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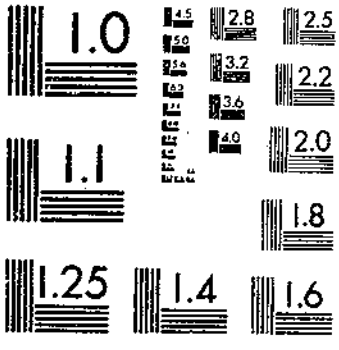

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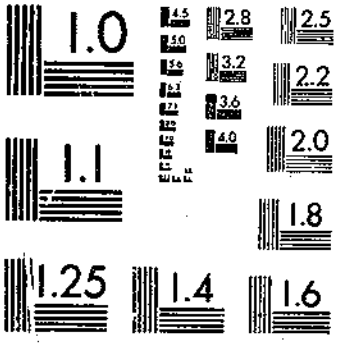

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Methods of Making Potato Silage and Tests of Its Feeding Value For Dairy Cows[1]

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INTRODUCTION

Approximately 3,000,000 acres of potatoes are harvested each year in the United States and the total annual production varies from about 325,000,000 to 450,000,000 bushels (*14*).[3] Dice (*7*) has estimated that about 5 percent of the crop is fed to livestock each year. Cull and undergrade potatoes (and occasionally surplus potatoes) are used for that purpose. Usually the potatoes are chopped and fed raw, but they may be cooked and fed immediately or they may be made into silage for later feeding.

The necessity of keeping potatoes over a considerable period of time, in order to use them to best advantage for feeding dairy cattle, has stimulated interest in potato silage. A number of research workers have described various methods of ensiling potatoes, alone or in combination with other materials, and have discussed the value of potato silage as a feed.

The experimental work described in this bulletin was undertaken to obtain additional information on methods of ensiling potatoes, by using different materials in varying proportions as preservatives, and to test the relative palatability of the resulting silages. With such information at hand, possibly a better disposition can be made of cull and surplus potatoes in the future by feeding them to dairy cattle.

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[1] Submitted for publication November 20, 1945.
[2] Retired July 31, 1944.
[3] Italic numbers in parentheses refer to Literature Cited, p. 13.

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REVIEW OF LITERATURE

The value of raw and cooked potatoes for dairy cattle has been reported by Atkeson and Anderson (*1*), Dice (*6*, *7*), and Bunger (*4*). The results of their findings are summarized as follows: Raw and cooked potatoes are about equal in feeding value. When fed in large amounts potatoes tend to produce a laxative condition in the cow. Feeding therefore should be limited to 40 pounds or less daily. Potatoes, either raw or cooked, are about as palatable as corn silage but on a dry weight basis they are slightly lower in feeding value. Potatoes may be incorporated in an otherwise balanced ration in moderate amounts without danger of causing abnormal changes in the quality or composition of milk and butterfat. However, as a precautionary measure, potatoes should be fed after milking.

Watson (*16*) stated that the most efficient way to ensile potatoes was to steam them and pack them immediately in a tight container. He reported that the loss of dry matter was 12 percent when raw potatoes were ensiled without a preservative and that the loss was somewhat less when acid was added as a preservative. Wallace (*15*) produced a silage of good quality by ensiling successive layers of green grass and potatoes in a large stack at the rate of 1½ tons of grass to ½ ton of potatoes. Using small containers as silos, Scheffer and Burkhardt (*12*) ensiled alfalfa and meadow grass with different percentages of steamed potatoes or with 2½-year-old potato silage. When the potato silage was mixed with either the alfalfa or the meadow grass, at the rate of 30 to 50 percent of the mixture, good quality silages were produced; whereas when the steamed potatoes were mixed with these forages at these percentages, satisfactory results were obtained with the grass but not with the alfalfa.

Ulvesli (*13*) ensiled potatoes alone and also with mineral acids and found the comparative losses of nutrients to be as follows: Dry matter, 16 and 5 percent; organic matter, 16 and 4 percent; and protein, 55 and 30 percent. Sheep digested 83 percent of the organic matter in the potato silage and 88 percent in the potato-acid silage. Bollmann (*3*) found no difference in the digestibility of steamed potatoes and steamed-ensiled potatoes, but he found the digestibility of raw potatoes to be somewhat lower. Isaachsen and associates (*9*) compared ordinary potato silage with potato silage made by the A. I. V. mineral-acid method.[4] They found the dry-matter loss to be 15 percent for the former and 3 percent for the latter.

The comparative feeding value of potato silage and corn silage was determined by Woodward and associates (*17*) in experiments with milking cows. The potatoes were ensiled alone, after they had been

[4] The A. I. V. method of making silage from hay crops was developed in Finland by Virtanen. The method takes its name from the initials of its sponsor. It is based on the theory that, if the acidity of the material placed in the silo is increased so that the pH value falls below 4.0, there will be no destruction of the protein or vitamins. A mixture of concentrated hydrochloric acid and sulphuric acid diluted with five times as much water by volume is usually used to reduce the pH value. This method of siloing unchopped grasses and legumes is used successfully and to a considerable extent in some of the north-European countries.

run through a machine that thoroughly mashed them. The cows that were fed the corn silage produced slightly more milk and butterfat, but gained less in live weight, than the cows that were fed the potato silage. The differences, however, were too small to be considered significant. The potato silage was found to be as palatable as good quality corn silage.

Richter and associates (*11*) found that when 12 kilograms of raw potatoes replaced 32 kilograms of beets (equal starch basis) in the ration, milk production dropped 5 percent with no change in the fat content of the milk, but when the same amount of steamed-potato silage replaced the beets (on an equal starch basis) the milk production dropped 4 to 6 percent, the average fat content of the milk dropped from 3.4 percent to 3.14 percent, and total fat production dropped 11 percent. Frolich and Luthge (*8*) observed a 6- to 8-percent increase in milk production and a corresponding decrease in fat percentage when steamed-potato silage replaced corn silage in the ration of milking cows.

Zorn (*18*) has summarized the work of five different German institutes on the feeding value of potatoes. All five institutes reported a slight decrease in milk production as a result of feeding potatoes, either raw or as steamed-potato silage. The results were variable concerning the butterfat test and total butterfat yield. No bad effect on the physical character of the milk was reported.

Connell and associates (*5*, *5a*), using the trench silo method, compared the feeding value of three kinds of potato silage made as follows: Four parts raw potatoes to one part dry corn fodder; four parts raw potatoes to one part alfalfa hay; and potatoes alone, which were steamed for 35 minutes before they were ensiled. Each method of ensiling potatoes produced a satisfactory silage. Results of feeding experiments with yearling fattening heifers and steers indicated that the animals fed potato-corn fodder silage or potato-alfalfa hay silage made larger gains and required less feed per 100 pounds of gain than did similar animals receiving corn silage. The potato-corn fodder silage and the potato-alfalfa hay silage were about equal in feeding value. The steamed-potato silage gave variable results, which were not in agreement with the potato-corn fodder silage and the potato-alfalfa hay silage, in that it had a high value when there was no cottonseed meal in the ration, and a low value when the ration included cottonseed meal.

MATERIALS AND METHODS

The potatoes used in these studies were small, early type U. S. No. 2 grade.[5] They were ensiled in 4- by 8-foot wooden-stave silos, either alone or with different materials added as follows: 0.75 percent of salt; 3.0 percent of ground yellow corn; or 5, 10, 15, 20, or 22 percent of dry chopped hay. The hay was a mixture of orchard grass and clover, containing about 40 percent legumes. It was cut early and was U. S. No. 2 grade. From 1 to 2½ tons of material was placed in each silo, the total weight decreasing in the different silos as the percentage

[5] Surplus potatoes supplied by the Commodity Credit Corporation.

of hay was increased. Because of insufficient potatoes, not all of the silos were filled to the top.

The potato-22 percent hay mixture was ensiled by running the potatoes and long hay through the cutter together, with the potatoes on top of the hay. The other mixtures were ensiled by running the potatoes through the cutter alone and putting the chopped potatoes in each silo in 50-pound lots, along with the required weights of chopped hay, salt, or corn meal, until the filling was completed.

No difficulty was encountered in putting the potato-hay mixture through the silage cutter. When the potatoes were chopped through alone, however, they tended to mash up too fine and clog the blower pipe. It was found possible to overcome this difficulty by setting the machine for the longest cut and operating the cutter at a reduced speed. For best results it was also found necessary to set the blower pipe perfectly upright—using the shortest pipe possible, with an open hood and no distributor.

The material placed in each silo was evenly distributed. The mixtures were heavy and only those containing the larger percentages of dry chopped hay were tramped. The material in each silo was topped with 200 to 250 pounds of chopped green alfalfa and a wooden cover weighted down with 250 or 500 pounds of broken concrete. The larger weight was used on the silages to which 10, 15, 20, and 22 percent of hay had been added.

The weight and chemical composition of the materials ensiled and of the good silage removed were determined. The effluent from the silos was weighed only for the three containing the largest proportions of hay.

All of the top spoilage in each silo occurred in the green alfalfa.

Each silage was fed to four milking Holstein cows for a 6- to 9-day period, depending on the amount available, to observe the relative palatability of the silages, as measured by silage and total feed consumption, and the effect of the ration on the live weight of the cows and on the quantity and quality of the milk produced.

The silages were fed in the following order: Potato-22 percent hay; potato-20 percent hay; potato-15 percent hay; potato-10 percent hay; potato-5 percent hay; potatoes alone; potato-3 percent corn meal; and potato-0.75 percent salt. The cows were on rather poor pasture prior to the experiment but were kept off pasture during the potato silage feeding periods. The potato silage feeding trials were followed by four 6- to 9-day periods in which the cows were fed raw potatoes (one period), corn silage (two periods), and pasture with no silage (one period) in the order mentioned.

The cows weighed 1,358 pounds on the average and were producing an average of 42 pounds of 4-percent-fat-corrected milk per day at the start of the experiment. They were fed as much of the test silage as they would eat in two feedings per day along with early-cut leafy alfalfa hay (equivalent to the top of U. S. Grade No. 2) and an 18-percent-protein grain mixture. The amount of hay and grain fed daily remained practically unchanged throughout the experiment, the average being 9 pounds of hay and 13.8 pounds of grain per cow per day.

Records were kept of the live weight, milk production, and feed consumption of the individual cows. The milk was analyzed for butterfat,

flavor and odor,[6] and specific gravity. The iodine and saponification numbers [7] of the butterfat were determined.

RESULTS

Effects of Various Methods of Ensiling Potatoes

Table 1 shows the composition of the dry matter of the materials that were used in making the silages, also the composition of the dry matter of the resulting silages and of the feeds fed with the silages.

Table 1.—*Chemical composition of materials ensiled and of silages and other feeds fed to cows*

Material	Dry matter	Composition of the dry matter					
		Protein	Fat	Fiber	N-free extract	Ash	Carotene [1]
Ingredients used in making silage:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Milligrams per gram*
Potatoes	20.01	11.00	0.48	2.52	80.07	4.93	0
Mixed hay	86.50	13.43	2.07	34.79	42.20	7.51	32.41
Corn meal	86.11	9.48	4.03	2.12	83.15	1.22	[2] 2.20
Silages:							
Potato-22 percent hay	33.97	12.26	1.67	18.51	60.67	6.86	----------
Potato-20 percent hay	31.55	12.61	1.63	22.79	56.38	6.55	31.07
Potato-15 percent hay	33.28	11.61	1.47	18.62	61.84	6.46	27.13
Potato-10 percent hay	30.33	9.68	1.21	16.62	67.23	5.26	18.53
Potato-5 percent hay	32.27	7.07	.60	5.54	78.91	4.59	14.68
Potato	20.07	5.65	.35	2.75	87.07	3.23	0
Potato-3 percent corn meal	31.08	6.28	.78	2.83	86.81	3.30	1.10
Potato-0.75 percent salt	34.54	5.40	.32	2.07	87.33	4.22	0
Ration used in feeding tests:							
Grain mixture	----------	20.66	3.77	4.05	68.12	3.40	----------
Alfalfa hay [3]	----------	20.13	2.05	31.96	38.72	7.14	----------
Corn silage	----------	9.56	2.54	24.42	58.17	5.31	----------

[1] Analysis made on unchromatographed solution containing the extracted carotene.
[2] Includes cryptoxanthin.
[3] Early cut, U. S. No. 2 leafy.

The composition of the dry matter of the silages varied with the composition of the materials ensiled, as modified by the nutrient losses which occurred during the storage period. The straight potato silage, the potato-salt silage, and the potato-corn meal silage were each very low in crude fiber, high in nitrogen-free extract, and practically devoid of carotene.

Carotene determinations (unchromatographed) indicated a good preservation of this nutrient, which was present originally only in the dry hay and in extremely small quantities along with cryptoxanthin in the ground yellow corn.

Table 2 shows the dry matter content of the materials ensiled; the proportion of the dry matter derived from the potatoes; the dry matter content and pH of the good silage removed; and the percentage loss of total weight, dry matter, and protein in each kind of silage.

[6] The milk was scored for flavor and odor by William White and C. S. Trimble.

[7] For iodine, the "number" or "value" is the number of centigrams of iodine absorbed by 1 gm. of the substance analyzed.

For saponification, the number or value is the number of milligrams of potassium hydroxide absorbed by 1 gm. of the substance analyzed.

TABLE 2.—*Dry matter content of the materials ensiled and of good silage obtained; percentage losses in total weight, dry matter, and protein; and the pH of the silages*

Materials ensiled				Good silage obtained			Gross losses			Storage time
Mixture	Dry matter			Dry matter		Hydrogen-ion concentration	Total weight [1]	Dry matter [2]	Protein	
	Total		Proportion from potatoes							
	Pounds	*Percent*	*Percent*	*Pounds*	*Percent*	*pH*	*Percent*	*Percent*	*Percent*	*Days*
Potato-22 percent hay	656.22	32.01	51.2	[3] 633.88	33.07	5.28	[4] 9.0	3.40	2.77	41
Potato-20 percent hay	751.20	30.96	53.6	[3] 655.52	31.55	4.45	[5] 14.3	12.74	11.00	47
Potato-15 percent hay	721.41	28.86	61.3	[3] 652.02	33.28	4.42	[6] 21.6	9.54	14.37	54
Potato-10 percent hay	573.80	26.05	69.8	[3] 498.02	30.33	4.90	[7] 25.5	13.18	28.49	61
Potato-5 percent hay	584.08	23.18	82.2	[3] 521.00	32.27	5.25	[7] 35.9	10.79	44.83	67
Potato-3 percent corn meal	780.77	22.17	88.6	[8] 667.81	31.68	4.05	[7] 40.1	14.47	50.38	82
Potato-0.75 percent salt	634.41	20.47	99.2	[8] 521.21	34.51	4.15	[7] 51.3	17.84	57.90	89
Potatoes alone	970.48	20.01	100.0	[8] 832.16	30.97	4.15	[7] 41.6	14.25	55.98	74

[1] Includes weight of effluent.
[2] None of the dry matter loss was due to top spoilage.
[3] Material had a grass silage appearance with a mild odor, and was heavy and firm.
[4] 6.1 percent effluent.
[5] 8.9 percent effluent.
[6] 13.2 percent effluent.
[7] Amount of effluent not determined. However it constituted a large percentage of the total loss in weight.
[8] Material had an objectionable clinging odor and was very heavy, but soft and mushy.

Juice was dripping from the chopped potatoes as the silos were being filled. Almost immediately, after the silos were filled, effluent began to flow from all silos except those filled with mixtures of potatoes and 10, 15, 20, and 22 percent hay. The flow of effluent continued through most of the storage period. As the percentage of added hay increased, more and more of the excess moisture in the potatoes was absorbed and the quantity of the effluent decreased. Observations indicated that the addition of corn meal to the potatoes did not materially check the quantity of effluent and that the addition of salt seemed to increase the quantity slightly. The three silos containing potato silages with 15, 20, and 22 percent of added hay did not begin to leak juice as soon after filling as the others, and the effluent amounted to only 13.2, 8.9, and 6.1 percent, respectively, of the material ensiled. The composition of the effluent was determined only for that coming from the straight potato silage. It had a specific gravity of 1.020, a pH of 4.6, and a total solids content of 3.83 percent, which consisted of 0.93 percent ash, 1.41 percent protein, and 1.49 percent carbohydrates.

As shown in table 2 the percentage of dry matter in the silages as removed was higher in each case than that of the materials ensiled. It was slightly higher in the silages with 10 percent or more of added hay and considerably higher in all the other silages. Because of the greater quantity of effluent from the silages containing little or no hay, the loss in total weight was greater for these silages than for the others, and the dry matter content of the silages containing little or no hay was as high as that of the others, or higher.

All of the potato silages were heavier and settled more than silages that had been made previously from other crops in the same silos.

The silages with no hay added were heaviest of all and, despite their high dry matter content, were soft and mushy and had to be handled with a scoop shovel. They also had a very offensive pig-pen odor, although they were not spoiled. The silage from the potato-5 percent hay mixture was almost as heavy as the silages made with no hay, but it was solid underfoot and could be handled readily with a silage fork. The odor of this silage was somewhat more acceptable. The silages made from potatoes with 10, 15, 20, and 22 percent of added hay were all of good quality, with a mild pleasant odor and an appearance somewhat like that of good grass silage.

As shown in table 2, the highest acidity was developed in the silage made from the potato-corn meal mixture, and the next highest was in the silage from the potato-salt mixture and potatoes alone. The average pH readings were 4.05, 4.15, and 4.15, respectively. The pH values of the silages made with different amounts of hay added varied from 4.42 to 5.38, but did not vary proportionately with the percentage of added hay.

Losses in total weight during storage, as shown in table 2, were higher because of seepage, than the dry matter losses.

It is apparent that dry matter losses were somewhat higher in the silages containing no hay than in the silages with 5 to 22 percent hay added and highest of all in the potato-salt silage.

When potatoes were ensiled alone, or with salt, corn meal, or 5 percent of hay added, the losses of protein were extremely high in the resulting silages and they were very low in protein. The loss of protein in the potato-10 percent hay silage was proportionately greater than the loss of dry matter but in the silages with larger amounts of hay added the protein was preserved about as well as was the dry matter. Ulvesli (*13*) noted a loss of about 50 percent in protein as compared with a loss of about 15 percent in dry matter from ensiled potatoes.

Feeding Value of the Silages

Table 3 gives the average live weight, production, and feed consumption of the cows on the fourth, fifth, and sixth day of each period.

TABLE 3.—*Live weight, production, and feed consumption of 4 Holstein cows on the rations indicated (average per cow per day)* [1]

Feed fed in addition to hay and concentrates	Total length of feeding period	Live weight [2]	Production			Feed consumption			Dry matter consumed		Feed nutrients consumed			
			Milk	Butterfat		Silage	Hay	Concentrates	In silage	Total	Digestible protein	Total digestible nutrients	Fiber	Ether extract
	Days	*Pounds*	*Pounds*	*Percent*	*Pounds*	*Pounds*	*Pounds* [3]	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Pasture		1,358	44.6	3.60	1.61			13.2						
Potato—22 percent hay silage	6	1,376	50.5	3.20	1.62	60.5	6.4	13.7	20.6	38.3	4.7	28.3	7.0	0.93
Potato—20 percent hay silage	7	1,402	50.2	3.09	1.55	56.0	8.1	13.8	17.6	36.8	4.7	27.2	6.8	.90
Potato—15 percent hay silage	7	1,406	43.5	3.25	1.42	58.6	6.8	13.0	19.5	36.4	4.3	27.0	5.9	.84
Potato—10 percent hay silage	6	1,395	41.1	3.26	1.34	51.6	7.5	13.2	15.7	33.7	4.0	25.6	5.2	.76
Potato—5 percent hay silage	6	1,391	41.6	2.92	1.22	56.6	7.7	13.4	18.3	36.6	3.8	28.2	4.2	.70
Potato silage	9	1,393	38.3	2.60	1.00	53.0	8.3	13.8	16.4	35.8	3.8	28.2	3.3	.67
Potato—3 percent corn meal silage	7	1,419	35.3	2.27	.80	58.6	8.2	13.8	18.6	38.6	3.9	30.2	3.3	.75
Potato—0.75 percent salt silage	6	1,461	31.0	2.49	.77	51.8	7.2	12.1	17.9	34.8	3.4	27.4	2.9	.59
Potatoes (raw)	9	1,424	32.6	3.02	.98	[4] 79.3	8.3	13.8	[4] 16.2	35.5	4.1	27.9	3.2	.69
Corn silage	6	1,456	28.5	3.20	.91	45.8	7.1	13.8	15.6	33.4	3.9	24.5	6.2	.97
Do	6	1,461	27.7	3.66	1.01	48.0	8.7	13.8	14.5	33.7	4.0	24.6	6.3	.97
Pasture	6	1,420	24.5	3.92	.96		8.0	8.5						

[1] Averages based on the fourth, fifth, and sixth days that the cows were on the respective rations.
[2] Differences in live weight may be due partly to differences in "fill."
[3] Cows had free access to hay.
[4] Raw potatoes.

The cows consumed about the same amount of hay and concentrates each day when the different kinds of potato silage, raw potatoes, or corn silage were fed. They left small amounts of hay in the manger when potato silages containing hay or salt were fed, and also during the first corn silage feeding period. They cleaned up all or nearly all of their hay when they received straight potato silage, potato-corn meal silage, potato-salt silage, and raw potatoes, and also during the second corn silage feeding period. The concentrate was fed with the silage or potatoes. It was all eaten each time, except the small amounts that became mixed with uneaten potato silage. During the potato-salt silage feeding period a small amount of the concentrate was refused.

The cows consumed more each day of each kind of potato silage and of the raw potatoes than they did of corn silage, which indicated that all the potato feeds were palatable to the cows. The mushy condition and objectionable odor of the straight potato silage, potato-corn meal silage, and potato-salt silage apparently had little effect on the total consumption of these silages. However, they were consumed more slowly and with less apparent relish than the potato-hay silages or the raw potatoes.

The total dry matter consumption was slightly less when the raw potatoes, potato silage, and potato-salt silages were fed than when the potato-hay silages were fed. The one exception to this was the period when the potato-10 percent hay silage was fed. Two cows receiving this silage, developed a slight laxative condition, which was accompanied by a reduction in feed consumption.

In each period the cows consumed more digestible protein and total digestible nutrients than they required, according to Morrison's feeding standards (*10*). This excess of feed nutrients no doubt accounted for their gradual increase in live weight during the experiment.

The consumption of crude fiber and ether extract was highest when the potato-hay silages were fed. It decreased as the amount of hay in the silages decreased, reaching the lowest level when potato silage, potato-corn meal silage, potato-salt silage, and raw potatoes were fed, and increased again when corn silage was fed. When potato-corn meal silage was fed, fat consumption was slightly higher than when the other nonhay silages or raw potatoes were fed.

Yield and Composition of the Milk

The average daily milk production per cow increased by about 6 pounds when the cows were changed abruptly from rather poor pasture to potato silage containing 22 percent hay. (See table 3.) This level of milk production was maintained during the potato-20 percent hay silage feeding period. From this point on there was a gradual decrease in milk yield with each successive silage feeding period except when raw potatoes were fed. The decrease in milk yield became slightly greater near the end of the experiment because of the advanced stage of lactation of one of the cows.

The average fat content of the milk decreased when the cows were changed from pasture to the potato-22 percent hay silage, but the total quantity of fat produced remained practically unchanged. (See table 3.) The average fat content remained at about the same level, fluctuating within a rather narrow range (3.09 to 3.26 percent) dur-

ing the periods when potato silages containing 10, 15, 20, and 22 percent hay were fed. When the cows were fed the potato-5 percent hay silage, the average fat test dropped to 2.92 percent. Following this, when the straight potato silage, potato-corn meal silage, and potato-salt silage were fed, the fat content of the milk dropped still further (2.60 to 2.27 percent). During these periods the fat and fiber content of the ration was also low. The fat content of milk produced by other cows on other rations during this same period was not affected in a similar manner.

Changing from potato silage to raw potatoes caused an increase in the fat test, although there was very little increase in the fat and fiber content of the ration. The fat content of the milk continued to increase during the last three periods when corn silage and pasture were fed in place of the raw potatoes. The changes in fat content observed in this experiment when potato silages containing little or no hay were fed are similar to those observed by other workers (*8, 11*).

Total daily fat production tended to follow the percentage of fat in the milk, and it was relatively much lower than milk production during the periods when fat tests were below normal.

The percentage of solids-not-fat in the milk, as shown in table 4, fluctuated slightly and within a normal range throughout the experiment, showing no changes that could be attributed to the rations fed.

TABLE 4.—*Average solids-not-fat content of milk, the iodine and saponification values of the fat, and the flavor and odor score of milk produced by 4 Holstein cows on the rations indicated* [1]

Feed fed in addition to hay and concentrates	Solids-not-fat	Iodine value	Saponification value	Flavor and odor score [2]
	Percent			
Pasture	8.09	37.36	307.5	40.0
Potato—22 percent hay silage	8.13	29.23	313.5	40.0
Potato—20 percent hay silage	8.34	30.42	310.2	40.0
Potato—15 percent hay silage	8.46	26.85	316.7	40.0
Potato—10 percent hay silage	8.22	32.03	310.3	40.0
Potato—5 percent hay silage	8.39	32.20	306.8	38.8
Potato silage	8.34	36.54	303.2	39.0
Potato—3 percent corn meal silage	8.58	40.04	300.9	39.3
Potato—0.75 percent salt silage	8.35	42.37	297.3	39.3
Potatoes (raw)	8.44	39.04	300.4	39.3
Corn silage	8.71	40.34	296.4	39.8
Do	8.54	36.18	301.4	40.0
Pasture	8.24	43.16	294.1	

[1] Averages based on the fourth, fifth, and sixth days that the cows were on the respective rations.
[2] Perfect score is 45. A score of 40.0 represents a good commercial grade of milk.

Analyses for nitrogen made during the time the fat content of the milk was at its lowest levels showed that the milk contained a normal content of nitrogen.

CHARACTER OF THE BUTTERFAT

The iodine values of the milk fat dropped when the cows were changed from pasture to the potato-22 percent hay silage ration, and then remained low during the periods when the cows received potato silages made with 20 percent and 15 percent hay. (See table 4.) During this time total fat production was high and the percentage of unsaturated fatty acids was low. When potato silages containing 10 and 5 percent of hay, and potato silages containing no hay, were fed,

the iodine values of the fat were high. During this time total fat production was low and the percentage of unsaturated fatty acids was high. Iodine values remained high during the periods when raw potatoes, corn silage, and pasture were fed. Iodine values varied inversely with the quantity of butterfat produced, particularly when the potato silages containing a small amount of hay or no hay were fed.

Saponification values of the milk fat increased when the cows were changed from pasture to the potato-22 percent hay silage and remained high through the periods when they received potato-hay silages. (See table 4.) During this time fat production was high and the content of the more volatile fatty acids with a lower molecular weight was also high. When potato silages containing no hay or only 5 percent hay were fed, the saponification values of the milk fat decreased, remaining at a low level when the cows received raw potatoes, corn silage, or pasture in their ration. Saponification values seemed to vary almost directly with the quantity of butterfat produced.

Flavor and Odor of the Milk

The milk produced when the cows were fed the different silages was scored for flavor and odor, 45 points representing a perfect score. When the cows were on pasture or were fed potato-hay silage made with 10, 15, 20, or 22 percent hay added, the milk scored an average of 40 points, which represents a good grade of commercial milk. When the silages containing higher amounts of potatoes were fed and also when raw potatoes were fed, the milk was graded down slightly because of objectionable flavor and odor. The objectionable flavor and odor tended to persist during the first corn silage feeding period, which followed the feeding of raw potatoes.

Dice (*6*) found it impossible to produce "potato flavored" milk by feeding potatoes but when he stored cream in a potato cellar the butterfat took on such a flavor. In only one instance during the course of this experiment was the off-flavor of milk described as a "potato flavor." Babcock (*2*) produced slight off-flavors in the milk of some cows by feeding potatoes 1 hour before milking but no bad effects were observed when the potatoes were fed after milking.

In the experiments reported by Atkeson and Anderson (*1*), butter made from milk produced by cows fed raw potatoes was equal in body, texture, and flavor to that produced by cows fed corn silage. It would appear that potatoes or potato silage fed in moderate amounts after milking will in no way affect the flavor or odor of the milk or the quality of the butter produced from the fat.

SUMMARY AND CONCLUSIONS

Potatoes were ensiled alone and also with various materials added, as follows: 0.75 percent of salt, 3 percent of ground yellow corn, and with 5, 10, 15, 20, or 22 percent of mixed orchard grass and clover hay. Each of the resulting silages was fed to four milking cows for a 6- to 9-day period, depending on the amount available, along with the same quantity of a basal ration consisting of alfalfa hay and grain. Raw potatoes and corn silage were also fed for similar periods of time to provide comparisons with the experimental silages.

The cows consumed more total digestible nutrients and digestible crude protein than they required during each period. Comparisons were based on the live weight of the cows, on the milk and butterfat production, and on the feed consumption on the fourth, fifth, and sixth days of each experimental period.

The best silages were obtained when potatoes were ensiled with hay. From 15 to 22 percent of added hay was required to prevent excessive seepage and excessive losses of dry matter and protein. These silages looked much like good grass silage but were somewhat heavier. They had a mild, pleasant odor and a pH range of 4.42 to 5.28. They were eaten greedily and in larger daily quantities than corn silage on both a total weight and a dry matter basis. The cows made good gains in live weight and maintained their milk production well. The composition and quality of the milk was unaffected except when potato-5 percent hay silage was fed, in which case the fat content of the milk was lowered slightly and the milk contained some off-flavors.

Ensiling potatoes alone, or with 3 percent of corn meal, or with 0.75 percent of salt did not prove practical. The amount of seepage and the losses of dry matter and protein from these silages were excessively high. These silages were extremely low in crude fiber and fat and they contained no carotene. They were heavy, soft, and mushy and hard to handle. They had an offensive clinging odor, and a pH range of 4.05 to 4.15. Although the cows ate these silages rather reluctantly they consumed larger daily quantities of each than they did of corn silage. The ration did not prove unduly laxative. The cows maintained their live weight well. Milk production was maintained fairly well but, due to some unknown factor or factors, total fat secretion and the percentage of fat in the milk were sharply reduced. The solids-not-fat content and the protein content of the milk were unaffected. The milk also developed some off-flavors.

Raw chopped potatoes were eaten readily and in larger daily quantities than corn silage and did not produce a laxative condition. The cows maintained their live weight and milk production well. The composition of the milk was unaffected, but the milk developed some off-flavors.

The solids-not-fat content and the protein content of the milk remained at normal levels throughout the entire feeding experiment.

When the cows received potato silages containing no hay or very little hay, the milk had high iodine values and low saponification values. At this time, the percentage of butterfat in the milk and the total butterfat production were very low. The iodine values varied inversely with the quantity of butterfat produced, while the saponification values varied directly with this factor.

When the quantity of potatoes available for feeding is small they can be fed to best advantage in the fresh raw state. When the quantity is large they can be preserved satisfactorily as silage and fed over a longer period of time. For best results they should be ensiled with 20 to 25 percent of good quality hay or other dry forage.

If cull or surplus potatoes are on hand at the time the usual farm crops are being ensiled they can be put in the silo along with these crops provided the following precautions are observed: (1) Not more than 500 pounds of potatoes should be put in with each ton of green

crop; (2) when potatoes are siloed with corn or sorghum, the corn or sorghum crop should be well matured and not too high in moisture; and (3) when potatoes are siloed with legume hays or mixed hays, the hay should be wilted and contain not more than 60 percent moisture.

Potato silage can be made in either trench silos or tower silos. Both types of silo should be well drained so that the seepage can escape. Tower silos should be well reinforced, and they should be only partially filled with potato silage because of the heavy weight of the silage and the extremely high pressure it exerts against the silo wall.

The quantity of raw chopped potatoes or potato silage fed should be limited to about 4 pounds daily per 100 pounds of live weight. Such feeds should be fed after milking to prevent off-flavors in the milk. They should be fed along with good quality hay, grass silage, corn silage, or good pasture so that the ration will contain plenty of crude fiber, fat, minerals, and carotene.

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