THE PRACTICABILITY OF THE SILO AS APPLIED TO MILK PRODUCTION IN THE CORN BELT

Thesis for the Degree of M. S.

Walter J. Rawson

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Ensilage
Feeding + feeding stuffs
Table Milk production

Dairy husbandry

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Thesis

Respectfully submitted to the Graduate School of the Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of Master of Science.

by

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THESIS

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INTRODUCTION

The first silo in America was erected by Manley Miles of Michigan in 1875. In 1882 there were 92 silos in the United States. The increase in the number of silos was quite rapid, and by 1920 the feeding of ensilage had become a standard practice. Succulence was considered an essential factor in dairy feeding. Profitable milk production during the winter without ensilage was considered practically impossible.

It is no doubt true that experimental evidence was an important factor in the promotion of the use of silage. On reviewing literature, however, it is surprising how little useful data can be found. Silage feeding practices are really based on evidence that is scanty because of the small number of individuals used and the short duration of most of the tests.

Early experiments(1) conducted shortly after the introduction of the silo indicated a greater milk production through the feeding of silage. This was interpreted also to mean a lower cost of production. The building of silos was again stimulated by the results of Christi(2) in 1916-17 in which he showed that silage was a most economical feed not only for dairy cows, but for beef cattle and sheep as well.

Several recent investigations(3,4), however, indicate that either the importance of the silo might have been exaggerated or that due to a change of roughage fed or to superior methods of grain feeding and watering, the silo is regarded as less of a necessity. Also, since 1930, especially during 1932-33, many silos remained unfilled. This again raises the question as to the practicability of the silo.

It was the purpose of this investigation to determine if possible the value of corn silage in the dairy ration from the standpoint of economy.

A REVIEW OF THE LITERATURE

Although the experimental work deals only with the feeding value of corn silage, it will be necessary also to present, in the review of literature, data on certain other factors which have a direct bearing on economical production. These latter factors will be considered under two headings, cost of production and losses in feeding and storage. The review of literature will then be presented in three distinct topics, each topic being summarized and discussed separately.

Feeding Value

Digestible Nutrients and Production Energy

The feeding value of silage depends on the digestible nutrients it carries, its succulence, and palatability.

The following table gives the dry matter and digestible nutrients found in a silage and in other crops which might be substituted for silage:

	Dry Matter	Protein	Carbohydrates	Fat	Total Digestible Nutrients
	%	%	%	%	%
Timothy	88.4	3	42.8	1.2	48.5
Red Clover	87.1	7.6	39.3	1.8	50.9
Alfalfa	91.4	10.6	39	.9	51.6
Corn Silage	26.3	1.1	15	.7	17.7
Corn Fodder	57.8	2.5	34.6	1.2	39.8

It is apparent from the above table that 2.9 lbs. of silage would replace 1 lb. of alfalfa hay on the basis of total digestible nutrients.

Pearson and Gaines (5) stated that a ton of ordinary corn silage contained 354 lbs. of digestible nutrients. With an average yield, 4.6 bu. of corn were found in each ton of fodder. If 4.6 bu.of corn contain 211 lbs. of digestible nutrients, this leaves 133 lbs. of digestible nutrients to come from the roughage part of the silage. It takes 280 lbs. of timothy or 250 lbs. of clover to furnish 232 lbs. of digestible nutrients. Therefore, 1 ton of silage equals 4.6 bu. of corn plus 280 lbs. of timothy or 250 lbs. of clover from the standpoint of energy. Fraps(6) found that average alfalfa and corn silage produced 37.4 and 15.6 therms of energy per cwt. respectively. On the basis of productive energy 2.4 lbs. of silage should be as good as 1 lb. of alfalfa.

Succulence and Palatability

The Maine station (1) in 1889 found that the addition of ensilage to the ration increased the milk yield over that which was indicated by the dry matter eaten. This increase must have been due to the superior value of the nutrients in the silage over those in the hay or to a general physiological effect of feeding a variety of feeds. An increase of 85 lbs. of milk to a ton of silage was attained. This superior feeding value of silage, however, was so slight that Bartlett(1) in his summary is quoted as follows: "It should be remembered that greenness and wetness add nothing to what a food can supply to the animal body in the form of matter and energy, but are merely conditions affecting palatability". "Dryness," he stated," is of no disadvantage as to digestibility. Therefore, the old theory that cattle foods have a nutritive value in proportion to the dry matter they contain still holds good."

As a portion of the conclusion to their dairy cow feeding experiment in 1920, Foster and Meeks(7) stated that there was no evidence to show that the addition of silage to the ration of alfalfa hay on account of its succulence increased the milk flow or kept the cows in a more healthy condition.

Converse(3), in 1928, found that the factor of silage succulence did not increase the value of a ration containing an ample quantity of good alfalfa hay and a satisfactory grain ration.

Succulence and Water Consumption

While many experiments have been carried on to determine the value of succulence in the ration, very little has been done to determine the actual value of water in the ration, its relation to succulence, or its value in a succulent feed. White and Johnson(8), however, conducted a series of experiments in 1930-33 which had as their object the role of succulence and water consumption. In a trial in which silage, moistened beet pulp and hay were compared on the basis of total water consumption and dry matter consumption very little difference was found. They stated that at the prevailing prices, the hay group produced milk more cheaply than either of the other two.

This close comparison may be seen in the following table:

Average daily Dry Matter and Water Consumption

	Dry Matter				Water		
	Hay	Succulence	Roughage	Total	Feed	Drink	Total
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Hay	22.3		22.3	31.7	3.20	141.93	145.13
Silage	16.	6.3	22.3	31.6	21.53	122.44	144.07
Beet Pulp	17.	5.7	22.7	31.4	39.68	95.72	135.40

The next table gives the results of different watering methods:

	Total Dry Matter	Water Consumption Feed	Drink	Total
	Lbs.	Lbs.	Lbs.	Lbs.
Hay Watered once	29.4	2.47	110.96	113.43
Silage Watered once	27.5	31.37	82.55	113.92
Hay Watered at will	33.5	2.81	136.52	139.33

Adding silage to the ration failed to increase the dry matter consumption, but providing a constant supply of water increased it considerably. They concluded that the amount of water drunk plus the water in the succulent feed is approximately equal to the water drunk by animals receiving no succulence.

They also concluded that farmers are not justified in going to unusual expense to provide succulence for dairy animals unless the dry matter in the succulent feed can be secured at as low or lower cost than in good hay, and that if animals have free access to water succulence is not necessary.

Comparative Feeding Tests

Compared with Corn Fodder At Vermont, in 1889, Hills(9) compared corn fodder and corn silage from the same source as to feeding values. The test showed that equal amounts of dry matter from either source had the same feed value. A similar test in Missouri was unfavorable to silage.

Compared with Grain In 1917, Christi (2) of Purdue performed several feeding experiments which proved quite favorable to the silo. He gave one group of cows a heavy grain ration and the other a heavy silage ration. The amount of feed consumed per 100 lbs. of milk produced is as follows:

	Grain	Silage	Stover	Hay
	Lbs.	Lbs.	Lbs.	Lbs.
Heavy Grain Group	80	-	28	37
Heavy Silage Group	20.5	298	-	34

Therefore, 100 lbs. of silage replaced 20 lbs. of grain.

With grain at	Silage is worth
$25.00 per ton	$5.00 per ton
30.00	6.00
50.00	10.00
60.00	12.00

At this rate Christi(2) stated that the value of silage exceeds the combined values of 4.5 to 5 bu. of corn in each ton of silage, plus the value of the stover, plus the cost of putting corn in the silo.

Compared with Clover and Timothy The Montana Station in 1913 (10) compared the value of clover and corn silage as feed for dairy cattle. One lot was fed grain, clover and alfalfa. The other lot was fed grain, clover, alfalfa and silage. The grain ration fed was 3 parts of bran, 2 parts of shorts, 3 parts of oats, 1 part of barley and 1 part of corn. The results indicated that 165.5 lbs. of silage was equivalent to 3.6 lbs. of clover hay. With grain at $20.00 and clover hay at $6.00, silage was worth $2.50. One pound of hay was equivalent to 3.6 pounds of silage. The cost of producing 100 lbs. of milk on clover was 73.9¢ and on silage 73.8¢. The cost of producing butterfat on clover was 17.9¢ and on silage 17.8¢.

In Minnesota(11), in 1888, ensilage was compared to timothy. A basal ration of 7 lbs. of wheat bran, 4 lbs. of corn and 3 lbs. of oil meal was used. Fourteen pounds of timothy hay were compared with 35 lbs. of silage. It was found that the hay did more good than 2.5 times the weight of the silage,and that the cows gained weight on the hay.

At the Maine Station(1), in 1889, 8.8 lbs. of silage were found slightly superior to 1.98 lbs. of timothy, and that silage was worth $2.25 when the hay was worth $10.00.

Compared with Alfalfa In 1920, Foster and Meeks(7) reported results of dairy feeding experiments in which corn silage was compared with alfalfa. Lot I received 30 lbs. of silage, all the alfalfa hay they would eat, and 1 lb. of grain for each 5 lbs. of milk produced. Lot II received all alfalfa and the same grain ration. The double reversal method was used and the test consisted of four 25-day periods. There were two lots of eight cows each. The addition of corn silage made a more palatable ration with a wider nutritive ratio. It increased the production of milk and butterfat. A second experiment was conducted on practically the same basis as above. The difference in the total quantity of milk produced by corn silage and alfalfa with grain as compared with the total milk produced with alfalfa alone with grain was 166.9 lbs. Foster concluded that the results favored the addition of silage to the ration, but was too slight to be considered. In this case the addition of the silage increased the cost of the ration. With grain at $30.00 and alfalfa at $10.00 per ton corn silage was worth $3.50. With grain at $60.00 and alfalfa at $20.00 per ton corn silage was worth $8.00. As an average of the two experiments 30 percent was saved but the cost of milk production was not reduced. It took 3 tons of silage to replace 1 ton of alfalfa. Four percent more milk and 2.4 percent more fat were obtained with alfalfa. There was little difference in the cost with hay at $10.00 and silage at $3.50 per ton. He stated that the results of these tests are not in accord with the common belief in regard to corn silage since they do not show that it either lowers the cost of the ration or the production. He stated that silage in the ration will take the place of the high priced alfalfa to the extent of nearly one-half. Silage will decrease the cost of feed if alfalfa is worth more than $6.00 per ton, without decreasing the production of milk and fat. Home-grown alfalfa which cannot be profitably marketed will make the feeding of silage of doubtful value. He concluded that with cheap pasture and cheap roughage the silo is not essential to successful dairying in New Mexico.

In 1924, Utah(12) reported a similar experiment. There were seven cows in each group. The experiment was conducted for two years. There were four weeks in each period, the reversal method was used, and one week's time intervened each of the feeding periods. In one ration the cows were given all the alfalfa they would eat three times a day, and one-half pound of grain for each pound of butterfat produced in a week. In the second period the Holsteins were given 30 lbs. of silage, and the Jerseys 25 lbs. of silage in addition to alfalfa. The results showed a slightly higher milk and butterfat production, but Carroll (12) stated that it is questionable that the difference is really significant. The amount of silage required to replace 1 ton of alfalfa hay for fat production was 2.69 tons; and for milk production was 2.9 tons. The percent of increase on silage was 5.2. The average gain per head on silage was 11.5 and without silage was 9.5 pounds.

Fairchilds and Wilbur(13) found that comparatively few experiments had been conducted to show the value of a ration containing silage with one containing no silage.

Therefore they made three trial tests which they reported in 1925. Each trial comprised a 28-day feeding period with a 7-day preliminary period in order to accustom the cows to the change. The reversal method was used. Silage was fed at the rate of 3 lbs. per cwt. to one group. One pound of alfalfa was fed per cwt. to the silage group and two pounds to the non-silage group. In all feeding periods one pound of grain was fed for each three pounds of 4 to 6 percent milk. Milk production decreased markedly when silage was not fed. When silage was fed milk production was maintained. The cost of the fat was reduced 6 percent; the cost of the milk was reduced 10 percent. The cows on silage maintained weight better. The silage ration contained 8 percent more protein than the requirements, and the non-silage ration 40 percent more protein. The total digestible nutrients were about the same as the requirements. The alfalfa was valued at $18.00 and the corn silage at $5.00 per ton.

Their results are as follows:

(a) With silage 19,360 lbs. of milk.

(b) Without silage 17,601 lbs. of milk.

(c) With silage the feed cost was $1.03 per 100 lbs.of milk.

(d) Without silage the feed cost was $1.14 per 100 lbs. of milk.

(e) With silage the total fat production was 634.2 lbs.

(f) Without silage the total fat production was 600.5 lbs.

(g) With silage the feed cost per lb.butterfat was 31½¢.

(h) Without silage the feed cost per lb.butterfat was 33½¢.

Converse (3) found some very interesting results in his study of the value of silage in the experimental ration. The best method of attack, he stated, for many nutritional studies is to find the ration that will allow the cows to give their maximum yield year after year with no interruption in production. The use of silage in such a ration increases the labor and decreases the accuracy of the results. So he attempted to determine whether silage was necessary.

Nine cows were fed alfalfa hay and grain. They were then reversed for two calendar months and put on silage, alfalfa hay, and grain. The cows on the non-silage ration produced an average of 2.8 percent more milk and 4.2 percent more fat than on the silage ration. He concluded that there was practically no difference whether silage was fed or not as to the milk yield. He also stated that from the result of the experiment it seems that the factor of succulence does not increase the value of the ration containing an ample quantity of good alfalfa hay and a satisfactory grain mixture. The Idaho Station (14) reported in 1929 no particular advantage gained by adding corn silage to a barley-alfalfa ration for either yearling or two year old steers.

The most recent work by way of comparison of alfalfa hay and corn silage as a feed for dairy cows was reported by White and Pratt (15) in 1930. The object of the experiment was to determine if possible the optimum amount of silage that should be used in the dairy ration. In other words, to determine whether a light or a heavy silage ration was the more efficient or the more economical. In this experiment one group of cows was fed 3 lbs. of silage per cwt. and the other group 1½ lbs. of silage per cwt. The heavy silage feeding resulted in slightly greater dry matter consumption and slightly greater milk production. With hay valued at $16.00 and silage at $9.00 and grain at $52.35 per ton the feed cost of 100 lbs. of milk was $1.95 for the heavy silage group, and $1.70 for the light silage group. With silage valued at $5.00 and hay at $25.00 per ton, the feed cost was practically the same, being $1.82 for the heavy silage group and $1.80 for the light silage group.

White concluded that this result would be received with much surprise and doubt by many advocates of silage feeding,but should stimulate the study of the adaptation of silage production to the conditions existing on a given farm and area.

Summary and Discussion of Feeding Value;

The succulence of corn silage is evidently of much less importance than was formerly believed. Only one experiment station attributed any value whatsoever to the succulence factor, and this gain was so slight as not to be significant. This was an early experiment in 1889. Tests in 1920 at New Mexico Station(7), and by Converse(3),in 1928, show conclusively that the succulence of silage did not increase the milk flow.

In these later experiments alfalfa hay was used. The following table is a brief summary of the results of comparative feeding tests:

Investigator	Experiment Station	Date	Results
Clark	Montana(10)	1913	Cost on Clover 73.9¢ " " Silage 73.9¢
Christi	Purdue(2)	1917	Ton silage exceeds the value of 4.5 to 5 bu. of corn plus the value of stover plus cost of putting in silo.
Foster & Meeks	New Mexico(7)	1920	4% more milk and 2.4% more B.F. on alfalfa
Williams et al	Arizona(16)	1917	2% more milk on alfalfa and 6% more nutrients in silage.
Carroll	Utah(12)	1924	5.2% decrease on silage
Davis	Nebraska(17)	1923	More milk and B.F. on ration without silage.
Fairchilds & Wilbur	Purdue(13)	1925	Cost of fat reduced 6% and milk 10%.Hay contained 40% more protein, other ration only 8% more protein.
Converse	U.S.D.A.(3)	1928	Non-silage ration produced 2.8% more milk and 4.2% more fat.
Clark	Idaho(10)	1929	Nothing gained by adding silage to ration of barley and alfalfa.
White	Storrs(15)	1930	Heavy silage ration slightly more milk much greater cost .

The following gives the replacing value of silage as determined by various stations:

Name of Feed	Station	Date	Lbs.Silage to one of other group	Investigator
Corn Fodder	Vermont(9)	1889	2¼ to 1	Hills
Grain	Purdue(2)	1917	5 to 1	Christi
Clover	Montana(10)	1913	3½ to 1	Clark
Timothy	Maine(1)	1889	4 to 1	Bartlett
Alfalfa	New Mexico(7)	1920	3 to 1	Foster & Meeks
Alfalfa	Utah(12)	1924	2.9 to 1	Carroll
Alfalfa	Arizona(17)	1917	3½ to 1	Williams & Cunningham
Alfalfa	Vermont(18)	1901	3½ to 1	Hills
Hay		1930	3 to 1	Hughes(19)

The amount of silage required to replace a ton of hay in the various feeding experiments averages somewhat more than three pounds. The ratio 4 : 1 obtained by Bartlett(1) with timothy is undoubtedly due to a poor grade of silage. With alfalfa the results are very uniform, ranging from 2.9 to 3.5, At this rate, Hughes'(19) estimate of 3 : 1 is somewhat low.

Of the investigations cited considering the feeding value as indicated by either increased production, or decreased cost of production, four should be considered unfavorable, three neutral, and only three favorable. Of the three favorable reports, alfalfa was used in two of them. The first, conducted by Carroll of Utah, found so little gain that he concluded it to be questionable if the difference was really significant.

The one experiment which was conclusively in favor of silage and in which it was compared to alfalfa, was conducted by Fairchilds and Wilbur(13) of Purdue. In connection with this experiment it should be noted that while the total digestible nutrients were about the same as the requirements, the non-silage group received 40 percent more protein than the requirements. This would unnecessarily increase the cost of the silage ration. Also, the alfalfa was valued at $16.00 and the silage at $5.00 per ton in computing the costs. The alfalfa should not be valued at more than three times that of silage as it contains only three times the total digestible nutrients. The proteins cannot be considered of any extra value as the silage ration already carried an 8 percent excess of protein. Silage should then be valued at $6.00 instead of $5.00 per ton. This makes one and one-half cents difference in the daily ration, or 6¢ difference in the cost of the silage group. This leaves a net gain of five cents per cwt. in favor of ailage for milk production. A correction, however, for excess of protein costs in the non-silage ration would have left very little gain in favor of the silage. Hence this test can scarcely be considered favorable.

The most unfavorable report in regard to the feeding value of silage was that of the Connecticut Station in 1930. It should be noted that in computing their costs they valued silage at $9.00 and hay at $16.00. This is giving silage much more than one-third the value of hay which is an unfair comparison when placed on a dry matter basis. Valuing the silage at one-third the value of the hay would considerably reduce the cost of the heavy silage ration as compared with the light silage ration. However, they stated that to make the costs the same hay must be valued at $23.00 and silage at $5.00. So the results must still be considered unfavorable. An interesting fact in regard to the neutral results is that corn silage was valued at approximately one-third that of the hay.

Christi's(2) results seem indisputably in favor of silage as a feed. Clover hay was the roughage used, and no statement was made as to the quality of the hay.

Cost of Production

Silage Production Costs

It is claimed that silage is a cheap feed; that more digestible nutrients can be stored in the form of silage at less cost than in any other form. The following cost figures are taken from the U.S.D.A. Yearbook(20), 1921:

Cost of Silage	Yield	Per Acre	Per Ton
New York, 1914	7.2	$30.89	$4.29
New York, 1913	6.3	31.07	4.93
Minnesota,(Rice Co.) 1908-12		19.95	
(Norman Co.)		18.01	
Wisconsin, 1915	9.5	31.76	3.36
Iowa, 1915	9.76	29.36	3.01
Cost of corn			
Iowa, 1917	48 bu.	24.16	
New York,1914	34	35.98	
Ohio, 1917	45	36.20	
Ohio, 1921	45	35.16	
Illinois,1917	46	23.33	
Cost of hay			
New York, 1914	1.28 tons	10.00	7.80
New York, 1913	1.39	11.58	8.33
New York, 1912	1.44	11.30	7.85
Minnesota(Rice Co.)1908-12	1.61	10.76	6.68
Wisconsin, 1909-18	2.02	11.12	5.05
Wisconsin, 1909-18 (Mixed hay)	1.4	9.00	6.43

Wisconsin(21) gave costs as follows for Walworth County:

Silage	Yield per acre Tons	Cost per ton	Total cost per acre
Average,1923	6.6	$4.75	$31.38
Average,1922	6.26	5.34	33.45
Average,1924	4.30	6.20	26.54
Average,(3 yrs.)	5.66	5.35	30.31
Corn		Cost per bu.	
Average,1923		.92	30.36
Average,1922		.80	35.62
Average,1924		.94	27.22
Average,(3 yrs.)		.87	31.86

Wisconsin,(21), gave as the total cost for silage for 1927 $6.76, of which $4.59 is charged to labor.

Duggar(22), of Alabama, stated that corn harvested there in 1929 required 0.93 days of labor and a total cost of $4.86 per ton. Compared with sorghum the labor was 0.86 days and the cost was $3.76 per ton.

Wallace(23) itemized the cost of producing silage per acre in Iowa as follows:

Two tons manure	$3.50
Spreading	1.30
Plowing	2.95
Repairing	2.10
Cultivating	3.58
Twine	1.15
Cutting	1.17
Filling	9.00
Coal	.60
Engine and engineer	2.85
Depreciation and int. on cutter	1.00
Depreciation and int. on plows	2.50
Land rental	9.00
Depreciation and int. on silo	2.75
Total	$43.55

The yield was 10 tons per acre.

Minnesota(25) gave the following comparative costs on various methods of harvesting:

Cost per acre, cut, shocked and husked	$21.50
Cost per acre, shocked and shredded	22.25
Cost per acre, husked in the stalk	20.74
Planted thickly,cut, hauled for fodder	19.51
Put in the silo	25.37

Wallace(24),1923, stated that with corn selling at 75¢ silage containing 4½ bu. of corn per ton, and made from corn yielding 9 tons per acre can be produced at a cost of $5.00 per ton, or roughly, for the value of 4 bu. of corn and 300 lbs. of hay. Silage containing 6 bu. of corn will always be very expensive but also quite valuable as a feed.

The cost of production of both silage and corn are greatly influenced by yield.

The U.S. Dept. of Agriculture Yearbook(20) of 1921 gave the following tables of cost and various yield groups:

Yield Group Bu.per acre	Total Cost	Credit (Stover)	Net Cost Per acre	Net Cost Per bu.
7	$12.12	$1.56	$10.56	$5.28
8 to 17	16.97	1.18	15.79	1.21
18 to 27	20.41	1.53	18.88	.86
28 to 37	24.67	1.95	22.72	.71
38 to 47	28.34	2.41	25.93	.63
48 to 57	32.35	2.77	29.58	.58
58 plus	38.32	3.71	34.61	.52
Average	25.20	2.10	23.10	.70
For the Corn Belt only:				
7 to 17	15.91	.98	14.93	1.49
18 to 27	17.82	.86	16.96	.74
28 to 37	21.54	1.08	20.46	.64
38 to 47	24.36	1.19	23.17	.57
48 to 57	27.50	1.10	25.90	.51
58 plus	31.53	1.74	29.79	.47
Average	23.64	1.15	22.49	.58

Metzgar and Sellman(25) found that the cost of silage from 1925-30 was $33.87 per acre, with a yield of 12.87 tons or $2.92 per ton. Of this total $14.04 was for harvesting and storing.

Lipscomb(26) found that in Mississippi the amount of land required to produce one ton of corn silage would produce 4.2 bu. of corn. Five and one-tenth hours of man labor and 2.8 hours of horse labor were required.

Willard(27) reported in 1920 a cost of $25.00 per acre for corn raised for grain, and $33.00 per acre for silage corn in the silo. The yields were 17.5 bu. and 4.5 tons respectively.

Minnesota Agr. Exp. Station(28) in 1906 and 1907 found that the cost of harvesting corn husked from standing stalks was $10.35 per acre. This included interest of 0.73¢ and depreciation of $1.43 per acre in the silo. The yields were 42 bu. for corn and 10.21 tons for silage.

The Canadian Station(29) for 1922 reported a cost of $3.05 per ton for silage as compared with $9.83 for hay. This was probably mixed clover and timothy.

Abel(30) in his "Time Studies on Haying and Ensiling on 86 farms in New Hampshire" found that corn silage required 6.5 hours per ton and hay 8.4 hours per ton.

The cost of production of alfalfa and timothy were compared under nearly the same conditions as possible. The results were as follows:

	Yield Tons	Cost per acre	Cost per ton
Alfalfa	2.6	$27.44	$10.63
Timothy	1.4	16.72	12.00

The life of the alfalfa was considered four years.

The following table was taken from Haecker's work at the Minnesota Station(28) and is a comparison of the cost of hay, fodder corn, mangels and silage:

	Cost per acre	Feeding Value per ton	Tons per acre	Feeding Value per ton
Clover and Timothy	$ 6.96	$6.35	2.5	$15.87
Ensilage	19.17	1.88	10.	18.80
Fodder Corn	12.19	4.90	3.5	17.15
Mangels	34.12	1.30	20.	26.00

He reported that one dollar expended in labor and capital with hay would give a return of $2.28; with fodder corn, a return of $1.40; with ensilage 0.98 and with mangels 0.76.

Bailey(28) commented on Haecker's work in the following manner: " Ensilage and mangels are expensive feeds as compared with hay and fodder corn. Ensilage is a profitable crop and utilized to adventage when the type of farming is intensive dairying, when markets are stable, and when cows are high producers. Under these conditions and when silos are of large capacity, the crop is profitable because it increases the number of cows that can be supported on a small acreage and thus increases the gross income, waranting the high cost of production. But the farmer with few cows and who carries on diversified farming, winter forage in the shape of hay supplemented with a few mangels gives a cheaper feed."

Filling Costs

McNall and Hartman(31) reported that the average cost of filling silos in 1926 was $2.06 per ton.

Jones and Smith(32) found that in Missouri the average cost of filling was $2.00 per ton. Labor was 42 percent and power 25 percent of this cost.

In 1930 Lush and Barr(33) found that the average cost of filling 282 silos in Wisconsin was $1.60 per ton.

Silo Costs

Silo costs vary greatly as to type, material and size.

Permanent upright silos Garret(34) gave the following types of wooden silos in the order of value: Redwood,cypress, white pine, Douglas fir and southern pine. He stated that cedar is expensive and needs considerable reinforcing, and added that the life of any of the above is from ten to twenty years, untreated, and twenty-five years treated.

Ribald(35) stated that the stave silo is cheap and easily constructed but that it is temporary and lasts only five to fifteen years.

Shedd and Foster(36) reported that two wooden hoop silos built in 1912 at the Iowa Station cost $254.84 each.

Five farmers at Litchfield,Minnesota(37) cooperated in buying materials and erecting home-made silos. The silos were 16 x 36 and of Washington fir at $32.00 per thousand feet. According to Wilson the lumber cost was $111.36 and the total cost was $228.78 per silo.

King(38) reported that the cost of thirteen hollow clay building block silos in Iowa ranged from $215.00 to $403.00. He stated that this type of silo is practically free from cost of repairs and that the duration depends on the quality of the blocks.

Jones and Swinehart(39) stated in 1929 that good silos are built in Wisconsin at a cost of about $5.00 a ton capacity. They continued that with strictest economy a silo can be built for $3.00 per ton capacity.

Ives(40) concluded that the average for all manufactured types is very close to $4.00 per ton capacity. It must be said in all fairness that the manufactured or patented types generally represent the greatest utility.

Ramsower(41) gave the costs of silos per ton capacity as follows:

Wooden stave	$2.75
Home-made hoop silo	1.70
Monolithic concrete	3.93
Concrete block	4.20
Vitrified tile	4.75
Metal	4.00

The life of the wooden silo was from ten to twenty years. These figures were the average of many Ohio farmers.

The following table from the price list of the Kalamazoo Tank & Silo Co. gives 1933 prices:

Dimensions	Glazed Tile Cash Price	Glazed Tile Capacity tons	Glazed Tile Cost per ton	Washington Fir Cash Price	Washington Fir Capacity tons	Washington Fir Cost per ton
8 x 20	$185.	18	$10.40	$170.	17	$10.00
10 x 20	226.	32	7.07	190.	30	6.63
10 x 25	279.	40	6.97			
10 x 30	336.	48	7.00	285.	48	5.97
12 x 20	260.	46	5.67	218.	45	4.85
12 x 25	322.	60	5.37			
12 x 30	383.	75	5.11	327.	75	4.36
12 x 35	447.	85	5.25			
12 x 40	508.	115	4.40			
14 x 30	433.	100	4.33	373.	100	3.73
14 x 40	578.	150	3.85			
16 x 30	485.	122	3.97	416.	120	3.45
16 x 40	647.	178	3.65			
16 x 45	741.	205	3.60			
18 x 40	716.	224	3.20			

Temporary Silos   Silos of a semi-permanent or temporary nature are being used with success in many states. For the renter or for the owner who occasionally has surplus roughage to store they may prove very practical.

According to Jefferson and Bell(42) of the Michigan Station crib silos have been used in the west for about five years. A few have been used satisfactorily in Michigan. The cost of a 16-ft.,50-ton silo is approximately $30.00.

A semi-permanent sheet metal silo was constructed in 1930 by the Agri.Eng. Dept. of Michigan State College. The cost of this 10 x 30 silo was $150.00 or $3.00 per ton capacity according to Jefferson and Bell (42). Am estimated life of ten years makes the cost $.60 per ton per year.

Trench Silos Trench silos are rapidly gaining in popularity because of their low cost and adaptability. Grimes and Nichols(43) reported that in Alabama where only labor is necessary a 50-ton silo can be built for $20.00 to $25.00.

Jefferson and Bell(42) estimated that the labor cost of a 50-ton silo was $18.00 and the reinforcing material was $10.00, making a total cost of $28.00 to $30.00. They stated that a permanent concrete lined silo of this capacity will cost about $100.00.

In a comparison of the efficiency of the trench and upright silos, Dawson and Van Horn(44) found that the cost per 100 cu.ft. in the trench silo was $1.78 as compared with $10.82 for the upright silo.

Jefferson and Bell(42) gave the following table on comparative costs of various types of silos:

Type of silo	Est. Cost	Cap. tons.	Cost per ton	Est. life	Cost per yr.	Cost per ton silo per yr.
Temp.crib	$35.00	50	$0.70	5 yrs.	$23.75	$0.47
Temp.trench	30.00	"	.60	2 "	18.75	.36
Sheet Metal	150.00	"	3.00	10 "	30.00	.60
Perm.trench	100.00	"	2.00	20 "	14.15	.28
" upright	300.00	80	3.75	20 "	42.00	.53
" "	500.00	"	4.50	40 "	57.50	.72

Summary and Discussion of Cost of Production

Silage Costs

Station	Date	Yield	Cost per ton
New York	1914	7.2	$4.29
New York	1913	6.31	4.92
Wisconsin	1915	9.5	3.36
Iowa	1915	9.76	3.01
Wisconsin Av.	1923-24	5.66	5.35
Oregon		5.7	7.40
Oregon		10.	5.03
Alabama	1929	8.	4.86
Iowa	1918	10.	4.36
Average		8.	4.73
Wallace estimate	1923	9.	5.00

Silage vs. Corn cost, per acre

		Silage	Corn
Minnesota (Rice Co.)	1908-12	$19.95	$16.21
Minnesota (Norman Co.)	"	18.01	13.42
New York	1914	30.89	35.98
Iowa	1915	29.36	24.16
Wisconsin	1915	31.76	-
Wisconsin Av.	1922-23-24	30.31	31.86

Hay Costs

		Yield per acre	Per acre	Per ton
New York	1912	1.44	$11.30	$7.85
New York	1913	1.39	11.58	8.53
New York	1914	1.28	10.00	7.80
Minnesota (Rice Co)	1908-12	1.61	10.76	6.68
Wisconsin				
Clover	1909-18	2.2	11.12	5.05
Mixed	1909-18	1.4	6.43	9.00
Canada	1923			
Nevada				
Alfalfa (34)		3.	36.00	12.00
Corn Belt Alfalfa		2.6	27.44	10.63
Corn Belt Timothy		1.4	16.72	12.00

Silage vs. Hay in New York

1914	Silage	7.2 tons	$4.29
	Hay	1.28	7.80
1913	Silage	6.3	4.92
	Hay	1.39	8.33

Silage costs averaged $4.73 with an average yield of 8 tons. The lowest cost was obtained in Iowa in 1914 with a yield of 9.76 tons. The highest cost in Oregon with the lowest yield. Yield influenced the cost much more than the location or the year.

A 10-ton yield in Iowa in 1918 cost $4.36. Wallace stated in 1923 that for Iowa a 9-ton yield could be produced for $5.00. It is reasonable to conclude that silage will cost at least $4.00 per ton in the corn belt for a 10-ton yield, and more elsewhere.

The per acre cost of producing grain and stover is just about the same as for silage when considering normal yields(45 bu. to 10 tons silage). New Yprk and Minnesota reported a greater cost for silage. The Wisconsin average is $1.00 per acre in favor of silage. Minnesota reported a cost of $3.00 more per acre for ensiling than for cutting, shocking and shredding. Haecker found that silage was expensive when compared with either hay or fodder. Apparently ensiling corn is as expensive as shocking and shredding and much more expensive than husking from the stalk.

Silage costs averaged from two to three times as much per acre and more than one-half as much per ton as timothy or clover hay. Comparisons with alfalfa were not available. A corn belt comparison with timothy showed that a 2.6 ton yield of alfalfa costs less than a 1.4 ton yield of timothy. A three ton yield of alfalfa in Nevada costs $12.00 under irrigation. Two dollars and fifty cents is charged for seeding. At that rate a 3-ton yield of alfalfa in the corn belt should not cost more than $9.00 or $10.00, or two to two and one-half times the cost of silage.

Silo costs ranged from $2.00 to $4.00 per ton capacity depending upon the size and material. In computing silo costs a depreciation charge of 10 percent was made on the average cost of the wooden type silo, $2.75. It was customary to charge the depreciation and interest rate of 15 percent on $2.75, or 41.5¢ per ton cost.

The present costs, however, are much higher. It will be observed from the Kalamazoo Tank & Silo Co.'s price list that height has very little influence on the per ton cost of the silo. This is greatly influenced, however, by the diameter. This is true of both the wooden stave and glazed types. Eight-foot silos or less than nine-cow silos are prohibitive in price at $10.00 per ton capacity. Ten-foot, or twelve-cow capacity silos are quoted at $7.00

per ton. Fourteen-cow silos can be bought for $5.00 if purchased in the twelve-foot size, but cost $7.00 per ton capacity in the ten-foot size. Eighteen-foot silos, 40 ft. in height, cost only $3.20 per ton in the semi-glazed tile when their capacity is about 224 tons.

Comparative Losses in Storing and Feeding

The silo is recognized as a great saver of waste.

Harvesting and Feeding Losses

Turner(45) stated that much more of the corn crop is lost in the harvesting and feeding operations when the crop is not ensiled. He claimed a saving of 20 to 35 percent of the total crop.

Storage Losses

It is also claimed that there is a great saving of dry matter and total digestible nutrients.

Becker and Gallup(46) found that the loss of whole corn in silage fed to dairy cows is much less than that which occurs when cattle consume shelled corn. The corn voided in the manure contains 5.22 percent of the digestible protein and 5.46 percent of the total digestible nutrients in the corn silage. Eight and forty seven hundredths percent by weight of the grain voided in the manue and only 4.36 percent by weight of the whole kernels was recovered as whole kernels from the manure.

Turner(45) stated that loss in dry matter is 16 percent as compared with 30 percent in corn fodder.

King(47) concluded in 1925 that there is a loss of 20.5 percent total dry matter and 20.6 percent loss of protein.

Stadler(48) found in a careful study of 54 silos that the unavoidable loss of nutrients was 7.59 percent of dry matter as compared with field corn with a loss of 15.12 percent of dry matter.

At Wisconsin(49), silage containing 29.33 percent of dry matter lost 8.53 percent. Silage containing 25.39 percent lost 10.01 percent, and silage containing 20.66 percent dry matter lost 24.35 percent. Corn silage well matured lost 5 percent to 10 percent and clover silage in full bloom lost 10 percent to 18 percent.

Shaw and Wright(50) found that there was a loss of 10 percent of dry matter, 6.34 percent of crude fiber, and some loss in total nitrogen, but a gain in ether extract. In 1921 they found that the loss of nitrogen in 2,579 lbs. of juice taken from several silos represented the protein in 1500 lbs. of silage (150 ton silo). The second year with immature corn the loss of nitrogen was equivalent to that found in 7500 lbs. of silage. They concluded that there was a perceptible loss of nitrogen, also sugar.

Perkins(51) found that during the storage of corn silage in Ohio in some cases the grain portion of the ensiled corn lost one-half of its protein, but where the juice was not lost the nitrogen increased. The protein lost from the kernels was found in the juice in the silo, not as true protein, but as products of protein hydrolysis. These results were obtained from three silos over a period of five seasons.

Ragsdale and Turner(52) gave the following loss of nutrients on 54 silos:

	Dry Matter	Protein	Fat	Crude Fiber	N.F.E.
	%	%	%	%	%
From silos	7.59	5.44 gain	18.04	1.95	10.29
From shocked corn	15.12	.84 gain	7.36 gain	3.82	22.51

They concluded that the loss of dry matter and the nitrogen free extract in field-curing is twice as great as the unavoidable loss of nutrients in the silo. The loss of nutrients in the silo is inevitable but much less than in field-cured corn, providing silage is properly made.

Perkins(49) found that in Ohio the grain, especially the broken kernels, had lost a considerable portion of its protein, which was recovered in the juice of the silo. The protein content of the silage was increased in many cases probably due to the reduction in the other constituents through fermentation. He further stated that there is a transfer of nutrients from the grain to the juice.

Summary and Discussion of Comparative Losses

The loss sustained in the harvesting and feeding of the corn crop probably averages 25 percent of the stover. As nearly 40 percent of the value of the crop is in the stover this means a net loss of 10 percent of the corn crop.

The data on losses of dry matter and total digestible nutrients are not satisfactory. For the silo they vary from 5 to 20 percent. The loss is probably 5 percent more for shocked corn. Turner(45) in one case obtained 4 percent greater loss with shocked corn and in another 7.5 percent.

Assuming that this loss is 5 percent, and the waste previous to storing is 10 percent, a saving of 15 percent should be credited to the silo. The cost of harvesting the "saved" stover is probably about 20 percent per ton of silage or 5 percent of its value. This leaves a net saving of at least 10 percent of the value of the silage due to the use of the silo.

EXPERIMENTAL WORK

Object

The object of this experiment is to determine the value of silage in the dairy ration for economical milk production.

Original Plan of the Experiment

Selection of Herds

Herds will be selected on the basis of accessibility, uniformity of size and breed, and whether or not the proper cooperation in supervision can be secured. It will be necessary to depend on the owners for part of the feed records. In most cases herds will be selected in which a Future Farmer can work with his father and make this a home project for him. Adequate facilities for weighing feed will be another consideration in the selection of herds.

Selection of Animals

Only healthy animals will be used in the experiment. Cows with normal udders and appetites, and whose lactation periods extend through the three months of the experiment will be chosen. Cows freshening or drying off during the experimental period will complicate results. If none of the foregoing objections exist in a herd the entire herd will be used, thus making the records more easily kept.

Time

The first three months of the year will be used for the experiment.

Kinds

Alfalfa and corn silage will be used for roughage. The concentrates used will be a simple grain mixture.

Method of Feeding

All herds will be fed silage and alfalfa during January and March, but only alfalfa as a roughage during the month of February. Two of the herds will be fed a full ration of silage and two will be given a limited ration. Alfalfa in all cases will be fed ad libitum. The cows will be grained at the rate of one pound of grain for each three pounds of milk produced daily during the previous month.

Feed Records

Feed consumed   Weights of silage will be obtained by weighing the silage in a basket on platform scales. Grain for the entire herd will be weighed in the same way and distributed by measure to each cow. These weights will be checked against the total amount ground for the period. The alfalfa will be weighed on spring scales, the hay being tied in bundles by means of clothesline rope. The roughage not consumed will be gathered into baskets and weighed being being used for bedding.

Nutrients consumed   The amount of total digestible nutrients will be com ared for each herd. These computations will be based on the results of the analysis of the roughages as obtained by the Section of Experiment Station Chemistry, and the analysis of concentrates as obtained from Henry and

Morrison. The digestible protein consumed will be obtained in the same manner.

Feed Analysis

Analysis of the roughage feeds will be made by the Section of Experiment Station Chemistry as to the amount of dry matter, protein, carbohydrates, fat and ash.

Production Records

Milk records The amount of milk produced will be obtained from the owner's monthly milk statement. Any milk used in the home will be weighed and added to this to get the total period production.

Butterfat records The amount of butterfat produced will be obtained from the monthly milk statement using the butterfat test as given by the Company tester.

Temperature Records

The daily temperature records for the time of the experiment will be obtained from the United States Weather Bureau.

Water

Water will be supplied in two different ways. Two herds will be equipped with drinking cups and two herds will be supplied by outside tanks.

Exercise

Three herds will be allowed to go to the tanks in the yard twice a day. On good days they will be allowed to exercise in the yard at will. One herd having access to drinking cups will remain stanchioned constantly.

Experimental Procedure

Selection of Herds

The selection of herds was made as planned. Results of two of the herds could not be used, however. In one herd where individual cups were used a frozen water system necessitated driving the cows a quarter of a mile to water in sub-zero February weather. There was such a falling off in production that the experiment with this herd had to be abandoned. Inaccurate feed records made the results of the other herd useless. It was therefore necessary to run these experiments the following year on two new herds.

Selection of Animals

The selection of animals was made as planned.

Time

The experiment was conducted at the time planned except that it had to be repeated with two herds the following year.

Feeds

The feeds were used as planned except that a complex grain mixture was used in the case of one herd during January and March. This ration had been worked out by the local milk tester. Some difficulty was also experienced in getting one of the herds to consume a full silage ration. Also a small amount of stover was used in one herd. This was fed in as near the same quantities each period as possible.

Feed Records

Feed records were kept as planned.

Feed Analysis

Analyses of feed were made as planned. The analyses of the silage and alfalfa used are found in Tables 1 and 2 of the Appendix.

Production Records

Milk and Butterfat records were made as planned.

Temperature Records

Temperature records were made as planned.

Water

Water was supplied as planned except that only one herd had access to drinking cups. However, one herd had water at will from an inside tank.

Exercise

Exercise was given as planned, except one herd exercised in the barn only.

Experimental Results

Production

The average daily fat-corrected milk production and butterfat production are given in Table 1. The production during the silage period was obtained by averaging the produotion for the January and March periods. The production during the alfalfa period was obtained from the February results.

Table 1.

	Fat-corrected Milk Lbs. daily				Butterfat Production Lbs. daily			
	Herds				Herds			
	No.1	No.2	No.3	No.4	No.1	No.2	No.3	No.4
Jan.(Sil.)	16.3	20.97	21.67	24.88	.710	.912	.935	1.10
Feb.(Alf.)	15.38	20.73	19.57	21.46	.678	.920	.845	.933
Mar.(Sil.)	14.14	19.78	18.29	19.92	.623	.861	.795	.734
Silage period	15.22	20.39	19.98	22.40	.666	.886	.869	.991
Alfalfa period	15.38	20.73	19.57	21.46	.678	.920	.845	.933

The production records from which the results in Table 1, were obtained are found in Tables 13 - 16 of the Appendix.

The formula used for obtaining the amount of fat-corrected milk was .4M plus 15F. (53).

Feed Consumption

Herd No. 1 This herd consisted of eleven grade Guernseys which averaged about 1000 lbs. in weight. The silage was limited to not over 20 lbs. daily. The feed consumption is given in Table 2.

Table 2.

	January		February		March	
	Total Feed	Av.daily ration	Total Feed	Av.daily ration	Total Feed	Av.daily ration
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Alfalfa	5040	16.36	6768	22	4495	14.59
Silage	6160	20.	-	-	5456	17.7
Grain	1400	4.55	1672	5.42	1524	4.62
Digestible Protein	737,85	2.39	768.48	2.49	693.86	2.25
T.D.N.	4695.94	15.24	4669.09	15.16	4498.09	14.60
Energy Therms		12.90		12.74		11.83

<u>Herd No. 2</u> This herd consisted of six grade Jerseys which weighed about the same as in Herd No. 1. A full silage ration was fed. Feed consumed by this herd is given in Table 3.

<u>Table 3.</u>

	January Total Feed	January Av.daily ration	February Total Feed	February Av. daily ration	March Total Feed	March Av.daily ration
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Alfalfa	2016	12	3696	22	2058	12.25
Silage	5040	30	-	-	5040	30.
Grain	1008	6	840	5	924	5.5
Digestible Protein	336.47	2.0	404.58	2.41	341.27	2.03
T.D.N.	2672.16	15.9	2451.86	14.59	2630.29	15.6
Energy Therms		12.55		12.53		13.17

Herd No.3 This herd consisted of seven Guernseys which weighed about 1100 lbs. each. A limited silage ration was fed.Feed consumed by this herd is given in Table 4.

Table 4.

	January		February		March	
	Total Feed	Av.daily ration	Total Feed	Av.daily ration	Total Feed	Av.daily ration
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Alfalfa	3206	16.35	3640	18.57	2885.4	14.7
Silage	2744	14	-	-	2744	14
Grain	1484	7.57	1484	7.57	1484	7.57
Digestible Protein	501.2	2.56	458.44	2.34	498.9	2.49
T.D.N.	3268.8	16.6	3086.37	15.7	3131.90	15.9
Energy Therms		13.99		12.53		13.17

<u>Herd No. 4</u> This herd consisted of six Jerseys which weighed about 800 lbs. each. It was planned that this herd was to be fed a full silage ration, but it would not consume that much. Feed consumed by this herd is given in Table 5.

Table 5.

	January		February		March	
	Total Feed	Av.daily ration	Total Feed	Av.daily ration	Total Feed	Av.daily ration
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Alfalfa	1400	8-1/3	2352	14	1200	7.12
Silage	2800	16-2/3	-	-	3000	17.8
Stover	504	3	648	3.86	767	4.56
Grain	1316	7.83	1166	6.97	1053	6.27
Digestible Protein	306.54	1.83	271.67	1.42	253.52	1.507
T.D.N.	2416.36	14.3	2482.1	14.7	2287.58	13.6
Energy Therms		12.12		11.17		11.53

Digestible Nutrients

The nutrients required according to the Haecker standard as well as the nutrients received are found in the Appendix, Tables 13-16. In Table 17 of the Appendix will be found the digestion coefficients used in determining the digestible nutrients of alfalfa samples, and in Table 18, the digestible nutrients furnished by the alfalfa and silage used.

Table 6. gives the relative intake of protein, total digestible nutrients and therms of energy of the silage and alfalfa rations. The average consumption of the January and March periods gives the data for the silage ration.

Table 6.

	Herd No.1	Herd No.2	Herd No.3	Herd No.4	All Cows
	Digestible Protein				
Silage ration	2.32	2.02	2.55	1.66	2.14
Alfalfa ration	2.49	2.41	2.34	1.42	2.16
	Total Digestible Nutrients				
Silage ration	14.92	15.75	16.33	14.0	19.5
Alfalfa ration	15.16	14.59	15.7	14.7	19.29
	Therms of Energy				
Silage ration	12.31	13.36	13.58	11.85	12.77
Alfalfa ration	12.74	12.53	12.53	11.17	12.26

<u>Cost of Feeds</u>

In computing costs, the prices as quoted by Ulrey(54) for 1933 and 1934 were used for the home-grown feeds. To these prices were added the local cost of grinding. Commercial feed prices were obtained from the Michigan State Farm Bureau. Table 19 in the Appendix gives the prices used in computing the costs in the following table of herd costs:

Table 7.

Total Costs

	Herd No.1 2 lbs.silage per cwt.	Herd No.2 Full silage	Herd No.3 1½ lbs. per cwt.	Herd No.4 2 lbs. per cwt.
Silage period	26.94	15.30	35.32	24.53
Alfalfa period	27.35	13.44	31.22	21.30

Cost of Digestible Nutrients

Table 8 gives the cost per pound of digestible protein, total digestible nutrients and cost per therm of energy.

Table 8.

Cost of Total Digestible Nutrients per lb.

	Herd No.1	Herd No.2	Herd No.3	Herd No.4
Silage ration	.586¢	.577¢	1.78	1.04
Alfalfa ration	.585¢	.548¢	1.01	.86
Cost of Digestible Protein per lb.				
Silage ration	3.756	4.51	6.83	8.04
Alfalfa ration	3.56	3.32	6.81	7.84
Cost of Energy per Therm				
Silage ration	.61	.68	1.33	1.23
Alfalfa ration	.7	.655	1.27	1.13

Milk and Butterfat Costs

The cost of a pound of butterfat and 100 lbs. of 4% milk is given in Table 9.

Table 9.

Cost per 100 lbs. of 4 percent Milk

	Herd No.1	Herd No.2	Herd No.3	Herd No.4
Silage ration	57.65	44.6	90.2	65.2
Alfalfa ration	57.7	38.6	61.3	59.0
	Cost per pound Butterfat			
Silage ration	13.15	10.65	20.7	14.7
Alfalfa ration	13.12	8.70	18.8	13.5

The prices used in 1933 (herds 1 and 2) for silage and alfalfa were $2.50 and $6.00 respectively. In 1934 the prices were $3.00 and $9.00 respectively. The price of hay was particularly low in 1933. Had average prices been used the results might have been different.

Table 10 gives the cost of milk and butterfat based on 1910-14 prices and on 1924-33 average prices.

Table 10.

Cost of 100 lbs. 4% fat-corrected milk

	1910-1914 Ave.		1924-1933 Ave.	
	Alf.& Sil.	Alf.	Alf.&Sil.	Alf.
Herd No.1	1.37	1.42	1.33	1.35
Herd No.2	1.08	1.01	1.02	.975
Herd No.3	1.20	1.10	1.17	1.11
Herd No.4	.808	.829	.850	.853
	Cost per pound Butterfat			
Herd No.1	33.6	33.7	30.5	30.66
Herd No.2	24.8	22.8	23.5	22.0
Herd No.3	27.5	25.4	27.0	25.7
Herd No.4	18.1	19.0	19.1	19.6

The average prices of grains for the five-year period, 1910-14, and the ten-year period, 1924-33, are found in the Appendix, Table 9.

DISCUSSION OF EXPERIMENTAL RESULTS

In this investigation, rations consisting of alfalfa and grain were compared with rations of alfalfa, corn silage and grain. Four farm herds were used. Each herd was fed for three periods of 28 days each. During the first and third periods they received the silage ration and during the second period they received the alfalfa ration.

The average daily milk production for all cows in the four herds used in this investigation was slightly greater on the silage ration than when alfalfa was the sole roughage used. Milk production on the silage ration was 19.5 lbs. daily, while the average on the alfalfa ration was 19.29 lbs. daily. Production was higher in both herds on the non-silage ration in 1933, but it was lower in both herds in 1934. Temperature may have influenced these results. The mean monthly temperature as indicated by Table 20 in the Appendix for February (the alfalfa period) 1934 was 15.2 degrees, which is 15 degrees below the January and February monthly average for the same year. The mean monthly temperature for February 1933 was 23.40 degrees. This was nearly 10 degrees above the average for the same month in 1934, and was only 8.5 degrees below the January and March averages.

The digestible protein consumption was greater during the non-silage periods than during the silage periods. This is to be expected since a ration of alfalfa and corn cannot be balanced for low producing cows unless an excess of grain is used in proportion to hay. In herd No.3, however, the February protein consumption fell below that of January and March. This was due to the fact that the owner desired to feed home-grown soy beans as part of the grain mixture.

The average daily total digestible nutrient consumption for all cows was 15.25 lbs. during the silage period, and 15.041 lbs. during the non-silage period. One and twenty-eight hundredths pounds of 4 percent fat-corrected milk was produced per pound of total digestible nutrients for each period.

The total feed cost was somewhat less for the non-silage ration with the exception of herd No.1. Expecting their dry matter consumption from roughage to fall off somewhat when changed to alfalfa, the grain allowance for this herd was increased. This,however, did not happen, with the result that there was a larger consumption of total digestible nutrients which increased the cost during the February period.

The cost of digestible protein was less in all herds on a non-silage ration. The greatest difference in cost per pound was found in the fúll silage ration and the least difference in the limited silage ration. This was due to the fact that the protein was furnished by alfalfa hay when the cows were fed the non-silage ration.

The cost per pound of digestible nutrients was somewhat less in all herds when fed the non-silage ration. The silage was valued at 40 percent of the value of the hay in 1933,and at one-third of its value in 1934.

The cost per therm was less on the non-silage ration in all of the herds except No.1. There was less difference in the cost per therm during the two periods, however, than when compared on a total digestible nutrient basis. The rations including silage ran relatively higher in therms of energy than in total digestible nutrients.

The real test of a ration is its economy for maintenance and production. The production of these herds followed closely their consumption of total digestible nutrients. The total digestible nutrients seemed to influence production more than did the protein consumption. This might have been due to the fact that all herds were fed at all times more than their protein requirements according to the Haecker standard.

While the cost of production of milk and butterfat was practically the same during both periods with herd No. 1, it was about 20 percent less in herd No.2 and 10 percent less in each of the other two herds while receiving the non-silage ration. Herd No.1 was fed about 15 percent more grain and Herd No. 2 was fed about 15 percent less during February, while the other two herds were fed the same amount during both periods.

The least difference in the cost of production was found in those herds which received a limited silage ration and the greatest difference in those herds which received a full silage ration.

Low priced corn and alfalfa would be expected to be favorable to a non-silage ration. Therefore, it appeared desirable to use average feed costs over a period of years. When applying 1910 to 1914 prices to all feeds except silage and estimating the value of silage at one-third that of alfalfa there was a slightly greater feed cost for the group on the non-silage ration and a somewhat less cost for the other two groups. When the 1924-33 prices were used the cost of production was about the same in all four herds during the two periods. Two herds favored the non-silage ration and two the silage ration. The price of corn was higher, and the prices of soy beans and cottonseed meal were cheaper in 1924-33 than in 1910-14. This made the cost of production somewhat less while on the silage ration, and more on the non-silage ration.

Carbonaceous grain prices were higher in 1924-33 than in 1910-14, while alfalfa was cheaper. This accounts for the fact that herd No.4 had a greater cost of production in 1924-33 than 1910-14. A greater corn and less cottonseed meal cost accounts for the apparent discrepancy with herd No. 3. There was a decrease in the cost of production while on the silage ration but an increase during the non-silage period.

In obtaining the 1924-33 costs, alfalfa was valued at $12.00 per ton and silage at $4.00. At these prices two herds produced milk and butterfat somewhat more cheaply on the alfalfa ration than on the silage-alfalfa ration. The prices for the same period as quoted by the Farm Management Department of Michigan State College were $11.50 and $4.34 respectively. Had these prices been used for herd No.4, for instance, milk would then have been produced on the non-silage ration for 82.7¢ per hundred and on the silage ration for 85¢ per hundred, and butterfat for 19¢ per pound and 19.1¢ per pound respectively. The price of silage as used here was only slightly above one-third that of alfalfa, therefore, had silage been valued at greater than one-third that of alfalfa the non-silage ration would have produced milk and butterfat at the least cost in every case.

Herd No.4 was watered by means of individual drinking cups. The total digestible nutrient consumption was slightly greater on the non-silage ration; the therms of energy slightly less and the production was less. This herd was fed about 4 pounds daily of corn stover which they seemed to relish more than the silage. An attempt was made to make them consume more silage by withholding hay but with little success. Possibly the constant water supply was responsible for the lack of appetite for silage. Also the silage was high in moisture and low in total digestible nutrients because of the small amount of grain present. It is also possibly true that any benefits that might have been derived from the use of drinking cups were offset by lack of exercise. This herd was stanchioned constantly.

Herd No.2 had water at will supplied by a tank in the barn. They were stanchioned only when milked and were allowed to drink and exercise at will in the barn. This herd consumed less digestible nutrients and therms of energy during the alfalfa period than during the silage period, but produced more milk and butterfat. The cost of production of milk was 13.5¢ per cent less on the non-silage ration. When using 1910-14 prices it was 4.4 percent less than on the silage-alfalfa ration.

It is apparent that a succulent feed is not necessary where watering facilities are adequate; and that installation of individual drinking cups should be considered seriously before erecting a silo of the more expensive type.

These results indicate that the value of silage as a feed is determined by the amount of total digestible nutrients it furnishes, which makes it worth about one-third that of alfalfa hay. It follows,then, that silage production is only profitable when it can be made to produce three or four times as much tonnage per acre as alfalfa, or when the cost of production is one-third or less the market price of alfalfa.

In years when alfalfa is scarce and the corn crop is abundant, the silo becomes a valuable asset to the dairy farm. However, if average conditions of crop production and price are assumed, the value of the silo must depend on other factors than the feeding value of the silage, such as prevention of loss of dry matter and total digestible nutrients. But as alfalfa becomes more abundant and cheaper this saving factor becomes of less importance. Probably fewer silos will be erected where alfalfa can be grown profitably. The type constructed in the future will be more of a temporary or semi-permanent type, especially on the smaller farms.

SUMMARY AND CONCLUSION

The total cost of feed was less in three out of the four herds when on the non-silage ration.

The cost per pound of digestible protein and also total digestible nutrients was less in all four herds when fed the non-silage ration.

The cost per therm of energy was less in three of the four herds while receiving the non-silage ration.

The production of fat-corrected milk was slightly greater for two herds and slightly less for two other herds during the alfalfa period.

The average daily production of fat-corrected milk for all cows in all herds, per pound of digestible nutrients, was the same for both the silage and the non-silage groups.

Alfalfa and corn prices were abnormally low at the time the trials were made. When 1910-14 feed prices were used, there was less difference in cost on the two rations, but the experiment still favored a non-silage ration.

When the prices for the ten-year period, 1924-33, were used and silage was valued at one-third that of alfalfa there was practically no difference in the cost of production on the two rations.

The least cost of production was obtained during the non-silage period in the herd which had water at will and some exercise. The greatest cost was obtained in a herd when receiving a limited silage ration where water was supplied twice daily from a tank in the yard.

The results of this experiment indicate that where water is constantly supplied, when average prices covering a ten-year period are used, and when silage is valued at one-third that of alfalfa hay, there is no advantage in adding silage to the dairy ration.

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A P P E N D I X

Table 11.

Analysis of Samples of Alfalfa and Silage used in Experiments in 1933.

Period	Herd No.	Sample	Moisture	Protein	Ash	Fat	Crude Fiber	N.F.E.
Jan.	1	Alfalfa	8.49	14.42	8.23	.93	35.67	32.26
Feb.& Mar.	1	Alfalfa	8.04	14.27	5.38	.50	36.77	35.04
Jan.	2	Alfalfa	8.45	13.96	7.78	.65	36.25	32.95
Feb.	2	Alfalfa	8.71	14.15	7.37	.55	36.12	33.1
March	2	Alfalfa	7.10	15.53	6.62	1.31	26.28	43.16
Jan.	1	Silage	69.48	3.31	2.26	.439	9.17	15.33
March	1	Silage	69.52	3.78	1.92	.55	8.91	15.26
Jan.	2	Silage	69.76	2.9	1.73	.433	9.23	15.95
March	2	Silage	73.79	2.88	1.76	.276	5.92	15.35

Table 12.

Analysis of Samples of Alfalfa and Silage used in Experiments in 1934

Period	Herd No.	Sample	Moisture	Protein	Fat	Crude Fiber	Ash	N.F.E.	Carb.	Ca.	P.	Mg.
Jan.& Feb.	3	Alfalfa	8.65	13.61	1.83	33.18	4.75	37.98	71.16	1.46	.174	.535
Mar.	3	"	8.35	15.01	2.50	33.40	4.99	35.75	69.15	.779	.289	.325
Jan.	4	"	8.44	13.74	1.65	34.07	5.88	36.22	70.29	1.24	.231	.336
Feb.	4	"	8.47	11.32	2.36	35.77	4.22	37.86	73.63	1.13	.136	.300
Mar.	4	"	8.64	12.47	3.00	33.28	4.84	37.77	71.05	1.57	.148	.421
Jan.,Feb. & Mar.	3	Silage	67.79	2.51	.805	8.05	1.49	19.28	27.31	.142	.049	.152
Jan.Feb. & Mar.	4	"	75.07	2.05	.547	5.91	1.07	15.35	21.26	.133	.039	.110

Table 13.

Herd No. 1 - Average daily milk and butterfat production. Digestible Protein and Total Digestible Nutrients required according to the Haecker standard. Digestible Protein and Total Digestible Nutrients received.

Period	Average daily milk production	B.F. test	Average daily butterfat	Nutrients Required		Nutrients Received	
				Digestible Protein	T.D.N.	Digestible Protein	T.D.N.
	Lbs.	%	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Jan.	14.1	5.0	.71	1.58	13.03	2.39	15.24
Feb.	13.03	5.2	.678	1.5	12.74	2.49	15.16
March	12.0	5.2	.623	1.44	12.37	2.25	14.6

Table 14.

Herd No. 2 - Average daily milk and butterfat production. Digestible Protein and Total Digestible Nutrients required according to the Haecker standard. Digestible Protein and Total Digestible Nutrients received.

Period	Average daily milk production	B.F. test	Average daily butterfat	Nutrients Required Digestible Protein	Nutrients Required T.D.N.	Nutrients Received Digestible Protein	Nutrients Received T.D.N.
	Lbs.	%	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Jan.	18.2	5.0	.91	1.79	14.5	2.03	15.9
Feb.	17.94	5.3	.95	1.83	14.05	2.41	14.59
Mar.	17.2	5.0	.86	1.73	14.15	2.03	15.6

Table 15.

Herd No.3 - Average daily milk and butterfat production. Digestible Protein and Total Digestible Nutrients required according to the Haecker standard. Digestible Protein and Total Digestible Nutrients received.

Period	Average daily milk production	B.F. test	Average daily butterfat	Nutrients Required		Nutrients Received	
				Digestible Protein	T.D.N.	Digestible Protein	T.D.N.
	Lbs.	%	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Jan.	18.7	5.0	.935	1.89	15.48	2.56	16.6
Feb.	17.24	4.9	.845	1.79	14.92	2.34	15.7
Mar.	15.9	5.0	.795	1.72	14.47	2.54	15.9

Table 16.

Herd No. 4 - Average daily milk and butterfat production. Digestible Protein and Total Digestible Nutrients required according to the Haecker standard. Digestible Protein and Total Digestible Nutrients received.

Period	Average daily milk production	B.F. test	Average daily butterfat	Nutrients Required		Nutrients Received	
				Digestible Protein	T.D.N.	Digestible Protein	T.D.N.
	Lbs.	%	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Jan.	20.8	5.3	1.1	1.845	14.18	1.83	14.32
Feb.	18.66	5.0	.933	1.68	13.09	1.62	14.78
Mar.	14.5	5.2	.734	1.46	11.72	1.51	13.61

Table 17.

Digestion Coefficients used in Determining Digestible Nutrients of Alfalfa samples. (55) Morrison

	Protein	Fiber	N-free Extract	Fat	No. of trials
	%	%	%	%	
Alfalfa hay, under 25% fiber	73.4	40.8	75.8	32.8	28
Alfalfa hay, 25-28% fiber	75.2	41.6	72.2	42.6	49
Alfalfa hay, 28-31% fiber	72.0	42.64	71.44	28.48	76
Alfalfa hay, 31-34% fiber	71.3	43.9	69.9	31.1	40
Alfalfa hay, over 34% fiber	67.6	45.4	67.1	28.2	49
Alfalfa hay, 25-31%	73.6	42.12	71.82	35.54	

Table 18.

Digestible Nutrients in 100 lbs. of Alfalfa and Silage used in Experiments.

Herd No.	Sample	Period	Digestible Protein	Carbohydrates	Fat	T.D.N.
			Lbs.	Lbs.	Lbs.	Lbs.
1	Alfalfa	Jan.	9.75	37.83	.59	48.17
1	"	Feb.&Mar.	9.65	40.20	.32	50.17
2	"	Jan.	9.44	38.54	.4	48.39
2	"	Feb.	9.56	38.61	.35	48.52
2	"	Mar.	11.68	42.29	1,25	55.22
1	Silage	Jan.	1.66	16.75	.819	19.229
1	"	Mar.	1.89	16.57	1.026	19.486
2	"	Jan.	1.45	17.23	.799	19.479
2	"	Mar.	1.44	14.69	.507	16.637
3	Alfalfa	Jan.&Feb.	9.7	41.29	.7	52.59
3	"	Mar.	10.7	41.16	1.0	54.11
4	"	Jan.	9.21	40.40	.627	51.02
4	"	Feb.	7.92	42.64	.82	50.40
4	"	Mar.	8.75	41.50	1.17	52.51
3	Silage	Jan.&Mar.	1.28	18.91	.742	21.859
4	"	" "	1.05	12.6	.449	14.66

Table 19.

Feed Prices used in Determining Costs.

	Price per Cwt.			
	1933	1934	1910-14	1924-33
Alfalfa	$.25	$ .45	$ .70	$ .60
Silage	.10*	.15*	.23*	.20*
Corn Meal	.50	1.00	1.15	1.40
Corn and Cob Meal	.46*	.92*	1.00*	1.25*
Ground Oats	.60	1.20	1.33	1.37
Ground Wheat	.90	1.40	1.50	1.87
Wheat Bran	.80	1.20	1.20	1.60
C.S.M. 41%	1.10	1.65	1.90	2.32
Spy Beans	.75	1.50*	3.00	2.50*
Corn Stover		.20*	.35*	.30*

* Estimates

Table 20.

Temperature Chart- Mean Daily Temperatures, in Degrees Fahrenheit

Date	1933 Jan.	1933 Feb.	1933 Mar.	1934 Jan.	1934 Feb.	1934 Mar.
1	18	40	30	28	19	28
2	32	30	32	18	14	34
3	34	28	34	24	16	41
4	35	13	20	29	22	37
5	32	12	32	38	16	36
6	37	22	33	34	16	28
7	35	16	36	33	6	26
8	32	2	34	34	-4	22
9	30	-6	18	30	-8	14
10	37	4	12	30	10	13
11	30	6	17	36	26	16
12	18	8	36	35	28	25
13	30	24	43	34	15	40
14	27	25	38	32	26	24
15	34	18	25	32	22	32
16	42	26	32	24	14	38
17	34	26	43	18	21	38
18	30	26	30	30	20	17
19	40	32	28	28	2	24
20	32	33	30	26	5	32
21	40	21	30	42	24	30
22	47	39	29	43	15	14
23	36	40	27	31	4	18
24	34	38	28	38	3	23
25	35	36	30	34	12	24
26	34	30	32	28	2	26
27	26	30	38	38	4	16
28	21	38	32	22	18	14
29	18		34	2		34
30	24		40	8		34
31	36		54	24		42
Mean Max.	39.5	31.9	38	35.7	23.4	36.2
Mean Min.	24.5	15.0	25.5	22.7	2.9	18.0
Mean Monthly	32.0	23.4	31.8	29.2	13.2	27.1
Normal Monthly	22.4	22.9	32.2	22.4	22.9	32.2