	4.03	25.37	64.09
28	40		15.28	20.89	1.59	4.29	17.46	44.11
28	30	6.3# Molasses	14.97	20.38	1.53	3.31	14.80	37.39
28	30	2.9# Soybeans 2.5# Starch	13.30	19.35	1.28	4.12	8.90	22.48

during both periods after an increase. The first two weeks molasses was fed.

In comparing this experimental lactation with Eckles, normal, it is seen that during the first periods on alfalfa hay production was irregular but follows the same general trend. The decrease on the milk powder is slightly more than expected. Alfalfa hay alone after the milk powder ration brought about a decidedly greater decline as shown by the experimental lactation curve dropping below the normal. The decline in production on fish meal and meat meal follows very closely the expected. Production during the periods on alfalfa hay alone, beet pulp and blood meal was above the Eckles normal. Alfalfa hay alone, dehydrated molasses and soybeans were fed consecutively with decline about normal. As seen in Figure 1, cow 322 showed a decided lack of persistency in her second lactation when alfalfa hay only was fed. During the fifth lactation on limited concentrates her production followed the normal fairly well.

Experimental cow 334

Production and consumption data of cow 334 are given in Figure 2 and table 6. Number 334 began production at rather a high level and declined rapidly

during the third week on alfalfa hay alone. Average production was highest during this period and it was taken as the 100 per cent period. The nutrients consumed during the three weeks on alfalfa hay and the following 4 week period, when milk powder was substituted for part of the hay, were insufficient to meet the amount required. During the first week milk powder was fed, production increased considerably but declined rapidly the other three weeks; however, an average of 97 per cent as much was produced as in the previous period.

Sugar was fed during the period following milk powder. The intake of total digestible nutrients was not sufficient to supply that required. As shown by the lactation curve in Figure 2, milk yield decreased rapidly the first week sugar was included in the ration and held practically constant the second and declined uniformly the remainder of the period. The average amount of milk produced was 73 per cent of that of the high period.

The consumption of total digestible nutrients for the remainder of the lactation exceeded the requirements. A check in decline occurred the first week the cow was again placed on alfalfa hay alone and then declined through the third week. A slight increase occurred

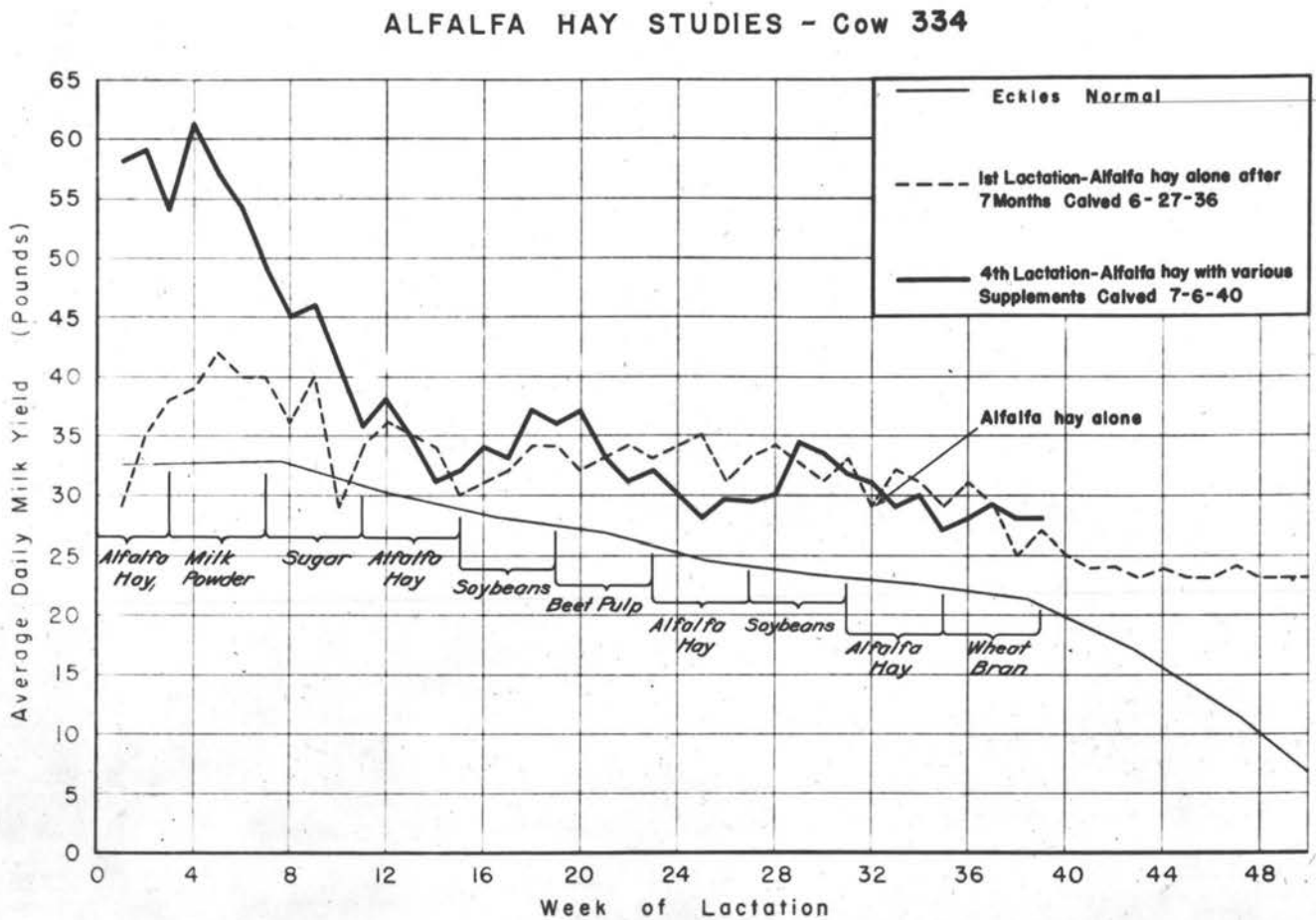

ALFALFA HAY STUDIES - Cow 334
Eckles Normal
1st Lactation-Alfalfa hay alone after 7 Months Calved 6-27-36
4th Lactation-Alfalfa hay with various Supplements Calved 7-6-40
Alfalfa hay alone
Alfalfa Hay, Milk Powder
Sugar
Alfalfa Hay
Soybeans
Beet Pulp
Alfalfa Hay
Soybeans
Alfalfa Hay
Wheat Bran
Average Daily Milk Yield (Pounds)
Week of Lactation
0
5
10
15
20
25
30
35
40
45
50
55
60
65
0
4
8
12
16
20
24
28
32
36
40
44
48

Figure 2

during the fourth week.

The feeding of ground soybeans for 4 weeks after alfalfa alone increased the milk yield considerably. During the previous period on alfalfa hay production was 60 per cent of the high period and with soybeans in the ration this increased to 61 per cent. The feeding of beet pulp followed that of soybeans and held the production at a slightly higher level during the first week of feeding but it declined rapidly the second and third weeks and increased slightly the fourth week. The average milk yield during the beet pulp period was 58 per cent of the high period. For the following period on alfalfa hay alone production decreased the first two weeks, raised the third, and remained constant the fourth week of the period. Fifty-one per cent as much milk was produced as in the high period.

Ground soybeans feeding again increased production after the alfalfa hay period. A slight increase occurred the first, a greater increase the second, and small declines the third and fourth weeks of the soybean feeding period. Production for the 4 weeks was 56 per cent of the high period. Alfalfa hay alone again followed soybeans with resulting decreases the first two weeks, a small increase the third, and a decline the fourth resulting in all average production of 51 per

Table 6. Average daily consumption and production of cow 334

Days in period	Feed: Alfalfa (pounds)	Feed: Concentrate	Digestible Nutrients: Total: Required (pounds)	Digestible Nutrients: Total: Consumed (pounds)	Digestible Nutrients: Protein: Required (pounds)	Digestible Nutrients: Protein: Consumed (pounds)	Milk (pounds)	Milk yield based on highest period (per cent)
28	40		27.01	20.92	3.37	4.20	57.54	100.00
28	30	2.87# Milk Powder 2.59# Starch	25.82	20.32	3.22	4.14	55.85	97.06
28	30	5.0# Sugar	21.60	20.51	2.60	3.16	42.23	73.39
28	40		19.55	20.92	2.29	4.20	34.59	60.11
28	30	2.9# Soybeans 2.5# Starch	19.30	19.54	2.31	4.15	35.63	61.92
28	30	7.0# Beet Pulp	18.84	21.25	2.18	3.46	33.76	58.67
28	40		18.48	21.25	2.13	4.17	29.41	51.11
28	30	2.9# Soybeans 2.5# Starch	17.89	19.35	2.20	4.12	32.30	56.13
28	40		18.32	20.72	2.10	4.16	29.73	51.66
28	30	7.3# Wheat Bran	17.94	20.78	2.04	4.10	29.02	50.43

cent of the high period. After alfalfa alone wheat bran was substituted in the rations. Production increased steadily the first two weeks, dropped a little the third, and remained constant the fourth week of the period. Fifty per cent as much milk was produced on wheat bran as during the high period.

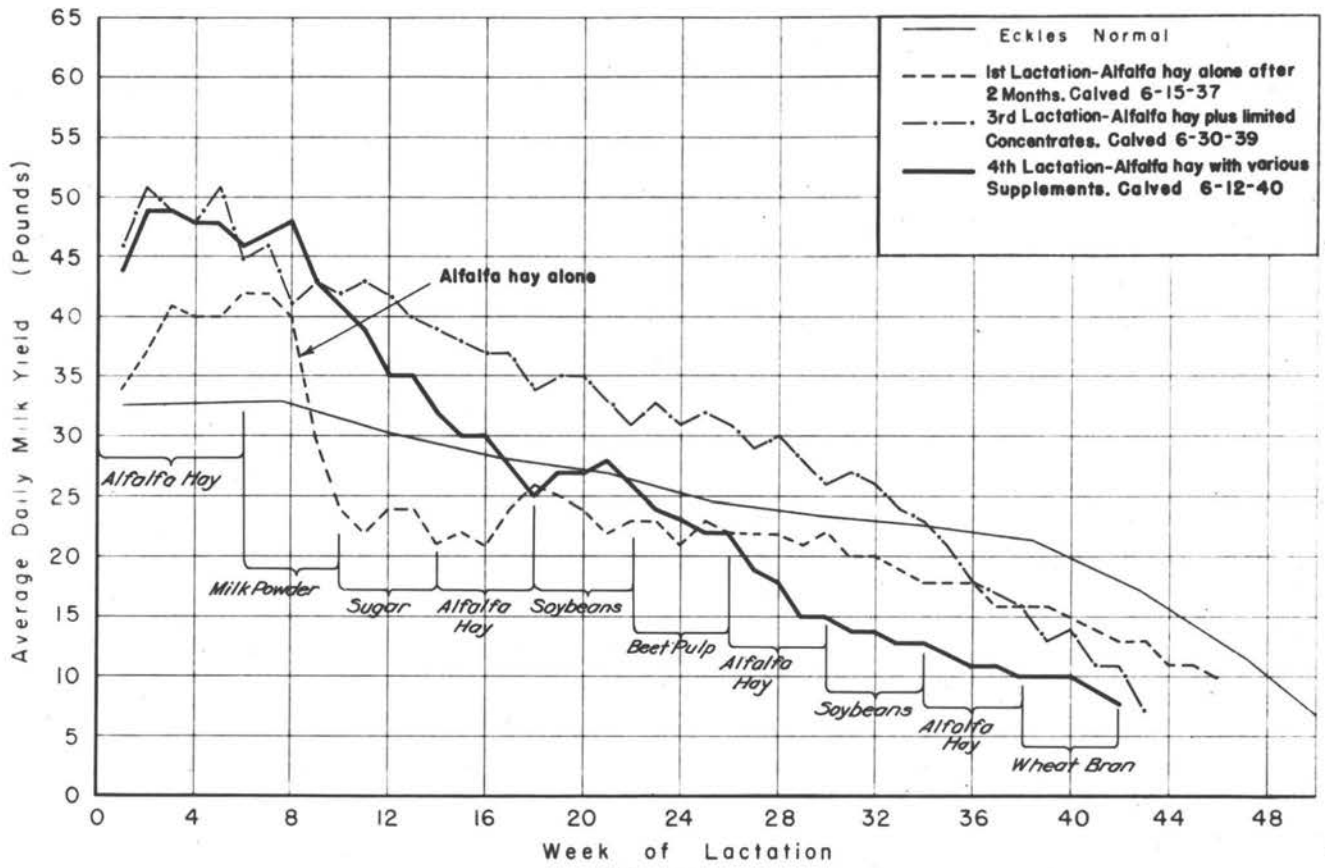
When compared with Eckles normal lactation curve, the decline in production during the period alfalfa hay alone, milk powder, sugar, and alfalfa hay alone were fed was much more rapid. The feeding of soybeans effected an increase instead of the expected decline in production. A period on beet pulp resulted in a greater than normal decrease in milk yield. Average decline on alfalfa hay alone was about normal. Soybeans again made an incline in the lactation curve when fed after alfalfa hay alone. Soybeans were followed by alfalfa hay again which resulted in a decline greater than the normal. Decrease on wheat bran was less than normal.

Production on this lactation began as might be expected, at a much higher level than the first calf lactation of cow 334. However, when the yield declined to approximately the same level as in the first lactation, production for both lactations remained practically the same throughout.

Experimental cow 336

Records of production and nutrient intake for cow 336 are summarized in Figure 3 and table 7. Milk production on alfalfa hay alone declined markedly during the sixth week. Average production for the six week period was taken as 100 per cent. Milk powder, the first feed substituted, brought about an increase in production the first two weeks, but it decreased the remainder of the period. The amount produced was 94 per cent of the previous period. Total digestible nutrient intake for both the alfalfa and milk powder period was not sufficient to meet the requirements.

The feeding of sugar after milk powder brought about a decided decline in average production for the period with only 74 per cent as much as during the high period. The decline on sugar was practically constant. The digestible nutrients consumed during the period sugar was feed and the remainder of lactation were greater than that required. Alfalfa hay fed after sugar produced a comparatively uniform decline in the production curve and the production was only 60 per cent of the high period. The substitution of ground soybeans for a part of the alfalfa hay checked the rate of decline appreciably. The lactation curve shows an increase in pro-


ALFALFA HAY STUDIES - Cow 336
Eckles Normal
1st Lactation-Alfalfa hay alone after 2 Months. Calved 6-15-37
3rd Lactation-Alfalfa hay plus limited Concentrates. Calved 6-30-39
4th Lactation-Alfalfa hay with various Supplements. Calved 6-12-40
Alfalfa hay alone
Alfalfa Hay
Milk Powder
Sugar
Alfalfa Hay
Soybeans
Beet Pulp
Alfalfa Hay
Soybeans
Alfalfa Hay
Wheat Bran
Average Daily Milk Yield (Pounds)
Week of Lactation
0
5
10
15
20
25
30
35
40
45
50
55
60
65
0
4
8
12
16
20
24
28
32
36
40
44
48
Figure 3

duction for the first three weeks with a slight decline the fourth week. Production for the period was 57 per cent of the highest period. During the feeding of beet pulp following soybeans, production declined steadily the first three weeks of the period. The average yield of the period was 48 per cent of the highest yield.

Milk production declined sharply when the cow was fed alfalfa hay alone after beet pulp with a resulting production of 36 per cent of the highest yield. Soybeans, alfalfa hay alone, and wheat bran were then fed consecutively. None of the feed changes had an appreciable effect on production which might be expected considering the stage of lactation.

Cow 336 decreased about as expected on the first alfalfa hay period. Decline in production while milk powder was fed was a little greater than the decline in the Eckles lactation curve. Sugar and alfalfa hay only caused very rapid declines which brought the level of production below the normal. Soybeans materially increased production as shown by the incline in the production curve. Production decreases were greater and total production less than the corresponding periods of Eckles normal curve when beet pulp, alfalfa hay, soybeans, alfalfa hay alone and wheat bran were fed successively.

The first lactation of cow 336 dropped considerably

Table 7. Average daily consumption and production of cow 336

Days in period	Feed: Alfalfa (pounds)	Feed: Concentrate	Digestible Nutrients: Total: Required (pounds)	Digestible Nutrients: Total: Consumed (pounds)	Digestible Nutrients: Protein: Required (pounds)	Digestible Nutrients: Protein: Consumed (pounds)	Milk (pounds)	Milk yield based on highest period (per cent)
42	40		24.02	20.92	2.91	4.20	48.10	100.00
28	30	2.87# Milk Powder 2.59# Starch	22.53	20.32	2.35	4.10	45.30	94.17
28	30	5.0# Sugar	19.92	20.51	2.20	3.16	35.82	74.46
28	40		18.14	20.92	2.04	4.20	28.86	60.00
28	30	2.9# Soybeans 2.5# Starch	17.51	19.54	1.95	4.15	27.53	57.23
28	30	7.0# Beet Pulp	16.50	21.25	1.75	3.46	23.10	48.02
28	40		15.24	20.92	1.58	4.17	17.37	36.11
28	40	2.9# Soybeans 2.5# Starch	14.45	19.35	1.45	4.12	13.88	28.85
28	40		13.86	20.72	1.36	4.16	11.48	23.86
28	30	7.3# Wheat Bran	13.84	20.78	1.32	4.10	10.09	20.97

below Eckles normal curve after being placed on alfalfa hay alone. Production during the third lactation on limited concentrates was above the normal until the later part of lactation when production dropped below. Early pregnancy may have caused the decline in later lactation.

Experimental cow 341

The lactation curve of cow 341 on various supplements is compared with a lactation curve by the same cow on limited concentrates in Figure 4. Consumption and production data are tabulated in table 8. Alfalfa hay alone was fed for five weeks and average production during the period was considered 100 per cent.

Fish meal, the first substitution for part of the alfalfa hay was fed for five weeks. Production decreased the second, fourth and fifth weeks. Milk production was only 90 per cent of that of the previous period.

The production on soybean oil meal, fed after fish meal was quite irregular, declining approximately six pounds daily from the first through the second week, increasing seven pounds from the second through the third week, and then declining four pounds during the fourth week. During the period on soybean oil meal the average production was 76 per cent of the highest yield. The amount of total digestible nutrients consumed during the

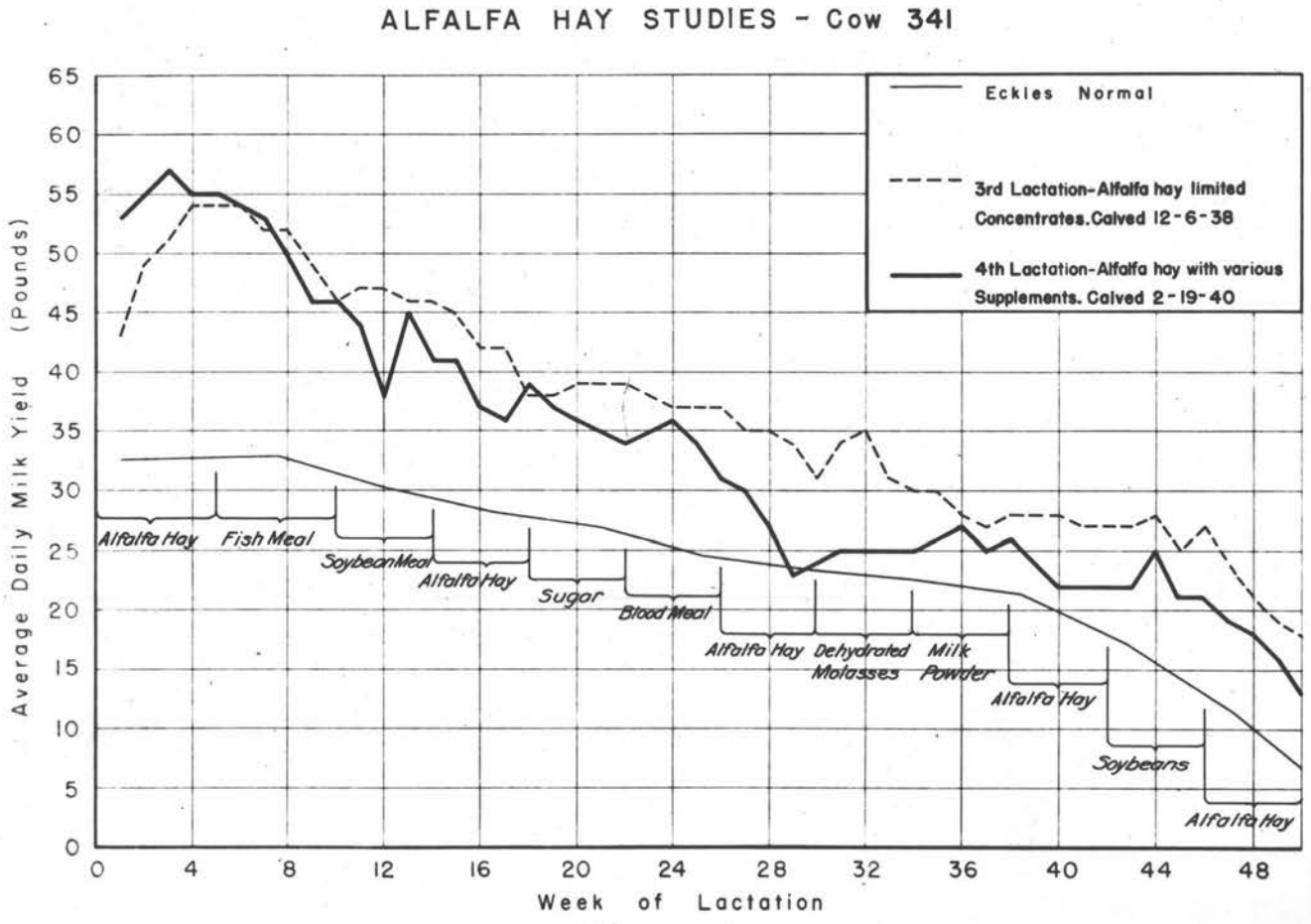

ALFALFA HAY STUDIES - Cow 341
Eckles Normal
3rd Lactation-Alfalfa hay limited Concentrates. Calved 12-6-38
4th Lactation-Alfalfa hay with various Supplements. Calved 2-19-40
Average Daily Milk Yield (Pounds)
Week of Lactation
Alfalfa Hay
Fish Meal
Soybean Meal
Alfalfa Hay
Sugar
Blood Meal
Alfalfa Hay
Dehydrated Molasses
Milk Powder
Alfalfa Hay
Soybeans
Alfalfa Hay

Figure 4

periods when alfalfa hay, fish meal, and soybean meal were fed were insufficient to supply the amount required.

Alfalfa hay alone held the production at the same level the first week following the soybean oil meal feeding. Production then decreased five pounds during the second and third week, and increased the last week of the period. The amount of milk produced in the period was 70 per cent of the highest yield. Sugar feeding followed the alfalfa hay alone period and the decrease in production was fairly constant from week to week throughout the period. The resulting milk production was 64 per cent of the highest yield.

Blood meal fed after sugar raised production the first two weeks, then a five pound decline occurred the last two weeks. A sharp decline occurred during the first three weeks of the alfalfa hay period following blood meal. Production dropped from 62 per cent on blood meal to 47 per cent of the highest yield on hay alone.

Dehydrated molasses substitution in the ration checked the decline, increased production the first week, and maintained production at a constant level the remainder of the period. For this period production was 45 per cent of the highest yield.

Milk powder increased production up to 47 per cent of the highest yield when fed after molasses. Alfalfa

hay alone followed milk powder and resulted in rapid declines the first two weeks and then held production constant the remainder of the period. Production averaged 41 per cent of the high period.

On feeding soybeans production remained at its previous level the first week, increased the second, decreased the third, and remained at the same level the fourth week. Alfalfa hay was fed during the last period and the decline in production was rapid.

Milk production began at a rather high level and remained fairly constant during the first five weeks of the lactation on alfalfa hay only. Large decreases in production occurred on fish meal, soybean oil meal, alfalfa hay alone, and sugar when compared to Eckles normal curve corresponding to the same stage of lactation. The decrease in production during the period when blood meal was fed was approximately normal. The period on alfalfa hay after blood meal resulted in a marked decrease which reduced the production level below Eckles normal. Dehydrated molasses and milk powder raised and maintained the production at a fairly constant level during the periods they were fed. Alfalfa hay alone followed milk powder and decline in production during the period was greater than normal. Soybeans fed after alfalfa hay showed a favorable effect. Alfalfa hay alone

Table 8. Average daily consumption and production of cow 341

Days in period	Feed: Alfalfa (pounds)	Feed: Concentrate	Digestible Nutrients: Total: Required (pounds)	Digestible Nutrients: Total: Consumed (pounds)	Digestible Nutrients: Protein: Required (pounds)	Digestible Nutrients: Protein: Consumed (pounds)	Milk (pounds)	Milk yield based on highest period (per cent)
35	39		25.52	20.17	3.19	4.05	55.49	100.00
28	35	1.0# Fish Meal 1.0# Starch	22.30	19.80	2.74	4.20	50.24	90.53
28	35	1.12# Soybean Meal 1.13# Starch	20.59	20.06	2.47	4.10	42.40	76.41
28	40		19.32	20.98	2.28	4.20	38.89	70.09
28	30	5.0# Sugar	18.80	20.52	2.18	3.18	35.95	64.78
28	30	1.34# Blood Meal 3.99# Sugar	18.79	20.28	2.18	4.03	34.42	62.02
28	40		16.90	20.89	1.89	4.29	26.48	47.72
28	30	6.3# Molasses	16.42	20.43	1.82	3.31	25.23	45.46
28	30	2.87# Milk Powder 2.59# Starch	16.62	20.49	1.82	4.14	26.23	47.26
28	40		15.88	20.93	1.83	4.16	25.00	41.44
28	30	2.9# Soybeans 2.5# Starch	15.91	19.43	1.73	4.15	22.61	40.74
28	40		14.77	20.92	1.54	4.20	17.05	30.72

was again fed and production declined about as expected for stage of lactation.

During the third lactation of cow 341, as shown in figure 4, production was much higher than Eckles normal. The ration consisted of alfalfa hay and mixed protein concentrates.

Experimental cow 356

Lactation curves of cow 356 and a summary of consumption and production data are given in figure 5 and table 9 respectively. The decline in production on alfalfa hay alone was rapid and relatively constant for the first period. The intake of total digestible nutrients was insufficient to meet the requirements on alfalfa hay alone. Beet pulp was then used as a supplement and it did not check the decline in production. The average production on beet pulp was 88 per cent of the previous period.

The production on blood meal, which was fed after beet pulp, showed a decrease the first week, remained at the same level the second and third weeks, and declined sharply the fourth week of the period. Eighty per cent as much milk was produced as the average during the highest period.

Alfalfa hay alone fed after blood meal caused a

marked decline after the first week. The resulting production was only 66 per cent of the highest yield. Dehydrated molasses seemed to stimulate milk flow the first week then production declined through the second and third weeks and increased a small amount the fourth week. The average production on molasses was 57 per cent of the maximum period.

Ground soybeans were fed the period after molasses and they increased production markedly to 59 per cent of the high period yield. The greatest increase in yield came the third week of the period. Milk production declined during the period on alfalfa hay alone following soybeans. Sharp declines occurred the first two weeks and the lower level of production was maintained the last two weeks of the period.

Soybeans were again substituted for a part of the alfalfa hay and brought about a definite increase in milk production from 49 per cent on alfalfa hay alone fed the previous period to 56 per cent of the highest yield. Production for the period reached its highest point during the third week. Alfalfa hay again followed soybeans and production decreased to its former level of two periods previous; namely, 49 per cent of the highest yield.

After the period on alfalfa alone beet pulp was fed.

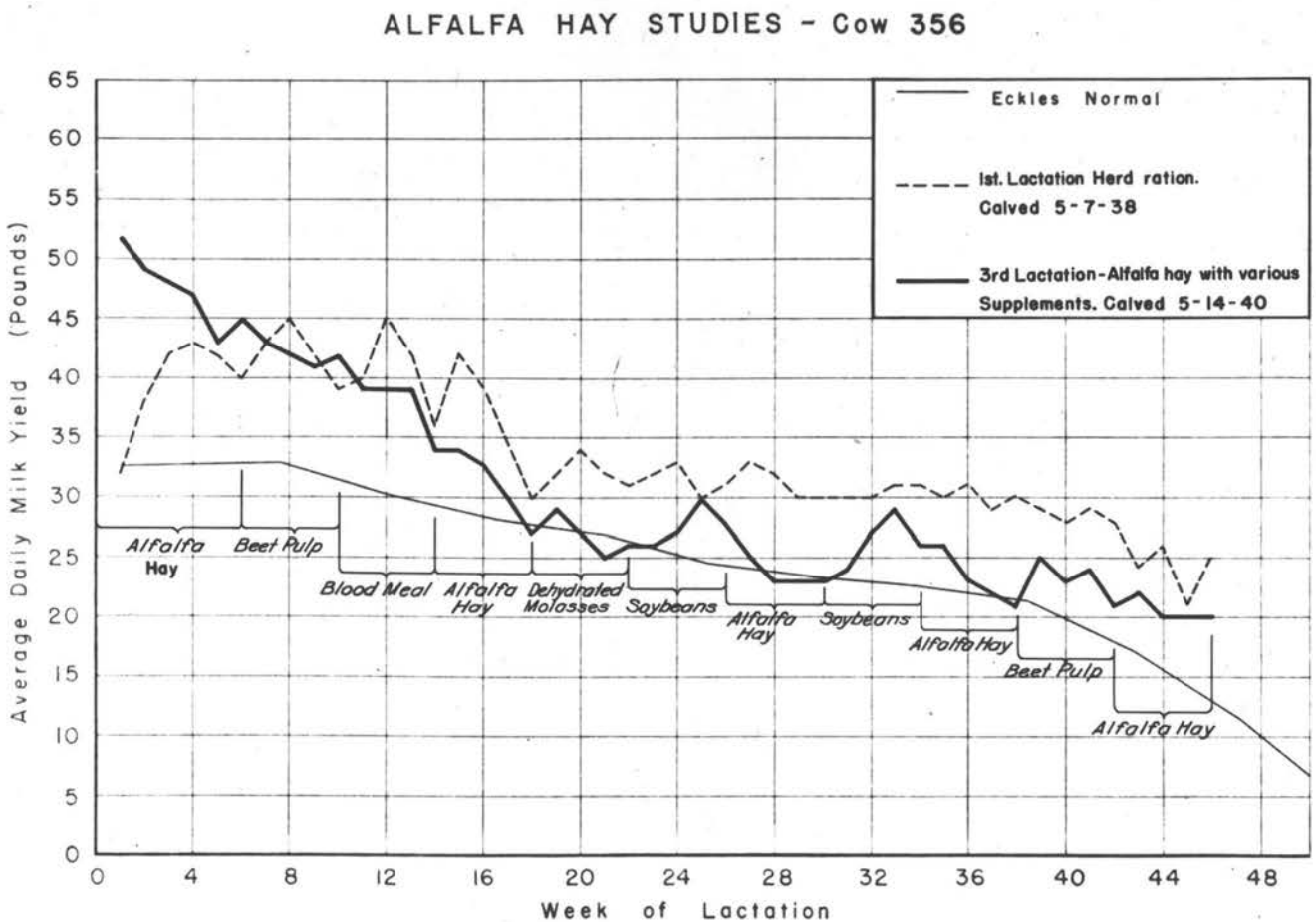

ALFALFA HAY STUDIES - Cow 356
Average Daily Milk Yield (Pounds)
Week of Lactation
Eckles Normal
1st. Lactation Herd ration. Calved 5-7-38
3rd Lactation-Alfalfa hay with various Supplements. Calved 5-14-40
Alfalfa Hay
Beet Pulp
Blood Meal
Alfalfa Hay
Dehydrated Molasses
Soybeans
Alfalfa Hay
Soybeans
Alfalfa Hay
Beet Pulp
Alfalfa Hay

Figure 5

Production increased the first week, decreased the second, increased the third, and decreased again the fourth. The average production of the period was practically the same as on alfalfa, or 49 per cent of the highest yield. Alfalfa hay was again fed and production decreased to 43 per cent of the high yield.

Production declined comparatively fast during the first alfalfa hay period whereas for the corresponding period on the normal lactation curve production increased slightly. The periods beet pulp, blood meal, alfalfa hay alone, and dehydrated molasses were fed the decrease in production was greater than the normal. Soybean feeding brought about a marked increase in production. Milk yields decreased rapidly in alfalfa hay alone after the feeding of soybeans. Another incline in the lactation curve resulted with the feeding of soybeans. Alfalfa hay again caused a sharp decline in production. Decrease in milk yields on beet pulp and alfalfa hay in late lactation were about normal.

Experimental cow 700

Lactation curves, consumption, and production data of cow 700 are presented in figure 6 and table 10. The cow remained on alfalfa hay alone for the first nine weeks of her lactation, and production declined rapidly.

Table 9. Average daily consumption and production of cow 356

Days in period	Feed: Alfalfa (pounds)	Feed: Concentrate	Digestible Nutrients: Total: Required (pounds)	Digestible Nutrients: Total: Consumed (pounds)	Digestible Nutrients: Protein: Required (pounds)	Digestible Nutrients: Protein: Consumed (pounds)	Milk (pounds)	Milk yield based on highest period (per cent)
42	38		23.26	19.96	2.86	4.01	47.68	100.00
28	30	7.0# Beet Pulp	20.09	21.24	2.44	3.48	42.20	88.92
28	30	1.34# Blood Meal 3.99# Sugar	19.39	20.29	2.33	4.03	38.18	80.07
28	40		18.05	20.89	2.10	4.29	31.53	66.12
28	30	6.3# Molasses	16.60	20.38	1.90	3.31	27.20	57.04
28	30	2.9# Soybeans 2.5# Starch	17.08	19.35	1.96	4.12	28.51	59.79
29	40		15.83	20.72	1.78	4.16	23.74	49.79
28	30	2.9# Soybeans 2.5# Starch	16.99	19.54	1.96	4.15	27.04	56.71
28	40		16.00	20.92	1.79	4.20	23.77	49.86
28	30	7.3# Beet Pulp	16.21	31.49	1.82	3.47	23.67	49.64
28	40		15.53	20.92	1.70	4.20	20.96	43.95

Production the first 5 weeks was highest for the lactation and was assessed a value of 100. The second period of 28 days on alfalfa hay alone averaged 78 per cent of the previous period. The policy of feeding alfalfa hay alone followed by two periods of concentrate substitutions and then alfalfa hay again had not been adopted during the earlier part of this cow's lactation. Consequently, meat meal, wheat middlings, peanut meal, and oat groats followed each other successively. Previous to the feeding of oat groats, the amount of nutrients consumed was inadequate to supply the requirements.

Some difficulty was encountered in getting this cow to eat meat meal which was the first feed substitution for part of the alfalfa hay. Average production on meat meal was 72 per cent of the highest period. Wheat middlings followed and production remained at its former level the first week and declined steadily the remaining three weeks of the period. Production was 70 per cent of the high period. Peanut meal was fed the following period and production increased considerably the first week, dropped again the second and third weeks, and raised again slightly the fourth week. The average production for the period was 69 per cent of the highest average yield, indicating a more favorable

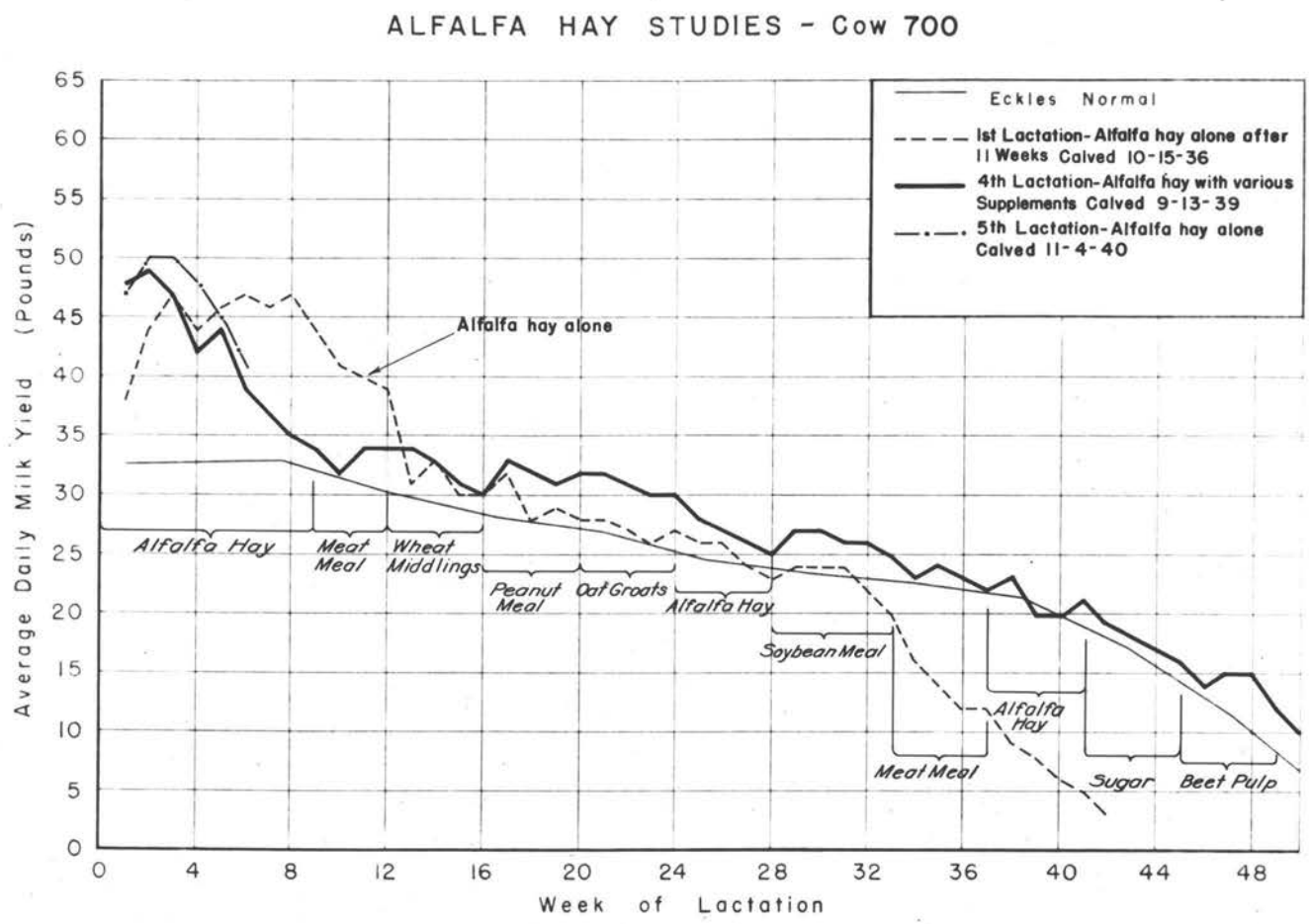

ALFALFA HAY STUDIES - Cow 700
Eckles Normal
1st Lactation-Alfalfa hay alone after 11 Weeks Calved 10-15-36
4th Lactation-Alfalfa hay with various Supplements Calved 9-13-39
5th Lactation-Alfalfa hay alone Calved 11-4-40
Alfalfa hay alone
Alfalfa Hay
Meat Meal
Wheat Middlings
Peanut Meal
Oat Groats
Alfalfa Hay
Soybean Meal
Meat Meal
Alfalfa Hay
Sugar
Beet Pulp
Average Daily Milk Yield (Pounds)
Week of Lactation
0
5
10
15
20
25
30
35
40
45
50
55
60
65
0
4
8
12
16
20
24
28
32
36
40
44
48

Figure 6

effect than wheat middlings.

Oat groats held production at its former level the first week. The second and third weeks milk decreased and held at the same level the fourth week. Average production was 66 per cent of the highest period. The change to alfalfa hay alone after oat groats resulted in more rapid and steady decline in production to 58 per cent of the high period. Soybean meal feeding checked the decline occurring when alfalfa alone was fed, the average production for the period being 57 per cent of the highest yield. Soybean meal was fed over a period of five weeks. The lactation curve showed an incline the first week, the same level the second, decline the third, the same level the fourth, and another decline the fifth week of the period.

Meat meal was the concentrate fed after soybean meal. A rise in production occurred the second week and a decline the other weeks of the period. Average production was 51 per cent of the high period. The lactation curve on alfalfa hay alone following meat meal shows an increase the first week, a three pound decline during the second, and maintenance at the same level the third, and an increase the fourth week. Average production decreased to 46 per cent of the high period. A constant decline occurred during the 4 week sugar

Table 10. Average daily consumption and production of cow 700

Days in period	Feed: Alfalfa (pounds)	Feed: Concentrate	Digestible Nutrients: Total: Required (pounds)	Digestible Nutrients: Total: Consumed (pounds)	Digestible Nutrients: Protein: Required (pounds)	Digestible Nutrients: Protein: Consumed (pounds)	Milk (pounds)	Milk yield based on highest period (per cent)
35	35		24.20	18.26	3.05	3.70	46.57	100.00
28	35		19.81	18.27	2.46	3.67	36.75	78.91
21	30	1.5# Meat Meal 1.5# Starch	19.19	17.84	2.34	3.88	33.76	72.49
28	30	3.25# Wheat Middlings	18.36	18.20	2.19	3.61	32.82	70.47
28	30	2.8# Peanut Meal 0.2# Starch	18.46	17.99	2.21	4.24	32.16	69.05
28	30	3.0# Oat Groats	17.87	18.43	2.12	3.59	31.10	66.78
28	35		16.78	18.22	1.94	3.65	27.09	58.17
35	30	1.25# Soybean Meal 1.25# Starch	16.16	17.45	1.87	3.58	26.60	57.11
28	30	1.0# Meat Meal 1.0# Starch	15.55	17.02	1.75	3.58	26.60	51.01
28	35		15.29	18.17	1.70	3.65	21.61	46.40
28	25	5.0# Sugar	14.60	17.69	1.59	2.66	18.00	38.65
28	25	7.0# Beet Pulp	14.19	17.13	1.51	2.86	14.63	31.41

feeding period with a resulting production of 38 per cent of the high. Production on beet pulp after sugar showed a decrease the first, an increase the second, the same level the third, and a decrease again the fourth week of the period. The production for the period was 31 per cent of the highest yield.

Production on alfalfa hay alone declined rapidly during the preliminary periods as compared to Eckles normal. Meat meal checked the decline but the decrease on wheat middlings was greater than the expected. Peanut meal, and oat groats fed consecutively held the rate of decline above the expected as shown by comparing the normal and experimental lactation curves. The decrease in production occurring on alfalfa after oat groats was greater than for the normal for the corresponding period of time. Soybean oil meal after alfalfa hay checked the rate of decline of the previous period and the rate of decline was comparatively normal. Production decreases on meat meal, alfalfa hay alone, sugar and beet pulp followed closely the expected.

Per cent fat

Figure 7 gives the per cent of fat of the composite milk samples tested weekly. This shows that there was

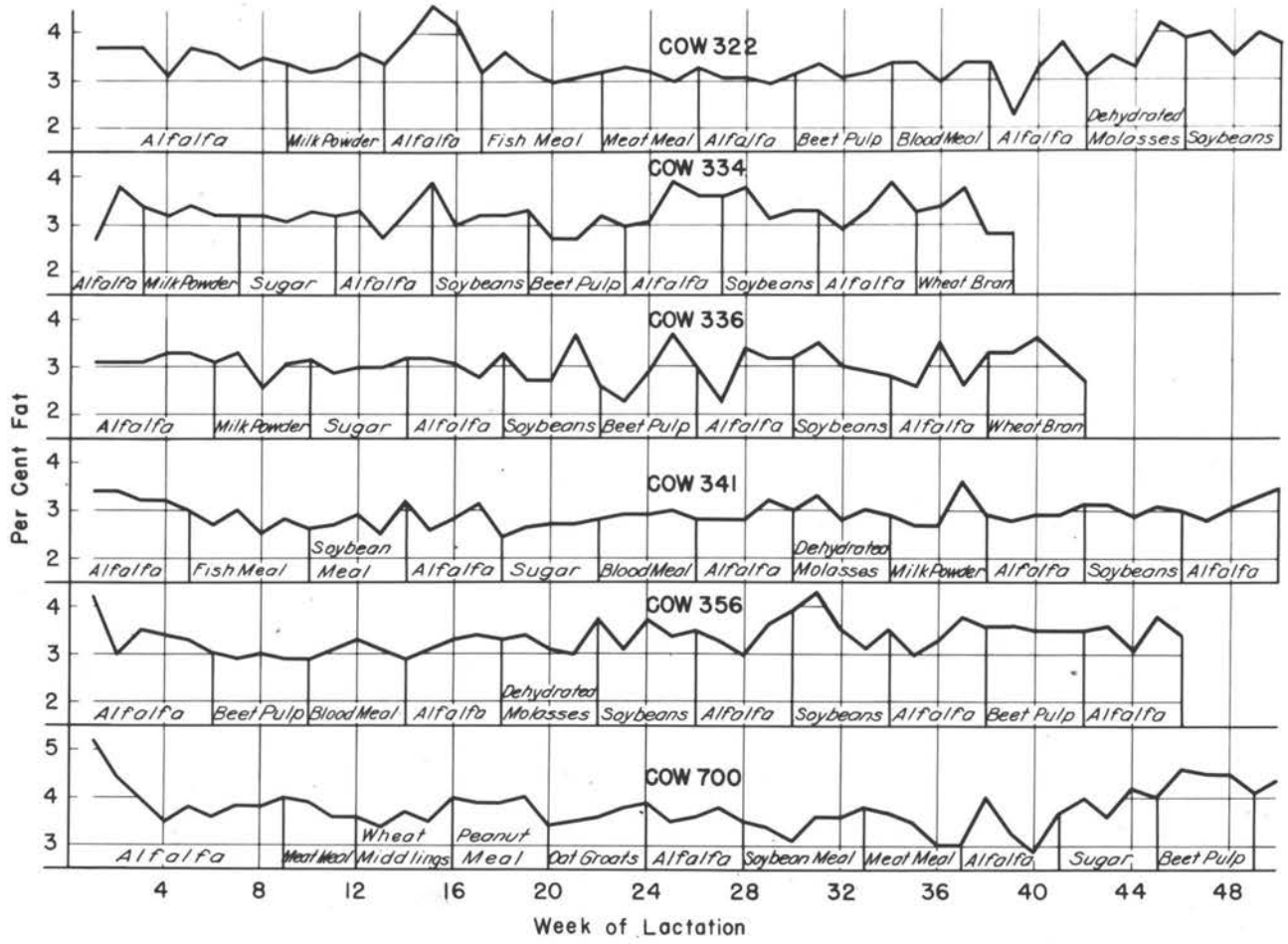

COW 322
Alfalfa
Milk Powder
Alfalfa
Fish Meal
Meat Meal
Alfalfa
Beet Pulp
Blood Meal
Alfalfa
Dehydrated Molasses
Soybeans
COW 334
Alfalfa
Milk Powder
Sugar
Alfalfa
Soybeans
Beet Pulp
Alfalfa
Soybeans
Alfalfa
Wheat Bran
COW 336
Alfalfa
Milk Powder
Sugar
Alfalfa
Soybeans
Beet Pulp
Alfalfa
Soybeans
Alfalfa
Wheat Bran
COW 341
Alfalfa
Fish Meal
Soybean Meal
Alfalfa
Sugar
Blood Meal
Alfalfa
Dehydrated Molasses
Milk Powder
Alfalfa
Soybeans
Alfalfa
COW 356
Alfalfa
Beet Pulp
Blood Meal
Alfalfa
Dehydrated Molasses
Soybeans
Alfalfa
Soybeans
Alfalfa
Beet Pulp
Alfalfa
COW 700
Alfalfa
Meat Meal
Wheat Middlings
Peanut Meal
Oat Groats
Alfalfa
Soybean Meal
Meat Meal
Alfalfa
Sugar
Beet Pulp
Per Cent Fat
Week of Lactation
4
8
12
16
20
24
28
32
36
40
44
48

Figure 7

a marked variation in the fat percentage of all cows at times during the lactation. However, it seems that there was no consistent increase or decrease of fat percentage concomitant with the different periods of feeding. There did not appear any correlation of the butterfat test with the season of the year. This effect is not ordinarily expected to be great under Oregon climatic conditions.

Body weights

The weight data for the cows are presented in figure 8. Body weights are given three weeks prior to calving when such weights were available. Average daily weights are plotted by weeks throughout the lactation periods. Daily body weights were not taken until the later part of the lactation of cows 322 and 700; consequently, their weight curves show more fluctuations than the other four cows. The cows usually lost weight in early lactation on the ratioh of alfalfa hay alone.

Breeding performance

All cows used in this study, except 356, had been on alfalfa hay experiments during one or more of their previous lactations. Reference to table 1 shows that their past breeding records have been comparatively

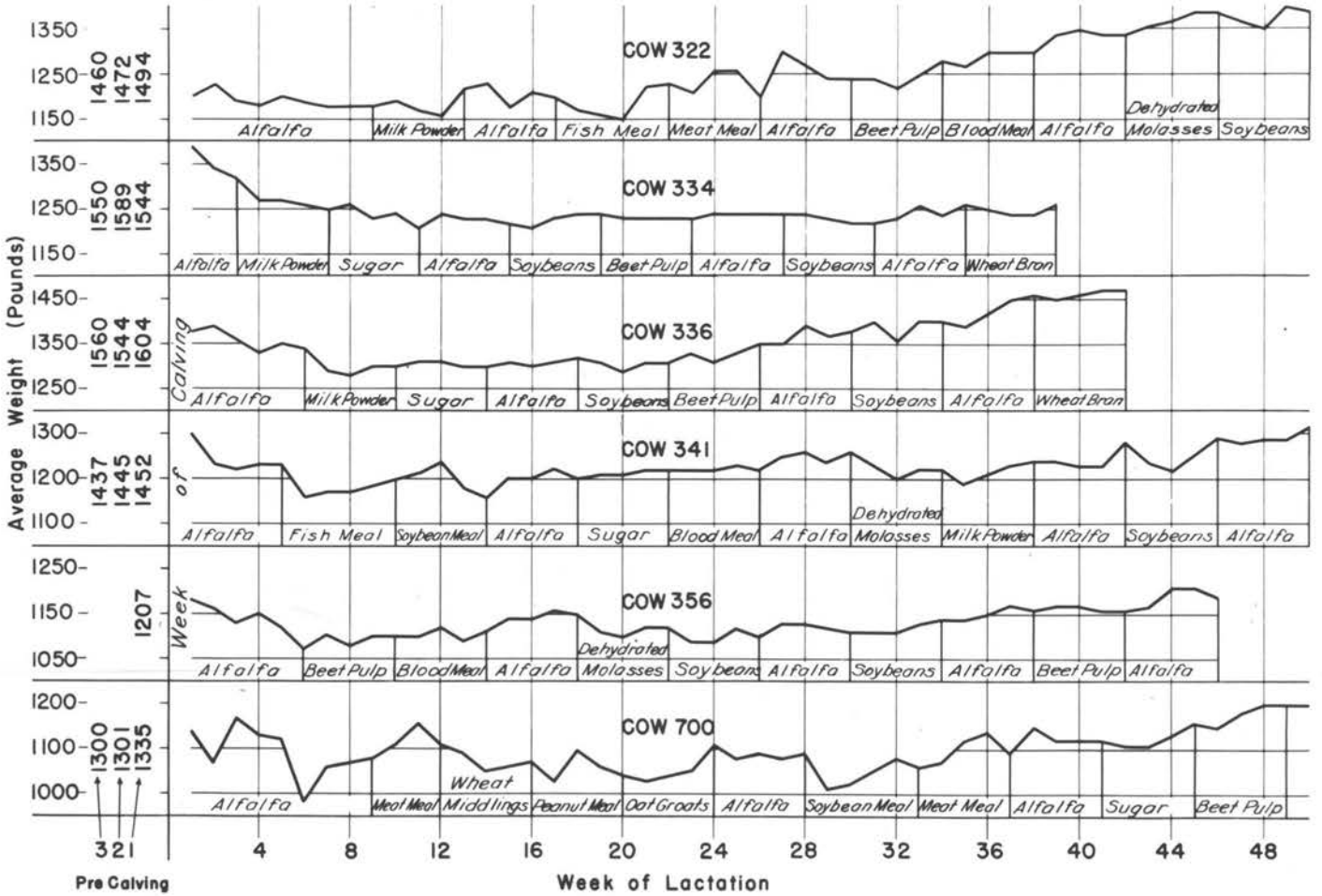

Average Weight (Pounds)
COW 322
1460 1472 1494
Alfalfa
Milk Powder
Alfalfa
Fish Meal
Meat Meal
Alfalfa
Beet Pulp
Blood Meal
Alfalfa
Dehydrated Molasses
Soybeans
COW 334
1550 1589 1544
Alfalfa
Milk Powder
Sugar
Alfalfa
Soybeans
Beet Pulp
Alfalfa
Soybeans
Alfalfa
Wheat Bran
COW 336
1560 1544 1604
Calving
Alfalfa
Milk Powder
Sugar
Alfalfa
Soybeans
Beet Pulp
Alfalfa
Soybeans
Alfalfa
Wheat Bran
COW 341
1437 1445 1452
of
Alfalfa
Fish Meal
Soybean Meal
Alfalfa
Sugar
Blood Meal
Alfalfa
Dehydrated Molasses
Milk Powder
Alfalfa
Soybeans
Alfalfa
COW 356
1207
Week
Alfalfa
Beet Pulp
Blood Meal
Alfalfa
Dehydrated Molasses
Soybeans
Alfalfa
Soybeans
Alfalfa
Beet Pulp
Alfalfa
COW 700
1300 1301 1335
Alfalfa
Meat Meal
Wheat Middlings
Peanut Meal
Oat Groats
Alfalfa
Soybean Meal
Meat Meal
Alfalfa
Sugar
Beet Pulp
3 2 1
Pre Calving
4 8 12 16 20 24 28 32 36 40 44 48
Week of Lactation

Figure 8

normal. Their breeding performance during the experimental lactations is presented in table 11. Cows 322 and 700 are the only ones to have calved again since completing the lactation with which this report is concerned. All cows required two services for conception with the exception that cow 356 required five services. Delayed heat periods accounted for the long interval between calving and conception.

Table 10. Breeding performance during the experimental lactation period

Cow number	Date of calving	Time from calving to first heat period	Times bred	Time from calving to conception	Length of gestation period	Calving condition	Sex of calf	Weight of calf
322	12-2-39	99	2	118	279	Normal	Female	110
334	7-6-40	62	2	225				
336	6-12-40	50	2	188				
341	2-19-40	79	2	165				
356	5-14-40	45	5	274				
700	9-13-39	12	2	138	280	Normal	Male	75

DISCUSSION OF RESULTS

Every feeding method has its advantages and disadvantages for studying lactation performance in dairy cattle. The method used in this study was to determine the amount of alfalfa hay a particular cow could consume the first 3 to 8 weeks after parturition. Following this period on hay alone the daily hay allowance was reduced by 5 to 10 pounds and the total digestible nutrients and digestible protein were replaced by equal amounts of various commonly fed concentrates and starch or sugar. In view of the fact that protein is not stored in appreciable amounts in the body, it was thought that abrupt changes in protein concentrates would demonstrate their value in supplementing alfalfa protein.

A reduction of 10 pounds of hay and the feeding of a concentrate supplement of less dry matter and bulk changed considerably the physical nature of the ration. The significance, if any, of such a change, remains to be determined.

Reference to the feed consumption tables of the individual cows shows that the amount of total digestible nutrients consumed was quite constant throughout the entire lactation and greater than the requirements except in early lactation. Due to the differences in the assumed and actual analysis there was a somewhat lower amount of total digestible nutrients consumed during the ground

soybean periods and a somewhat higher amount during the molasses beet pulp periods. Insofar as the digestible protein consumed is concerned this amounted to from 23 to 60 per cent more than the requirements of the individual cows in early lactation on alfalfa hay alone. Inasmuch as production declined as lactation advanced the protein supplied was always greater than requirements. However, in the periods when sugar, molasses, and beet pulp were fed there was a 10 to 20 per cent reduction in the protein intake.

Milk powder

Milk powder was fed to four different cows. To three of the cows milk powder was fed after the period on alfalfa hay alone at the beginning of each cow's lactation. For two of the cows on alfalfa for three weeks, figure 2, and 6 weeks, figure 3, the milk yields were 97 and 94 per cent of the highest average period yields respectively. The other cow was on alfalfa hay alone for eight weeks, figure 1, and her production was 88 per cent of the highest average period, which was the second four weeks on alfalfa hay alone. Milk powder fed to the fourth cow after dehydrated molasses in late lactation, figure 4, increased the yield by two per cent over the yield on dehydrated molasses. The decline in production was in all cases less than expected when skimmilk powder

was fed, indicating a supplementary effect.

Fish meal

Two cows received fish meal. Fish meal was fed in middle lactation after alfalfa hay alone to one cow, figure 1, and production dropped from 72 per cent of the high yield on alfalfa hay alone to 71 per cent. The other cow received fish meal after the preliminary hay feeding period, figure 4, and production was 90 per cent of the 100 per cent period.

Meat meal

Meat meal was fed for two periods to one cow and for one period to another cow. The first meat meal period for the first cow, figure 6, was after the second alfalfa hay alone period at the beginning of lactation. The second period on alfalfa hay production averaged 78 per cent of the high yield and the average on meat meal was 72 per cent. The second period on meat meal for the same cow was past middle lactation after a soybean oil meal period. Average production for the period was 51 per cent of the high. Meat meal was fed to the second cow after a fish meal period, figure 1, and production was 63 per cent of the average maximum yield as compared to 71 per cent for the previous period.

Molasses beet pulp

Beet pulp was fed five periods; once each to four cows and twice to another cow. Beet pulp was fed to one cow, figure 5, after a preliminary 6 week period on alfalfa hay alone and production was only 88 per cent of the previous period. The same cow received beet pulp again in late lactation after an alfalfa hay alone period. Production during the period was 49 per cent of the high being the same average production as was obtained the previous period. An increase of 4 per cent in production over the previous period occurred with a second cow, figure 4, when beet pulp was fed beginning with the thirtieth week of lactation after alfalfa hay alone. A third cow, figure 3, received beet pulp after soybeans in middle lactation. Production for the period was 58 per cent of the high, and showed a marked decline from the soybean period. Beet pulp was fed to a fourth cow, figure 2, after soybeans in middle lactation and production averaged 48 per cent of the maximum average yield. The fifth cow received beet pulp in late lactation, figure 6, after a period on sugar and decline in production was about as expected.

Blood meal

Three cows received the high protein concentrate, blood meal. Blood meal followed the period beet pulp

was fed, figure 5, in early lactation to one cow. The average yield for the period was 80 per cent of the high period, and the rate of decline about the same as when alfalfa hay alone or beet pulp was fed. Blood meal was fed another cow, figure 1, past middle lactation after a beet pulp period. Production was 64 per cent of the high as compared to 67 per cent the preceding period on beet pulp. Another cow, figure 4, received blood meal in middle lactation after a sugar feeding period. The resulting milk production was 62 per cent of the highest yield whereas production on sugar the previous period was 64 per cent.

Dehydrated molasses

Dehydrated molasses was fed one period to each of three cows. To one cow, figure 5, dehydrated molasses was fed in middle lactation after alfalfa hay alone. Production for the alfalfa hay period was 66 per cent and for the dehydrated molasses period 57 per cent of the high yield. Dehydrated molasses was fed to the second cow, figure 4, in the middle part of lactation after an alfalfa hay period. For the period production was 45 per cent, and on alfalfa hay alone the previous period production was 47 per cent of the highest average yield. The third cow, figure 1, was not fed dehydrated molasses until the later part of lactation after an

alfalfa hay alone period. Production during the period was below the Eckles' normal.

Soybeans

Ground soybeans were fed two periods each to three cows and once each to two other cows. One cow, figure 5, received soybeans for two periods in middle lactation; once after dehydrated molasses and again after alfalfa hay. Production increased above the average of the previous periods by 2 per cent and by 7 per cent respectively. When placed on hay alone again production declined rapidly. Soybeans were fed to a second cow, figure 2, after an alfalfa hay period in early lactation and after an alfalfa hay period in middle lactation. Milk production increased 1 per cent and 5 per cent respectively above the average of the alfalfa hay periods. Soybean feeding followed alfalfa hay periods in middle and late lactation to a third cow, figure 3. The first period soybeans were fed, production of 57 per cent of the high was obtained while on alfalfa the previous period production was 60 per cent of the high, a production better than expected. Production during the second period on soybeans for the same cow was normal. Soybeans were fed after alfalfa hay to a fourth cow, figure 4, in late lactation and the production during the period averaged practically the same as the previous period, or higher than normal. The fifth cow, figure 1, received

soybeans the last period of her lactation and showed no response to the feed substitution.

The feeding of ground soybeans as a substitution for part of the alfalfa hay markedly decreased the rate of decline in milk production over the previous period, during 6 of the 8 periods fed. The other two periods being late in lactation showed no effect. The chemical analysis of soybeans showed them to contain 20 per cent fat. The dry matter of the ration contained 4.15 per cent fat when soybeans were substituted as compared to about 2.5 per cent during the other periods. As previously indicated there was an actual decrease in the amount of total digestible nutrients furnished during the periods when ground soybeans were fed if reported digestion coefficients are applied to the actual chemical analyses figures obtained. No consistent increases were observed in fat percentages, figure 7, when soybeans were fed, the effect being on the amount of milk produced.

Sugar

Four cows received sugar during one period of their lactation. Sugar was fed after milk powder to one cow, figure 2, in early lactation. Production declined from 97 per cent of the high on milk powder to 73 per cent of the high on sugar. Another cow, figure 3, received sugar after the milk powder in early lactation. Production

on sugar was 74 per cent of the high as compared to 94 per cent of the high on milk powder. A third cow, figure 4, was fed sugar in middle lactation following an alfalfa hay alone period. On alfalfa hay alone the average production for the period was 70 per cent of the high yield, and when sugar replaced part of the hay the production was 64 per cent of the maximum yield. Sugar feeding followed an alfalfa hay period when fed to the fourth cow, figure 6, in late lactation. Decline in production was about as expected. It would seem that the decreased digestible protein and fat intake in the early stages of lactation when sugar was fed resulted in a more rapid decline in production. As to whether the reduction in protein or fat caused the effect cannot be definitely stated at this time.

Wheat bran

Wheat bran was fed to two cows in late lactation following alfalfa hay periods. Production for one cow, figure 2, during the period wheat bran was fed was 50 per cent of the high or a decline of only 1 per cent below the production of the previous period. Wheat bran was fed so late in lactation to the other cow, figure 3, that no appreciable effect on production was observed.

Soybean meal

Two cows received soybean oil meal during their experimental lactation. One cow, figure 4, was fed soybean oil meal after fish meal in early lactation. Production on fish meal was 90 per cent of the high and on soybean oil meal 76 per cent. The other cow, figure 6, received soybean oil meal in the later part of middle lactation after a period on alfalfa hay. Production decreased from 58 per cent of the high on alfalfa hay alone to 57 per cent on soybean oil meal. In view of the effect of substituting ground soybeans, further study with soybean meal should give information as to whether the effect of the soybeans was due to their protein or fat content.

Peanut meal

Peanut meal was fed one period to one cow, figure 6, in early lactation after wheat middlings. Production was 69 per cent of the high which was 1 per cent below the average production on wheat middlings, indicating a favorable effect of the peanut meal feeding.

Oat groats

Oat groats were fed to one cow, figure 6, one period in middle lactation after peanut meal. Average production was 66 per cent of the high and for the preceding period 69 per cent, or somewhat better than normal.

Wheat middlings

For one period one cow, figure 6, received wheat middlings after meat meal in early lactation. The average production on meat meal was 72 per cent of the high and on wheat middlings 69 per cent.

SUMMARY

Either the rate of decline decreased or there was an increase in production in early or middle lactation when soybeans were substituted for part of the alfalfa hay in the ration. Whether the effect of the soybeans was due to the increased fat intake or to protein supplementation cannot be definitely stated at this time. The total digestible nutrient intake was lower during the periods when ground soybeans were fed.

Skim-milk powder seemed to supplement the deficiencies of alfalfa ration somewhat more effectively than the other protein concentrates of animal origin.

Large decreases in production resulted when sugar was substituted for an amount of hay equivalent in energy. Whether the effect was due to the decreased fat or decreased protein intake, or both, cannot be stated at the present time.

The decline in production when the cows received the ration of alfalfa hay only, whether in early, middle, or late lactation was practically always much more rapid

than when part of the alfalfa hay was replaced by equal amounts of digestible protein and total digestible nutrients in the various concentrates used. This either indicates a deficiency in the quality of alfalfa protein inasmuch as the amount supplied was much greater than the requirements, or the commonly used digestion coefficients for the various concentrates are too low when fed at a low level to milking cows, or the digestion coefficients for high quality alfalfa hay when fed to dairy cows to the limit of their capacity are too high.

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