Bulletin No. 216

Potatoes As a Feed for Dairy Cows

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MOSCOW, IDAHO MAY, 1935

Published by the University of Idaho, Moscow, Idaho

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THE annual gross income from the potato crop in Idaho makes it one of the most important crops in the state. During the six-year period 1929-1934 the crop averaged about 20 million bushels. Whether the potatos are grown for market or for seed they should be graded. The cull potatoes may be used for livestock feed. Ordinarily, standard grades of potatoes are too high priced to be considered for that purpose. Some years, however, the market price is so low that the cost of digging, grading, and sacking does not justify the farmer in attempting to ship his crop.

Each year thousands of tons of cull potatoes, and some years a large percentage of the entire crop, are available for livestock feed. Utilization of these waste products to advantage is not only a serious consideration in livestock management, but also is of economic importance to all persons interested in increasing the annual gross income of the state. The interest in potatoes as a livestock feed is greatest in years of low potato prices.

In Germany 40 per cent of the potato crop is fed to livestock, while in the United States not to exceed 5 per cent of the total is used in this manner. (3) Many dairymen in southern Idaho have fed potatoes to their cows with variable results. Recommendations to farmers in regard to feeding potatoes have differed considerably. The tonnage available annually, together with the lack of established feeding practices, justified the feeding trials reported in this publication.

Review of Literature

Several investigators (7, 9, 16, 18) have reported that raw potatoes were equal to corn silage when used for fattening steers and lambs. It is recommended (5, 16, 19, 24) that potatoes should always be cooked when fed to hogs.

Although it has been suggested (4, 12, 14, 16, 17, 19, 22, 23) that cull potatoes or surplus potato crops might be utilized by feeding them to dairy cows, relatively few feeding trials have been conducted on the value of potatoes as a dairy feed. In 1914 Lindsey (15) reported that three dairy cows were fed potatoes in varying amounts up to 50 pounds daily and natural decline in milk production was checked in 2 of the 3 cases. No comparison was made, however, with any other feed. One of the earliest feeding trials were reported by Hills (10) in 1892. He compared raw potatoes with corn silage for dairy cows, concluding that, "The potato ration was eaten more freely than was the silage, yet produced neither more nor better milk. A hundred pounds of dry matter and of digestible dry matter in corn silage proved superior to similar amounts in potatoes." Butter from the potato-fed cows was "judged to be on the whole the most salvy."

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One of the most complete investigations of potatoes as a feed for dairy cows was reported by Dice (3), 1931, of the North Dakota Agricultural Experiment Station. When the cows were fed 25 to 40 pounds of potatoes daily they produced as much milk and fat as when fed silage, the same quantities of feed and digestible nutrients being consumed on the two rations. He stated that the potatoes were not quite so palatable as corn silage and more laxative than the silage.

Isaachsen (13) reported, after three years' comparison of potatoes with turnips, that in quantities of 6, 10, or 11 kg. per head daily (approximately 13 to 24 pounds), potatoes replaced similar quantities of dry matter in turnips in the ration of 12 cows. No unfavorable influence on the quality of the butter or its chemical characteristics (Iodine number, Reichert-Meissl number, or water content), nor on the general health and well-being of the cows, resulted from the feeding of potatoes.

Feeding trials by Woodward (25) and associates showed potato silage to be equal to corn silage for butterfat production and in palatability. Another trial showed that 1.28 pounds of dried potato meal were equal to 1 pound of corn meal.

Voltz and Dietrich (20) compared raw, steamed, and ensiled raw and steamed potatoes for milk production. Steamed potatoes and ensiled raw potatoes had little effect on the milk yield as compared with the basal ration of meadow hay, oat straw, and brewers' grains. Material increases were obtained when ensiled steamed potatoes were fed. Highest yield was obtained from raw potatoes, the yield being 2.5 times the yield from steamed potatoes.

Maynard (16) cites investigations in Sweden showing that raw potatoes have as high feeding value as cooked potatoes for dairy cows.

A number of writers (16, 19, 21) have mentioned the poisonous material, solanin, which is regularly found in all parts of the tuber but in dangerous quantities only in unripe, green, or sun-burned potatoes and sprouts. Rotting does not change the solanin content. Hansen (8) reported cases of solanin poisoning and attributed it to some form of bacterial toxin instead of to solanin as he concluded that solanin was hydrolized in the gastro-intestinal tract into solanidin, which is practically insoluble. Holt (11) reports yearling heifers died in a short time from potato poisoning when small potatoes containing many sun-burned and green tubers were fed. Dice (3) reported that, "Cows were fed considerable periods on potatoes that were (a) partly decomposed, (b) sprouted, (c) sun-burned, (d) that had been frozen and thawed out for short and long periods, (e) that were decomposed, sprouted, and sun-burned, and (f) on potato sprouts,—but in no case did the animals show any evidence whatever of toxic symptoms from possible poisonous properties in the potatoes or potato sprouts, and only one case of slight digestive disturbance occurred."

Many writers state that butter made from milk produced by cows fed potatoes is salvy, basing their statements on the early writings of Kellner (14) or on experiments that are either not conclusive or are questionable due to the small lot of cream churned by hand. More recent work done by Dice (3) failed to show any difference between butter from potato-fed

cows and butter from silage-fed cows, as measured by texture of the butter, mechanical tests for hardness, and Iodine numbers and Reichert-Meissl numbers of the samples.

It has also been suggested that feeding potatoes causes off-flavors in the milk and cream. In carefully controlled experiments by Babcock (1) flavors and odors were so slight that they would seldom be perceived by the average customer, even when 14.8 pounds of potatoes were fed just before milking. No definite potato odor was found. Brannon (2) has shown that a potato flavor in cream may be caused by organisms. Dice (3) was unable to obtain potato-flavored milk, even when special effort was made to do so by feeding large quantities of potatoes just before milking. His results show, however, that milk and cream readily absorb potato flavors from the air.

Potatoes Compete with Alfalfa Hay as a Feed

The price of cull potatoes is of little concern to the farmer who has a supply on hand and enough cows to feed them to. His dairy cows help him market what might otherwise be wasted. But, to the dairyman who is buying cull potatoes as a feed for his cows, the price is important and should be in line with their feeding value.

In southern Idaho alfalfa hay is the basic feed for dairy cows and is usually the cheapest source of nutrients. It is well to bear in mind that both potatoes and corn silage are succulent roughages and when added to the ration they replace part of the alfalfa hay. In other words, when potatoes are purchased they compete with alfalfa hay as a cheap source of nutrients. Unless total digestible nutrients can be purchased as cheaply in potatoes as in alfalfa hay there usually would be little object in buying them in preference to hay.

Potatoes are worth about one-third the value of hay on the basis of the total digestible nutrients contained in each feed (*Table II*). When alfalfa hay is valued at $6.00 per ton, potatoes would be worth $2.00 per ton. It is interesting to note that the price of potatoes per bushel should be the same in cents as hay is in dollars per ton; that is, when hay is valued at $8.00 per ton, potatoes would be worth 8 cents per bushel. One of the reasons why alfalfa hay is such a cheap source of nutrients compared with other feeds in southern Idaho is because it is sold "in the stack" with no added costs, such as delivery, baling, etc., that prevail in some areas. Nevertheless, in general, other feeds purchased must compete with hay at existing prices as a cheap source of total digestible nutrients.

Feeding Trials

In Trials I and II raw potatoes were compared with corn silage as succulent feed for dairy cows under conditions otherwise as nearly standardized as possible. Six purebred cows, four Holsteins and two Jerseys were selected from the University of Idaho herd for use in Trial I. Eight Holstein cows were used in Trial II. In each trial the cows were divided into two groups as equally as possible in regard to breed, weight, age, production, and periods of lactation and gestation.

The trials covered a period of 120 days, consisting of three experimental periods of 30 days each, with a 10-day preliminary period preceding each experimental period. The double reversal system of feeding was used. Cows in Group I of each trial were fed corn silage during the first and third periods and raw potatoes the second period. Simultaneously, cows in Group II were fed raw potatoes in the first and third periods and corn silage the second.

In preliminary feeding the amount of hay and succulent feed each cow would readily consume in addition to the grain mixture was determined. During all three experimental periods an attempt was made to keep the daily consumption of hay and succulent feeds constant for each cow. The grain was varied according to production, the Holsteins being fed at the rate of 1 pound of grain to 3 pounds of milk produced and the Jerseys at the rate of 1 pound to 2½ pounds of milk. Changes in the amount of grain fed daily were made every fifth day.

The grain mixture used was as follows:

350 lbs. wheat bran
200 lbs. ground barley
200 lbs. ground oats
100 lbs. linseed meal
100 lbs. cottonseed meal
36 lbs. mineral salt

Chemical analysis of feeds used as determined from composite samples are shown in Table III. Corn silage and potatoes are very similar in dry matter and protein content, but the potatoes are lower in crude fiber and higher in nitrogen-free-extract. The potatoes were culls, most of them being small, but only sound potatoes were fed. They were sliced by running them through a beet cutter to prevent the cows' choking. The alfalfa hay and corn silage were typical for this area.

Trial III, in which cooked potatoes were compared with raw potatoes, was conducted under the same general plan as Trials I and II, the exceptions being that the experimental periods covered 20 days instead of 30 and only two experimental periods were used for each group instead of three. Group I was fed raw potatoes the first period and cooked potatoes the second, while Group II was fed just the reverse.

The potatoes were cooked by turning live steam into a closed vessel containing the potatoes. The cooking was not always as complete as it might have been. Each cow's allowance of potatoes was weighed out and cooked separately and all the potatoes and juices fed to the cow. For that reason no analysis was made of the cooked potatoes, the nutrients in the original raw potatoes being used for calculations.

Results

A summary of the results of the three feeding trials is presented in Table IV. The average of the first and third periods was compared with the second period in Trials I and II to offset decline in milk production and to control other factors as the experiment progressed. The average of both groups together in Trial III shows the results obtained from the eight cows while on raw potatoes and while on cooked potatoes. The fact that the cows in each of the six groups produced an average of about

a pound of butterfat daily indicates that the cows were producing enough to be sensitive to any marked differences in the rations.

Raw Potatoes Compared with Corn Silage

The results obtained in the two trials in which raw potatoes were compared with corn silage showed that in Trial I the average daily feed consumption per cow for the two groups was 29.0 pounds of silage, 14.0 of hay, and 8.4 of grain mixture when corn silage was fed, and 32.2 pounds of potatoes, 15.5 of hay, and 8.4 of grain mixture when raw potatoes were fed. Milk and butterfat production on the two feeds was quite similar, being 24.2 pounds of milk and 0.98 of a pound of butterfat per cow daily when silage was fed and 24.3 pounds of milk and 0.97 of a pound of butterfat when raw potatoes were fed. When the milk and butterfat were corrected to 4 per cent milk ("fat-corrected basis" [6]) the daily production per cow was 23.8 pounds on corn silage and 24.2 pounds on potatoes.

The average weights of the cows when placed on the two rations were quite close, 1234 pounds when started on the corn silage ration and 1217 when started on the potato ration. The increases in weight were about equal on both rations, being 33 pounds per cow on corn silage and 27 pounds on potatoes.

The daily consumption of nutrients per cow was 2.47 pounds of digestible crude protein and 17.63 pounds of total digestible nutrients when corn silage was fed and 2.54 pounds of digestible crude protein and 19.99 pounds of total digestible nutrients when raw potatoes were fed. The nutrients consumed per 100 pounds of 4 per cent milk produced were 10.38 pounds of digestible crude protein and 74.08 pounds of total digestible nutrients on the corn silage ration and 10.49 pounds of digestible crude protein and 82.60 pounds of total digestible nutrients on the potato ration. Greater consumption of hay accounted for most of the increased consumption of nutrients when potatoes were fed.

In Trial II the average of both groups gave results very similar to those obtained in Trial I except that the production of 4 per cent milk averaged about 21 per cent higher than in Trial I. Consumption of feeds was quite similar for the two groups in Trial II except that when potatoes were fed hay consumption again was greater than when silage was fed. Daily production of 4 per cent milk was practically equal on the two rations. Differences in body weight increases seemed to be within the limits of experimental error. Greater hay consumption resulted in higher daily intake of total digestible nutrients. With production about the same and more nutrients consumed, the total digestible nutrients consumed per 100 pounds of 4 per cent milk produced was greater when potatoes were fed than when corn silage was fed. Less digestible crude protein and total digestible nutrients were required per 100 pounds of 4 per cent milk in Trial II than in Trial I.

The results of these two trials, representing 4 groups, or a total of 14 cows, indicate that raw potatoes may be used to good advantage as a succulent feed in the dairy ration.

Results obtained in all four groups were remarkably consistent throughout. In each instance the cows ate more hay when potatoes were fed

than when silage was fed. This resulted in more total digestible nutrients consumed while the cows were on the potato ration and, likewise, more total digestible nutrients required per 100 pounds of 4 per cent milk produced. The increase in total digestible nutrients required per 100 pounds of 4 per cent milk when potatoes were fed was 11.5 per cent in Trial I and 7.6 per cent in Trial II. Stated in another way, the potato ration was 90 per cent as efficient as the corn silage ration in Trial I and 93 per cent in Trial II, when considered on the basis of nutrients consumed and milk produced. It would seem safe to conclude that raw potatoes are at least 90 per cent as valuable as corn silage in the dairy ration.

Cooked Potatoes Compared with Raw Potatoes

The results obtained from Trial III in which cooked potatoes were compared with raw potatoes are summarized in Table II. When the two groups were averaged together the average daily consumption of feeds per cow was practically the same for all three feeds when the cows were on each of the rations. Actual milk production was practically the same but when corrected to a 4 per cent basis the cows averaged one pound more per day when cooked potatoes were fed, the production being 25.7 on raw potatoes and 26.7 on cooked potatoes. Body weights of the cows when placed on the two rations were quite similar, averaging 1269 pounds when started on raw potatoes and 1277 pounds when started on cooked potatoes. The cows gained weight on both rations, but the difference between the average gain of 14 pounds on raw potatoes and 37 pounds on cooked potatoes is not very significant.

The average daily consumption of digestible crude protein was exactly the same on the two rations, and the intake of total digestible nutrients was as close as might be expected. The digestible crude protein and the total digestible nutrients consumed per 100 pounds of 4 per cent milk were slightly less on cooked potatoes than on raw potatoes. This would indicate greater efficiency for the cooked potatoes, but the fact that the difference was slight and the results in the two groups were opposite to each other would justify the conclusion that both raw and cooked potatoes gave equally good results. As far as production returns are concerned, there would be no advantage in cooking potatoes for dairy cows.

Observations in Feeding

None of the cows used in any of the trials had ever been fed potatoes previously, except two Holstein cows in Trial III which had also been used in Trial I. Very little difficulty was experienced in getting the cows to eat the potatoes. In the beginning, it was necessary to place the grain mixture on the potatoes to get some of the cows started to eat them. Once started the cows consumed the potatoes readily and there was very seldom any weigh-back. The cows were started on small quantities of potatoes, which were gradually increased to the desired amounts.

In general, 30 pounds of potatoes were fed daily to Holsteins and 25 pounds to Jerseys. Some Holstein cows ate as much as 40 pounds. Table II shows that in Trial 1 the cows in Group I consumed an average of 35.3 pounds of potatoes daily, while Group II averaged 29.1 pounds, or an average for the two groups combined of 32.2 pounds per cow. In

Trial II an average of 28.4 pounds was consumed daily by Group I and 27.3 pounds by Group II, or an average of 27.9 pounds for the two groups combined.

In Trial III the cows in Group I consumed an average of 27.4 pounds of raw potatoes and 30.0 pounds of cooked potatoes. The average for Group II was 31.0 pounds of raw potatoes and 30.5 pounds cooked. The average for the two groups combined was 29.2 pounds of raw potatoes and 30.3 pounds of cooked.

Since the cows used represented the Holstein and Jersey breeds and the groups varied in average weight, the daily consumption of potatoes was computed on the basis of 1000 pounds of live weight. On this basis the weighted average of the six groups, representing 22 cows, was 23.3 pounds of raw potatoes daily, varying from 28.1 pounds to 20.9 pounds.

None of the cows were off feed while being fed raw potatoes and were in good health throughout the trials. In most cases, however, the manure passed was thinner than when corn silage was fed. In the preliminary feeding when the cows were being brought on to full feed of potatoes there were some slight cases of scours and also some bloating. One of the most evident findings was the fact that cows of the same breed and about the same weight vary greatly in the amount of raw potatoes they can consume without digestive disturbances. Many writers protect themselves by recommending only small quantities of potatoes be fed daily, such as 15 pounds to Jerseys and 20 pounds to Holsteins. Larger quantities of potatoes can be fed daily per cow if the feeder will, first, be careful to bring the cows on full feed gradually and, second, watch the manure of each individual cow and feed her accordingly. If the manure becomes thin the quantity of potatoes fed should be reduced or a case of scours, bloat, or both will soon result, even though a smaller cow in the same stable is eating more. Thumb rules are not very reliable guides in feeding potatoes unless a feeder is satisfied with feeding much less than he might otherwise do by exercising care in feeding each cow individually.

When cooked potatoes were fed digestive troubles, such as scours or bloat, occurred quite often. The cows seemed to be much more sensitive to increases in the quantity of cooked potatoes fed than in the case of raw potatoes.

Effect of Potatoes on Dairy Products *

A pint sample of milk before cooling was taken from each of the experimental cows. Another pint sample was taken from each of the same cows after the milk was aerated and cooled. Milk from the potato fed cows was as good in flavor as that produced from corn silage. The milk from both rations would be considered good, average milk in flavor. Twenty-four samples scored warm, averaged just the same as the samples when cooled and aerated.

Cream was separated from the milk produced by the cows being fed potatoes, and also from the group being fed silage. The two lots of cream were churned separately in a motor driven "Cherry Junior" churn,

*The scoring and processing of milk on milk and milk products were done by D. R. Theophilus, Associate Dairy Husbandman, Idaho Agricultural Experiment Station.

50 pounds of butter capacity. Two churnings were made from each lot of cream. All of the butter was excellent in body and texture, and none of the butter resulting from potato-fed cows had any tendency toward salviness. The average flavor score on the two lots of butter resulting from each ration was exactly the same, 35.5 points. No off-flavors were present, but the butter was criticized as being "flat" due to being made from pasteurized sweet cream to which no starter was added.

Precautions in Feeding Potatoes

Chop or cut potatoes to prevent the cows from choking. Feed only sound potatoes, being careful to sort out all decayed tubers. Do not feed "green" tubers or sprouted potatoes without first removing the sprouts. All potatoes contain slight quantities of solanin which is poisonous, but the sprouts and green tubers contain much more than ordinary potatoes. Start cows with small quantities of potatoes and gradually increase the amount. Since potatoes have a laxative effect on the bowels, do not feed with other feeds producing the same effect, such as molasses. Plenty of legume hay and some grain probably tend to keep down digestive disorders when potatoes are fed. Feed each cow as an individual, and if the manure becomes too thin cut down on the potato allowance before real trouble develops.

Summary and Conclusion

During the last six years the potato crop in Idaho has averaged about 20 million bushels. Thousands of tons of cull potatoes suitable for livestock feed are available each year. In years of low prices a large percentage of the entire crop could be utilized in this manner.

Potatoes are quite similar in chemical composition to corn silage and fulfill much the same purpose in the ration of the dairy cow, that is, a low protein, succulent roughage. In southern Idaho when potatoes are purchased for dairy cattle feed they replace some of the alfalfa hay in the ration. Based on the total digestible nutrients in alfalfa hay and in raw potatoes, the price per ton of potatoes should be about one-third the price of a ton of hay. Stated in another way, the price per bushel of potatoes in cents should be the same as the price of hay in dollars per ton, that is, 10 cents per bushel for potatoes when alfalfa hay is $10.00 per ton.

Raw potatoes were compared with corn silage as a succulent roughage in two feeding trials representing four groups, or a total of 14 cows. In addition alfalfa hay and a grain mixture were fed.

Results obtained in all four groups were remarkably consistent. Consumption of both succulent feeds and grain were quite similar, but in each instance the average consumption of hay was greater when potatoes were fed than when silage was fed. This resulted in more total digestible nutrients being consumed when potatoes were fed than when silage was fed. The average body weights at the beginning and the average change was quite similar for the two feeds being compared. Production of 4 per cent milk ("fat-corrected basis") was practically the same for each group on the two rations. Since more nutrients were consumed and milk production was about equal, the total digestible nutrients consumed per 100 pounds of 4 per cent milk produced was greater when potatoes were fed than

when silage was fed. Raw potatoes are at least 90 per cent as efficient as corn silage for milk production, being 90 per cent in Trial I and 93 per cent in Trial II.

A third trial was conducted in which cooked potatoes were compared with raw potatoes as a feed for dairy cows. Feed consumption of the cows on the two rations was practically the same, and production of 4 per cent milk and body weight increases were very similar. Raw potatoes and cooked potatoes produced equal results. Since more digestive disturbances occurred when the cows were fed cooked potatoes, it would seem advisable to feed potatoes raw rather than cooked to dairy cows.

If care is exercised at least 30 pounds of potatoes per day can be fed with safety to Holstein cows and 25 pounds to Jerseys. The weighted average of six groups, representing 22 cows, was 23.3 pounds of raw potatoes daily per 1000 pounds of live weight. No digestive disturbances resulted from feeding raw potatoes. Once accustomed to potatoes the cows ate them with relish.

Milk produced by the potato-fed cows had good, average flavor and was equal in flavor to the milk produced when corn silage was fed. Butter resulting from both groups of cows was excellent in body and texture, with no tendency toward salviness. No off-flavors were present.

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TABLE I

Production and Value of Idaho Potatoes, 1929-34.

Year	Total Production	Farm Value December 1	
		Average per Bushel	Total
	(bushels)	(dollars)	(dollars)
1929 (1)	15,416,000	1.20	18,499,000
1930 (1)	24,500,000	.60	14,700,000
1931 (2)	24,200,000	.30	7,260,000
1932 (3)	19,800,000	.17	3,366,000
1933 (3)	21,850,000	.41	8,958,000
1934 (3)	19,240,000	.36	6,926,000

(1) Crops and Markets, Vol. 8, No. 12, U. S. Dept. of Agr.
(2) Crops and Markets, Vol. 10, No. 12, U. S. Dept. of Agr.
(3) Crops and Markets, Vol. 11, No. 12, U. S. Dept. of Agr.

TABLE II
Value of Corn Silage and Potatoes Compared with Alfalfa Hay

Feed	Total Digestible Nutrients		Value per Ton		
	In 100 pounds	Compared to Alfalfa Hay			
	(pounds)	(per cent)	(dollars)	(dollars)	(dollars)
Alfalfa Hay	51.6	100.0	6.00	8.00	10.00
Corn Silage	17.7	34.3	2.06	2.74	3.43
Potatoes	17.1	33.1	1.99	2.65	3.31
"			(per bushel) 0.06	0.08	0.099

TABLE III
Chemical Analyses of Feeds
(In per cent)

Feed	Water	Ash	Crude Protein	Crude Fiber	Nitrogen Free Extract	Fat
Trials I and III						
Grain Mixture	12.0	5.7	17.4	9.6	49.8	5.5
Alfalfa Hay	7.2	6.6	9.5	42.0	32.5	2.1
Corn Silage	75.5	2.0	2.3	5.2	14.2	0.8
Potatoes	75.3	1.4	2.0	0.5	20.6	0.2
Trial II						
Grain Mixture	13.6	5.9	16.3	9.4	51.0	3.9
Alfalfa Hay	16.5	6.1	9.9	34.9	31.3	1.3
Corn Silage	71.8	2.0	2.3	6.3	17.0	0.7
Potatoes	77.8	1.3	2.5	0.6	17.8	0.1

Note—Chemical analyses made by Department of Agricultural Chemistry, Idaho Agricultural Experiment Station.

TABLE IV
Results of Two Feeding Trials Comparing Raw Potatoes with Corn Silage and One Trial Comparing Raw and Cooked Potatoes

	Trial I						Trial II						Trial III					
	Group I		Group II		Ave. both Groups		Group I		Group II		Ave. both Groups		Group I		Group II		Ave. both Groups	
	Corn silage	Raw potatoes	Corn silage	Raw potatoes	Corn silage	Raw potatoes	Corn silage	Raw potatoes	Corn silage	Raw potatoes	Corn silage	Raw potatoes	Raw potatoes	Cooked potatoes	Raw potatoes	Cooked potatoes	Raw potatoes	Cooked potatoes
PERIOD	I&III ave.	II	II	I&III ave.			I&III ave.	II	II	I&III ave.			I	II	II	I		
Number of cows used	3	3	3	3	6	6	4	4	4	4	8	8	4	4	4	4	8	8
Ave. lbs. silage consumed daily per cow	31.9	35.3	25.0	29.1	29.0	32.2	28.6	28.4	28.1	27.3	28.4	27.9	27.4	30.0	31.0	30.5	29.2	30.3
Ave. lbs. alfalfa hay consumed daily per cow	14.2	15.8	13.7	15.2	14.0	15.5	14.2	16.9	13.8	15.4	14.0	16.2	14.7	15.4	15.0	14.2	14.9	14.8
Ave. lbs. grain mixture consumed daily per cow	10.1	10.0	6.7	7.1	8.4	8.4	11.1	10.8	10.4	10.1	10.8	10.5	11.0	10.3	9.2	9.8	10.1	10.1
Ave. lbs. milk produced daily per cow	29.2	28.2	19.2	20.4	24.2	24.3	33.2	34.3	31.0	29.9	32.1	32.1	30.3	29.8	27.7	29.0	29.0	29.4
Ave. lbs. butterfat produced daily per cow	1.18	1.15	0.77	0.78	0.98	0.97	1.12	1.16	1.02	1.00	1.07	1.08	1.03	0.99	0.85	0.99	0.94	0.99
Ave. per cent fat in milk	4.04	4.08	4.01	3.82	4.05	3.99	3.37	3.38	3.29	3.34	3.33	3.36	3.40	3.32	3.07	3.41	3.24	3.37
Ave. lbs. 4 per cent milk produced daily per cow	29.4	28.5	18.2	19.9	23.8	24.2	30.1	31.1	27.7	27.0	28.9	29.1	27.6	26.8	23.8	26.5	25.7	26.7
Ave. body weight per cow at beginning (pounds)	1254	1260	1213	1173	1234	1217	1310	1310	1317	1305	1314	1306	1252	1296	1285	1257	1269	1277
Ave. gain per cow in body weight per 30-day period	+47	00	+19	+53	+33	+27	—23	+36	+23	+11	+7	+24	+13‡	+40‡	+15‡	+33‡	+14‡	+37‡
Ave. lbs. digestible crude protein* consumed daily per cow	2.75	2.82	2.17	2.31	2.47	2.54	2.79	2.94	2.68	2.73	2.74	2.85	2.80	2.78	2.60	2.64	2.71	2.71
Ave. lbs. total digestible nutrients* consumed daily per cow	19.36	21.85	15.85	18.36	17.63	19.99	17.82	19.56	17.11	18.23	17.49	18.96	20.39	20.79	20.04	19.94	20.23	20.40
Ave. lbs. digestible crude protein consumed per 100 lbs. 4% milk	9.35	9.89	11.92	11.61	10.38	10.49	9.27	9.45	9.67	10.11	9.48	9.79	10.14	10.37	10.92	9.96	10.54	10.15
Ave. lbs. total digestible nutrients consumed per 100 lbs. 4% milk	65.85	76.65	87.08	92.26	74.08	82.60	59.20	62.89	61.77	67.51	60.52	65.15	73.88	77.57	84.20	75.24	78.71	76.40

*Computed from chemical analyses in Table I and digestion coefficients in "Feeds and Feeding" by Henry and Morrison.
‡20-day periods in this trial.
Note—4 Holstein and 2 Jersey cows used in Trial I; 8 Holstein cows in Trial II; 6 Holstein and 2 Jersey cows in Trial III.