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Preparation of Feeds for Dairy Cows

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PREPARATION OF FEEDS FOR DAIRY COWS

C. C. HAYDEN, C. F. MONROE, AND A. E. PERKINS

The present trend toward maximum efficiency in most lines of endeavor has not been overlooked in the handling of farm animals. The present slogan is: "Increase profits by reducing costs. Reduce costs by eliminating inefficient animals and by better feeding and care." The economy or efficiency trend in feeding has led to attempts, by artificial methods, to render feeds more readily and more completely digestible and assimilable. In order to attain this end, various methods of preparing feeds have been devised, and unwarranted claims for benefits derived from them have been made by promoters of some of these schemes.

It has been claimed that the fine grinding, soaking, and fermenting of roughages wonderfully improved their utilization by dairy cows and that ground roughages fermented, or "predigested", were almost equal to grains. These processes appealed to farmers because the claims made for them seemed based on plausible reasons. It seems reasonable that grinding would save the energy of mastication, that the finer particles might be more readily acted upon by the digestive fluids, and that proper fermentation might aid in breaking down the less digestible parts of the feeds. However, things are not always what they seem to be, and these processes had not been tried out in carefully conducted experiments. The vigorous promotion of some of these processes in Ohio led to the experiments herein reported.

Part I of this bulletin deals with the grinding of hay and stover; Part II deals with the mixing of ground hay and grains; and Part III deals with the grinding or chopping of roughages and fermenting, or "predigesting", them with "converters". It is well to keep in mind that any advantage from grinding should come largely from reducing the coarse stems, which are largely crude fiber and have a low digestibility at best.

PART I

GROUND ROUGHAGE

This experiment was conducted during the winter of 1926-1927 and consisted of a comparison of ground with unground roughage for producing dairy cows. The roughage consisted of alfalfa hay and corn stover fed in the proportion of 2 parts of hay to 1 part of stover.

Due to the general propaganda at that time for grinding, workers at experiment stations in other states were also prompted to conduct similar experiments, and some have reported as follows:

Forbes and associates, at the Pennsylvania Station (3), found that, on a dry-matter basis, ground alfalfa hay was slightly less digestible than the unground hay.

Reed and Burnett, of the Michigan Station (10), fed ground and unground alfalfa hay and concluded that grinding alfalfa hay for dairy cows was neither necessary nor profitable.

Nevens, at the Illinois Station (6), found that the grinding of soybean and alfalfa hay did not increase milk production sufficiently to cover the cost of grinding.

Bechdel and Williams, of the Pennsylvania Station (1), found that grinding roughages and mixing grains with them tended to increase the digestibility of the total ration but that the crude fiber was rendered less digestible.

Ingham and Meade, at the Maryland Station (4), found that grinding soybean hay increased the milk production 1.3 per cent and the fat production 4.8 per cent. This was not sufficient to offset the cost of grinding roughage with a small mill.

Trials by Wilbur, Hilton, and Mayer, at the Indiana Station (16), indicated that grinding alfalfa hay increased milk production slightly but not enough to offset the increased cost.

Weaver and Matthews, at the Iowa Station (15), found that grinding roughage did not increase its palatability. Finely ground hay proved less palatable. A slight increase in milk was obtained but not sufficient to cover the extra cost.

Rupel and Roche, at the Wisconsin Station (12), found no advantage in grinding alfalfa hay of good quality.

At the South Dakota Station, Wilson, Olson, and others (8, 17) found that grinding roughage increased slightly the amount of milk but not enough to cover the added cost. The digestibility of the roughage was not increased.

Morrow and La Master, of the South Carolina Station (5), found that grinding did not increase the digestibility but that grinding may be profitable with a coarse hay.

PLAN OF EXPERIMENT

The cows.—Twelve cows, six Holsteins and six Jerseys, were used in this project. They were divided into two groups of six cows each and were as nearly equal in production and other factors as could be arranged with the animals available. The reversal system of feeding was used. The feeding started on November 16 and continued until the following May 9, making a total of 174 days. The rations fed four of the cows in each group were reversed on February 1. The rations fed the two remaining cows in each group were not reversed until March 15 because they calved after the first feeding period began.

The feeds.—The rations consisted of alfalfa hay, corn stover, feeding molasses, and a grain mixture consisting of 6 parts of ground corn, 4 parts of ground oats, 2 parts of wheat bran, and 1 part of linseed oilmeal, by weight. These feeds were weighed to the individual cows in the proportions of 2 parts of grain, 2 parts of hay, and 1 part of stover. One pint of molasses was diluted and sprinkled over the roughage at each feeding, or twice daily. The molasses was added to make the roughage more palatable and thus induce larger consumption. A part of the hay and stover was ground through a 7/16-inch screen in a hammer mill; the remainder of the stover was run through a silage cutter.

Whole hay, cut stover, and grain were fed to the cows in Group I during the first period, and ground hay, ground stover, and grain during the second period. The cows in Group II received the rations in the reverse order.

RESULTS

In summarizing the results, the data for 6 weeks immediately preceding the reversal of the rations and for 6 weeks of the second period immediately following the first 2 weeks of that period were used, 2 weeks being allowed for the cows to become adjusted to the change in ration.

The data for the two 6-week periods are presented in Table 1.

TABLE 1.—Milk and Fat Produced and Feeds Consumed During the 6-week Periods

Ration	Milk	Fat	4% milk	Grain	Hay	Stover	Molasses
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Ground roughage	15,301.6	585.363	14,901.0	6254	6254	3127	1381
Unground roughage	15,008.3	571.598	14,577.3	6222	6222	3111	1381
Difference favoring ground roughage	293.3	13.768	323.7	32	32	16	.....
Per cent difference	1.95	2.40	2.22	.51	.51	.51	.....
Per cent net difference*	.....	.....	1.71	.....	.....	.....	.....

*Net difference is the difference less the amount of milk creditable to the extra feed consumed.

This comparison shows a net difference of 1.71 per cent in favor of the ground roughage. This difference is well within the limits of experimental error and, therefore, is not necessarily due to the grinding. It amounts to 65 pounds of milk per ton of roughage ground. The cost of grinding was not determined, but it has been estimated that, if the difference had been due to grinding, it would not have offset the cost, even at the lowest cost reported below.

Fig. 1.—Margins and divisions are alfalfa stems from rather fine hay.

1. Alfalfa hay ground through a 7/16-inch screen in a hammer mill.
2. Fiber washed from feces of cow fed the ground hay.
3. Fiber washed from feces of cow fed unground hay.

The costs per ton of grinding reported by other experiment stations are shown in Table 2.

TABLE 2.—Costs of Grinding Roughages

		Dol.
Iowa (15)	Alfalfa hay	3.50
	Alfalfa hay and stover	1.75
Maryland (4)	Soybean hay (small mill)	6.35
South Dakota (17)	Alfalfa hay	2.72
	Sweet clover hay	4.78
	Corn stover	1.81
South Carolina (5)	Alfalfa hay, Soybean hay, Oats and vetch hay. Average	2.21

It is evident that the grinding of alfalfa hay and stover in this experiment did not greatly increase either palatability or the cow's capacity to consume good roughage, nor did the grinding aid materially in the utilization of the roughage.

While on the ground roughage, the cows gained an average of about 6 pounds more than while on the unground roughage. Two cows lost weight and one failed to gain while on the ground-roughage ration. The differences in weight are so small and irregular that they have no significance.

CONCLUSION

The results of this experiment agree quite closely with the results of similar experiments reported by other stations. They indicate quite clearly that the fine grinding of roughage for dairy cows is not likely to be profitable.

PART II

MIXING GRAINS WITH GROUND ROUGHAGE

Frequently the statement has been made that mixing grains with ground roughage would cause the grains to remain longer in the rumen, or paunch, and thus would cause a marked increase in their utilization. There was little experimental evidence to support this claim; therefore, this experiment was conducted to obtain information on this point and additional information on ground hay.

REPORTS FROM OTHER STATIONS

Olson, at the South Dakota Station (8), reports an experiment in which he found no advantage in grinding the roughage and mixing the grains with silage, so far as milk production was concerned. Digestion trials showed no increase in digestibility.

Bechdel and Williams, of the Pennsylvania Station (1), found that the mixing of ground alfalfa hay and grains tended to increase the digestibility of the whole ration but that the crude fiber was slightly less digestible.

Nevens, of the Illinois Station (7), found that the results were the same whether ground hay and grains were mixed together or fed separately.

PLAN OF EXPERIMENT

The cows.—Twelve cows were used and were divided into two groups, consisting of four Holsteins and two Jerseys each.

The cows were weighed on two successive days at regular intervals. The two groups were balanced in the various factors as nearly as possible.

The feeds.—The roughage used in the ration consisted of equal parts, by weight, of clover, alfalfa, and timothy hay. Hays of No. 1 grade, or better, were used. The hays were ground through a 7/16-inch screen in a hammer mill and thoroughly mixed. The grain mixture consisted of 4 parts corn, 3 parts oats, 3 parts wheat bran, and 2 parts linseed oilmeal, by weight. The experimental feeding began January 5; the rations were reversed March 1 and continued until April 30, 1928, making two periods of 55 and 61 days, respectively. Eight of the cows were continued on these rations until May 31. Group I received the hay and grain thoroughly mixed together during the first period and separate during the second period. Group II received the feeds in the reverse order.

The cows were given as much hay and grain as they would clean up well, in the proportion of 3 pounds of ground hay to 2 pounds of ground grain. The hay and grain were fed dry. Molasses was not used to make the ration more palatable as was done in Part I.

RESULTS

Difficulties were encountered from the beginning of this experiment. The dry, ground hay was much less palatable than unground hay. Probably the lack of palatability was due to its dry, dusty character, but it is also possible that the grinding in a hammer mill may have beaten and blown considerable of the flavor out of it.

The mixing of the grain with the hay for the one group seemed to improve its palatability. One cow in Group II refused the ration before the end of the first month and lost 83 pounds in weight.

Another refused it just at the close of the test, late in May. All cows but two were "off feed" at some time during the test, and it is interesting to note that these two cows had previously been on a very poor ration. There was a tendency to constipation. Although no digestion trials were made, it was evident from the character of the feces that the hay was not being properly digested. The particles were not softened and broken down as they should have been. Undoubtedly, a part of the hay, because of its fineness, passed on from the rumen too soon. This checks with the findings of Forbes (3) for ground hay; Nevens (6, 7), Schalk and Amadon (14), and others found that much of the ground grains passed on quickly.

The cows in both groups lost heavily in weight. The total loss in weight per cow from January 1 to April 30 was 53.2 pounds for Group I and 76.6 pounds for Group II. The average loss in weight for the five cows, while on the unmixed ration, was 105 pounds and for the five on the mixed ration 25.

The ration was fed dry until April 15, the cows being allowed all the water they would drink twice daily. From the fifteenth to the end of April, the roughage was soaked in its weight of water. From May 1 to 30, the roughage was soaked in twice its weight of water from one feeding to the next for the eight cows remaining on these rations. The cows ate the wet rations only slightly better than the dry.

As stated above, one of the cows refused the ration by the end of the first month and was dropped. To balance the groups, the data from a cow which freshened late were discarded from the other group. Therefore, the data from only 10 cows are presented.

Due to the fact that some of the cows were well along in gestation by the end of the second feeding period, thus shortening the period, the data for 6 weeks immediately before and 6 weeks immediately after the change of rations have been used for comparison. These data are presented in Table 3.

TABLE 3.—Milk and Fat Produced and Feeds Consumed
(Two 6-week periods)

	Milk	Fat	4% milk equivalent*	Hay	Grain	Per 100 lb. milk	
						Hay	Grain
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
The mixed ration	9521.3	449.22	10,546.8	7118.5	4745.3	67.49	44.99
The unmixed ration	9552.9	446.75	10,522.4	6391.0	4427.2	60.73	42.07
Difference	—31.6	2.47	24.4	727.5	318.1	6.76	2.92
Per cent difference†	.....	.....	.23	11.38	7.18	11.13	9.94

*Production calculated to 4% milk basis by Gaines formula.
†Based on results of unmixed ration.

It will be noted that the cows produced 0.23 per cent more milk and consumed 11.38 per cent more hay and 7.18 per cent more grain while on the ration in which the ground hay and grain were thoroughly mixed together. With the heavier consumption, it required 11.13 per cent more hay and 9.94 per cent more grain to produce a given quantity of milk. Apparently, the mixing of the grain with the hay made it more palatable, but the increased consumption of the ground hay reduced the utilization of the ration.

Eight of the cows continued to milk for some time after the close of the experiment, and it is interesting to note the marked increase in milk after the change in the rations. During the last 4 weeks of the ground-hay feeding, these eight cows produced 3655.3 pounds of milk; during the next 4 weeks, on the regular herd ration for 10 days and pasture for 18 days, they produced 4667.4 pounds of milk, a gain of 27.6 per cent. This was near the close of their lactation periods when they normally should have been decreasing rapidly.

CONCLUSION

In this experiment, mixing the grains with the ground roughage did not increase their utilization.

Mixing in the grains added to the palatability, causing increased consumption of the ground hay, but the increased consumption proved detrimental.

All cows except two went off feed at some time during the experiment and two refused the ground hay entirely, one at the beginning and one at the close of the test.

Considering the results of grinding roughages obtained in these two experiments and the results reported by other stations, we doubt the wisdom of buying alfalfa meal or rations containing alfalfa meal where hay of the same quality can be secured at the same, or a lower, price.

PART III

"PREDIGESTING" FEEDS

EXPERIMENT 1

Many methods of soaking, cooking, steaming, and fermenting feeds for dairy cattle have been tried out and but few of them have proved of value. Corn silage stands out as one marked exception to the above statement. New processes will appear, but probably most of them will be discarded; therefore, they should not be adopted by farmers without careful investigation.

At the time this experiment was planned, promoters were busy in Ohio selling apparatus to dairy farmers for fermenting roughages. One promoter stated that he had in his pocket $30,000 in farmers' notes for apparatus which he had sold.

A starter, or "converter", used in the process apparently depended for any reducing action on its diastase content. The final product was called "Sugar Jack".

The process consisted in cutting or chopping the roughage, mixing the starter with it as it was packed into a drum or wooden tank, and adding warm water or steaming. The materials were then weighted down and allowed to stand a sufficient length of time for fermentation to take place. The claim for the process was that it would break down the crude fiber, change the carbohydrates to reducing sugars (thus rendering the materials much more digestible), and also would effect a saving of 25 to 50 per cent in feeds, since the roughages so treated became almost equal to grains.

The results of practically no authentic experiments on this subject had been reported at that time, and many inquiries about the process were coming to the Station.

A number of farms where the process had been installed were visited. Ten samples were collected from various farms and analyzed for major chemical changes. No significant change could be detected. The crude fiber was not reduced, and reducing sugars were not found in any appreciable amount, as shown by the following figures which are averages from the 10 samples:

	BEFORE TREATING (Per cent)	AFTER TREATING (Per cent)
Crude fiber	24.72	24.37
Reducing sugars	1.66	1.90

In some cases, there was slightly more sugar present in the materials before processing.

The converters used consisted mainly of malted grains and depended upon diastase for converting carbohydrates to sugars. Diastase will change raw starches slowly and cooked starches rapidly to invert sugars. The action of diastase is best at temperatures ranging from 120° to 180° F. Below these temperatures yeasts and molds are apt to develop and to destroy the sugars as rapidly as they are formed. At temperatures above 190° F., the diastase ceased to act. The converter did possess the power to change starch to invert sugar, but its action was much less than that of Taka diastase, with which it was compared.

No increase in sugars was found in the roughages processed because they contained no starch. Their carbohydrates consist chiefly of cellulose, pentosans, and galactans, none of which are changed by the action of diastase.

TABLE 4.—Carbohydrates of Feeds

	Starch determined by		Sum of pentosans and galactans determined separately
	Inversion with diastase	Acid hydrolysis, includes most of pentosans and galactans	
Clover hay	None	10.1	17.64
Timothy hay	None	26.0	25.61
Corn stover	None	24.1	27.88
Alfalfa hay	None	14.8	20.12
Corn, grain	Abundant	58.5	5.14

In order to determine what assistance the changing of starch to sugar might be to animals, a mixture, consisting of corn 43 parts, oats 43, ground alfalfa 6.5, ground corn stover 6.5, and salt 1, was processed and fed to albino rats. The grains carried a considerable amount of starch which could be converted into sugars. The mixture was steamed for one-half hour, then cooled to 130° to 140° F. and divided into two portions. To one portion Sugar Jack converter was added, and the two portions were held at the above temperatures for 36 hours. Invert sugar to the extent of 10 per cent of the dry matter developed in the portion containing the converter; whereas none developed in the other portion.

There was practically no difference in the growth of the rats fed the two portions, and what difference existed favored the no-sugar ration (9). The results are shown in Figure 2.

Rats are not cows, nor are they primarily roughage consumers; hence, their digestive systems differ. More work was, therefore, needed to determine the value of such processes to dairymen.

The process was studied at other experiment stations, and the results were reported as follows:

The Ontario, Canada, Station (11), in an exhaustive study of "Sugar Jack", found it less economical than silage or the same kind of roughage treated with molasses. The processed feed proved no better than the dry feeds from which it was made.

The Ohio Experiment Station (2) conducted a test with steers and found no advantage in the process.

Rupel, Roche, Bohstedt, and Fuller, of the Wisconsin Station (13), found the processed feed less desirable than silage for cows. For work horses, the processed feeds were no better than unprocessed feeds and were far less economical.

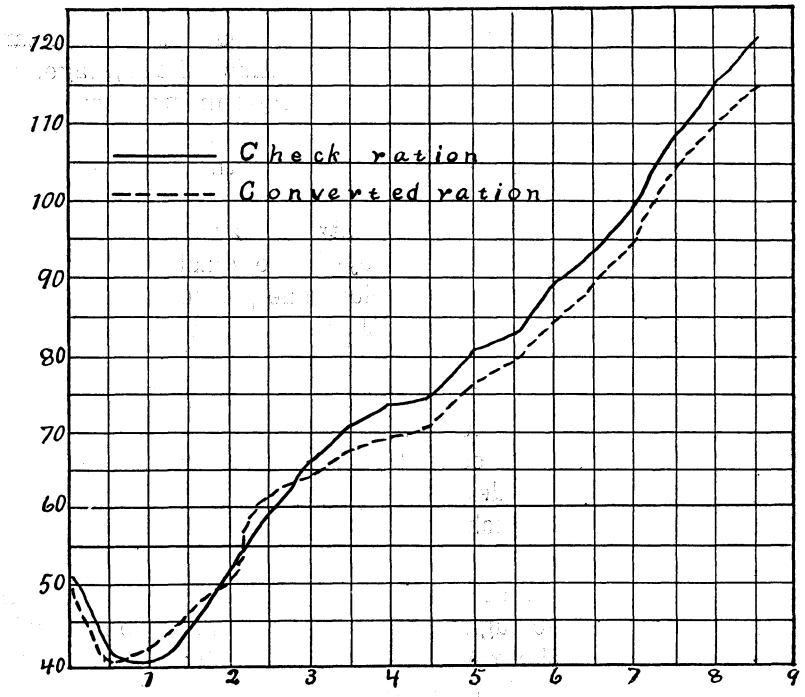

Fig. 2.—Growth curve for albino rats fed rations processed without converter and with converter

Vertical—weight in grams.
Horizontal—weeks.

PLAN OF EXPERIMENT 1

Since no change in the carbohydrates was noted in the above mentioned samples obtained from farmers and since diastase was the active agent in the converters used, it was decided to use diastase as the active agent in this experiment and to add the grains of the ration to the roughage before processing. This would furnish starch which could be changed to sugars by the diastase. "Diamalt", a malt extract, was used as the source of diastase. The diastase proved very active in laboratory tests.

The cows.—Six Holstein and four Jersey cows were used and divided into two groups containing three Holsteins and two Jerseys each. The groups were balanced as well as could be, all factors considered.

The feeds.—The roughage used consisted of equal parts of alfalfa hay and corn stover. These were run through an ensilage cutter and thoroughly mixed together. The grain mixture consisted of 4 parts ground corn, 3 parts ground oats, and 1 part each of wheat bran and linseed oilmeal.

The grain and ground roughage were placed in a wooden tank, at the rate of 100 pounds of grain to 160 pounds of roughage, and thoroughly mixed. Water was added and the mixture steamed for 15 to 30 minutes. This batch was then divided into two portions, one portion being removed to another compartment of the tank. Since diastase becomes inactive at temperatures above 190° F., cooking or steaming after adding the starter, as recommended by the promoters of Sugar Jack, destroyed the diastase. After the materials had cooled to 140° F. or below, one per cent of "Diamalt" was added to one portion, and the other portion was left without "Diamalt". Both portions of feed were allowed to stand for 12 hours before feeding.

The portion to which the Diamalt was added developed invert sugar to the extent of 6 per cent of the dry matter of the ration; whereas the other portion developed practically no additional sugar. The cows were given as much of these mixtures as they would consume readily.

Group I was fed the ration containing the sugar during the first period and the no-sugar ration during the second period. Group II was fed in the reverse order. The first feeding period began December 12 and closed February 28, and the second period began March 1 and closed April 30, 1929. The cows were then given the regular herd ration during the month of May. This ration consisted of the same grain mixture fed with corn silage and alfalfa hay.

RESULTS

Due to causes other than the ration, it became necessary to drop one cow from the experiment, and the data from the cow in the other group, which was paired with her, were not used in the comparison. The data from eight cows were used.

In making the comparison, the data for the last 6 weeks of the first period and the 6 weeks following the first 2 weeks of the second period have been used. The milk produced has been calculated to a 4% basis by the Gaines formula. The final data for the two 6-week periods are presented in Table 5.

TABLE 5.—Summary of Milk and Fat Produced and Feeds Consumed

Ration	Milk (actual)	Fat (actual)	4% milk equivalent	Feeds consumed
	Lb.	*Lb.*	*Lb.*	*Lb.*
Processed with "Diamalt"	7160.2	319.80	7661.0	23,473
Processed without "Diamalt"	6977.4	313.38	7491.6	23,121
Difference	182.8	6.42	169.4	352
Per cent difference	2.62	2.04	2.26	1.50
Per cent net difference*		.54	.76	

*Net difference is the difference less the amount of milk to be credited to the extra feed consumed.

Note that the net difference of less than one per cent, in favor of the ration containing invert sugar to the extent of 6 per cent of the dry matter, is so small that it can not be considered significant. If it could be correctly credited to the presence of the sugar, it would not justify the added expense.

At the close of this experiment, when the cows were fed the regular herd ration, they produced slightly more milk than when on the experimental ration, although normally they should have been decreasing in milk flow.

Both groups of cows lost weight slightly during the first period and gained slightly during the second period. There was very little difference in gain or loss in weight on the two rations.

CONCLUSION

The production of invert sugar to the extent of 6 per cent of the dry matter of the ration, by the use of diastase, was of little, if any, assistance to the cow in utilizing the feeds.

EXPERIMENT 2

A processing system of recent development, and one for which good results have been claimed, was the subject of the investigation reported here. This system was known as the "Kultogras" method of feeding. The converter used in this method was claimed to be a culture which produced a desirable chemical change in the feeds to which it was added.

The primary object of this work was to determine whether feeds processed with this converter would cause the cows to produce any more milk than the same feeds processed with a mixture of ground corn and oats substituted for the converter. The corn and

oats were used to make the two mixtures equal in food nutrients, and hence the sole difference between these two rations would lie in the specific effect of the converter. A secondary object was to compare these two processed rations with an equivalent ration not processed but containing dry roughage and corn silage.

This experiment was conducted with the cooperation of the State Department of Public Welfare, and a portion of the dairy herd at the State Institution for Feeble Minded was used. A representative from the Dairy Department of the Experiment Station personally directed the work, attending to weighing and mixing feeds and recording results.

PLAN OF EXPERIMENT 2

The cows.—Two groups of 16 Holstein cows each were selected from the herd for the experiment. These cows were all in an early stage of lactation. They were fed and milked three times a day.

The entire experiment, which lasted 200 days, was divided into four periods, as follows:

Period A, 30 days, during which both groups were fed a normal ration containing silage.
Period B, 70 days, during which both groups were fed the processed roughage, without silage.
Group I received the roughage processed with the converter.
Group II received the roughage processed with the corn-and-oats mixture.
Period C, 70 days, was the same as Period B, except that the rations fed Groups I and II were reversed.
Period D, 30 days, during which both groups received the normal ration, as in Period A.

This scheme of arrangement is shown in Table 6.

TABLE 6.—Showing Experimental Divisions

Period ☞	A 30 days	B 70 days	C 70 days	D 30 days
Group I 16 cows	Normal ration	Converter ration	Check ration	Normal ration
Group II 16 cows	Normal ration	Check ration	Converter ration	Normal ration

The feeds.—The method used to process the roughage was that recommended by the manufacturers of the converter. The roughage mixture, composed of 60 parts of chopped alfalfa and 40 parts of chopped corn fodder, was put into an insulated tank. As the above mixture was being placed in the tank, salt, converter, and

water at 140° F. were added and distributed as evenly as possible. In another tank the check processed mixture was made in a similar manner except that the mixture of corn and oats was substituted for the converter. The formulas for these two mixtures are as follows:

CONVERTER MIXTURE	Pounds	CHECK MIXTURE	Pounds
Chopped alfalfa	60	Chopped alfalfa	60
Chopped corn stover	40	Chopped corn stover	40
Salt	1	Salt	1
Converter	3	Corn and oats	3
Water, 140° F.	300	Water, 140° F.	300

A sufficient quantity was prepared in each tank to feed 16 cows for one day.

These processed mixtures took the place of corn silage and most of the dry hay in the normal ration. They were fed at the rate of 7 pounds of the wet materials for every 100 pounds of live-weight. Grain was fed at the rate of 3 pounds for every 10 pounds of milk produced. As this level of feeding did not seem to satisfy the cows, some additional chopped alfalfa hay was fed. As the stalls were equipped with drinking cups, the cows had free access to water. For a few hours each day (the time depending upon the weather) the cows were allowed the freedom of a paved barn lot, where they had access to salt and water.

PROCESSED MIXTURES COMPARED

Table 7 gives the results obtained from feeding the two processed mixtures. These figures are for periods of 60 days on each processed ration, the data for the first 10 days having been eliminated to allow for the effects of the change in the ration. The data represent the averages for the 32 cows.

TABLE 7.—Summary of Results (Averages of 32 Cows for 60-day Periods on Each Ration)

	Milk produced	Fat	Fat	4% milk equivalent	Milk per 100 lb. dry matter	Gain per 100 lb. live-weight	Refuse	Cost of converter
	Lb.	%	*Lb.*	*Lb.*	*Lb.*	*Lb.*	%	*Do.*
On converter ration (Kultogras)	2033.2	3.38	68.8	1845.5	86.9	48.21	1.0	4.59
On check ration (Corn and oats)	2047.1	3.35	68.5	1845.7	87.3	14.98	1.2	.63
Difference*	−13.9	+.03	+.3	− .2	− .4	+33.23	− .2	−3.96

*—favors the check ration; +favors the Kultogras ration.

With respect to milk and butterfat production, there was as little difference between the two rations as could have been expected if the same ration had been fed to both lots throughout. With respect to the amount of processed feed refused, there was also very little difference, indicating that the check mixture was about as palatable to the cows as the converter mixture.

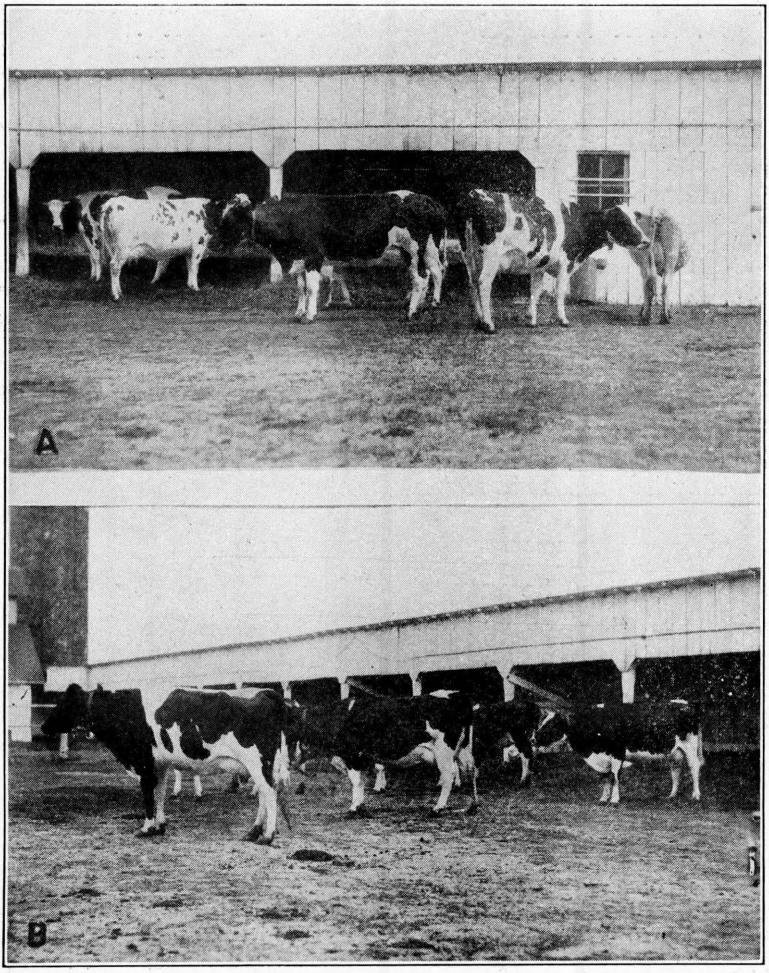

Fig. 3.—(A) Group I. Representatives from the group on the check ration, at the close of the experiment
(B) Group II. Representatives from group on converter ration, Kultogras, at the close of the experiment

The liveweight data offer some indication that the converter mixture tended toward a greater increase in body weight, the difference averaging 33 pounds per 1000 pounds liveweight during the 60-day periods. Just how much emphasis should be placed on this difference is a question, inasmuch as the cows kept in good condition on both feeds.

Toward the close of this experiment a group of experienced dairymen, who were looking at the herd, was asked to pick the group which they considered in the better condition. Of the five dairymen, three selected the group receiving the check mixture, while two picked the converter group; but all felt that there was very little difference between the two groups. The bowels of all the cows were apparently well regulated and the feces had much the same consistency as when on pasture.

In laboratory tests the converter was found to have diastatic power, or power to convert starches into invert sugars. However, when alfalfa hay and corn stover were processed with it there was little sugar produced. This was because the roughages did not furnish any starch and the little sugar that was formed came from the starch in the converter. Laboratory trials also failed to show that the liquid extracted from the converter-processed material was any richer in protein, ash, or total solids than the liquid from the check-processed material.

The most important difference was in the cost of the two rations. It cost $3.96 more per cow to feed the converter mixture for 60 days than it did the check mixture. The converter cost $13 and the corn and oats $1.50 per 100 pounds.

PROCESSED RATIONS COMPARED WITH DRY ROUGHAGE AND CORN SILAGE RATION

The cows.—For this comparison, the data from only 20 of the original cows have been used. Data from the other 12 cows have been eliminated for the following reasons: segregation following a positive reaction to the blood-test for abortion (6 cows); abortion (1); starting to dry up (1); freshening a few days after the experiment started (2); and, finally, two from one group to equalize the number in the two groups. The 20 cows remaining had a clear history for the entire 200 days of the experiment.

The feeds.—As shown in Table 5 the processed feeding periods were preceded and followed by a 30-day control period, in which the cows were allowed all the alfalfa hay they would eat and were fed corn silage at the rate of 3 pounds to every 100 pounds of liveweight. The same grain mixture was fed at the same rate as dur-

ing the processing periods. In fact, on the basis of total nutrients supplied, the two systems of feeding were almost identical. The difference between the two was that in the processing system most of the roughage was fed in a warm, wet, and softened condition after it had been chopped; while the roughage in the normal system was fed as ordinary whole hay and corn silage, the corn silage replacing the chopped corn stover in the processing system.

The method used in comparing the results under the different systems of feeding was essentially that used for the double reversal experiment; that is, the productions for the two groups for different periods on the same type of ration have been combined.

As the first 10 days of each period have been considered preliminary, they have not been included in the results. On this basis, there were 20 days in each control period and 60 days in each processing period. In order to place the productions on a comparable basis, the 60-day processing periods have been divided by three, giving for these periods an average 20-day production. For each of the 20 cows there were two control periods and two processed feeding periods.

RESULTS

The results of comparing the no-converter processed ration and the converter processed ration with the ration containing whole hay and corn silage are summarized in Tables 8 and 9.

TABLE 8.—Comparison of Normal System of Feeding to Processed System (without converter)

Av. per cow—40-day periods

	Milk	Test	B. F.	4 % milk	Liveweight
	Lb.	*Pct.*	*Lb.*	*Lb.*	*Lb.*
*Normal	1341.52	3.60	48.24	1260.30	1158.1
†Processed (no converter)	1349.55	3.30	44.57	1208.55	1164.5
‡Difference	+8.03	—.30	—3.67	—61.75	+6.4
§Per cent difference	+0.598	.....	—7.60	—4.89	.....

*Normal=Group II, Period D and Group II, Period A.
†Processed=Group I, Period C and Group II, Period B.
‡Normal=standard.
§Normal=100%.

The production of the two groups as given in Tables 8 and 9 represents the averages per cow for 40 days on each type of ration. The rate of production for the entire experiment averaged a little over 1000 pounds of milk and 36 pounds of fat per 30-day month.

Based on the whole hay and silage ration and 4% milk production, Table 8 shows 4.89 per cent lower production on the ration processed without converter and Table 9 shows 7.13 per cent less on the ration processed with converter.

TABLE 9.—Comparison of Normal System of Feeding to Processed System (Converter used)
Av. per cow—40-day periods

	Milk	Test	B. F.	4% milk	Liveweight
	Lb.	*Pct.*	*Lb.*	*Lb.*	*Lb.*
*Normal	1382.10	3.71	51.27	1322.05	1149.4
†Processed	1357.49	3.36	45.65	1227.71	1154.7
‡Difference	−24.61	−.35	−5.62	−94.34	+5.3
§Per cent difference	−1.78	.....	−10.96	−7.13	.....

*Normal=Group I, Period A and Group II, Period D.
†Processed=Group I, Period B and Group II, Period C.
‡Normal=standard.
§Normal=100%.

These comparisons show that there was little difference between the two systems of processing, as measured by a common standard.

The production of milk was nearly the same on the normal feeding as on the processed feeding. However, the butterfat production was from 7.5 to 11 per cent higher on the normal feeding than on the processed feeding. The average difference in butterfat test amounted to approximately .32 per cent. Butterfat tests for the individual cows (not given in table) show that this tendency was quite uniform; for, of the 40 individual comparisons here represented, 34 showed a higher average test in the normal feeding periods than they did in the respective processed feeding periods.

The liveweights, under the two systems of feeding, indicate a slight advantage for the processing system. The extent of fill may have played quite an important part in the liveweights. The processed rations, owing to their water content, weighed considerably more than did the normal rations. As the cows were weighed in the morning soon after feeding, it is possible that these heavier rations would affect the liveweights. However, under neither system of feeding were the cows out of condition or noticeably thin.

It is interesting to note that, although there was greater gain in weight on the converter ration than on the no-converter ration, both had about the same gain over the hay and silage ration.

CONCLUSION

Processed roughages produced by using a converter called Kultogras have been compared to like roughages processed with a mixture of corn and oats. Production of both milk and butterfat was practically the same on both types of processed roughage. There was a greater tendency to gain in liveweight when the converter processed roughage was fed. If there was any difference in palatability of the two roughages it was slight; on the converter roughage there was a refuse of 1 per cent, while on the check roughage there was a refuse of 1.2 per cent.

The processed roughage with and without the converter, compared with the ration containing whole hay and corn silage, showed lower production on the processed roughage.

When the processed rations were compared with the normal ration containing silage, there was rather a marked difference in the per cent of fat in favor of the normal ration.

GENERAL SUMMARY

From the results of these experiments and those reported by others, it appears that grinding good roughage for dairy cows is not usually profitable and that such materials finely ground may be detrimental to the animals. It is easy to believe that the harsh particles of ground hay passing on without sufficient time in the rumen for softening might irritate the remainder of the digestive tract causing indigestion. If this be true, it would seem logical that such fine materials should be soaked, or softened, before being fed. It would seem then that "predigesting" ground roughage should be beneficial. However, experiments show that those systems of processing developed to date are not profitable. This may be because the changes taking place are not equivalent to those which take place in the rumen. While there is little, if any, secretion of fluids from the rumen and reticulum, approximately 60 quarts (13) daily of saliva are poured into these compartments of the digestive tract, and the coarse feeds are subjected to the action of this fluid, plus water and bacteria, for long periods of time. Other changes than merely softening take place and the softening is more complete than in any practical process yet devised.

Should a system be devised whereby changes should take place in feeds equivalent to those taking place in the rumen, it would still be a question whether or not it would benefit the cow greatly. She has an excellent processing tank and a converter of her own which probably is sufficient to process feeds as rapidly as the remainder of her alimentary tract can make the best use of them.

Although the functional activity of the digestive tract undoubtedly varies greatly in different cows, it has its limit, and no attempt, on the feeder's part, can induce the cow to go beyond that limit.

It also is probable that the normal action of the rumen and reticulum and the act of ruminating have a stimulating effect on the remainder of the digestive organs. Any process, such as grinding roughage, which might tend to slow up these activities might cause a slowing up of digestion. The cow is by nature a consumer of roughage. In the natural state her ration consisted almost entirely of such food. She is thoroughly fitted to make use of it; therefore, dairymen would be wise to avoid investing in new systems of preparing roughages or other feeds until they have been proven valuable by careful experiments.

In the experiments herein reported, the emphasis has been placed on the results in terms of milk and fat production. However, there are certain other features which are quite important in practice, the chief of which is the extra labor involved in preparing roughage. The labor required increased with the various steps, grinding, grinding and mixing, and finally processing. In feeding processed hays, the handling of so much heavy wet material reminded one of carrying water to cows. Not only is extra work required, but this work is of a disagreeable type; grinding hay was a dusty, dirty job disliked by the men and not conducive to good health or cleanliness in the barn.

There is also a certain amount of special additional equipment necessary, including such apparatus as a roughage mill, tanks for processing, and a boiler with pipe lines for steam. Boilers or fires about the barn may be a fire hazard. The items of labor, cost of equipment, and upkeep should be taken seriously into account when such processes are under consideration.

One of the advantages claimed for processing was that low-grade roughages which would otherwise be wasted could be utilized. The writers are not aware of any practical system of preparation which will make low-grade roughage equal to high-grade roughage. Under present conditions we doubt the economy of filling cows with low-grade materials, especially such as are very high in crude fiber. Probably it would be more profitable to give more attention to the preparation of roughages of high quality.

High-quality hay is one of the important factors in milk production. In addition to supplying the nutrients necessary for the production of milk, it is of especial value in maintaining the health of the cows. The best source of vitamins and minerals for winter

feeding is the legume hays. The vitamins and minerals are found mainly in the leaves of the growing plants; therefore, to preserve them the hay should be harvested while growing, before the ripening process begins. Early-cut hay retains its leaves better, is more palatable, and is more easily digested. To obtain hay of the above quality, it should be cured with as little exposure to dews and rains as possible. Weather conditions can not be controlled; therefore, attempts are being made to cure hay artificially.

Some mechanical driers are now in use and others will come on the market. It would seem that hay so cured should be of the best quality, retaining all nutrients present in the plant when cut. No doubt, farmers will soon be urged to invest in this type of apparatus. Such investments should be made with caution until careful investigation is made. The first cost of apparatus will be no small item, and the cost of fuel and other operating expenses will be considerable. It remains to be determined whether or not this method of curing roughages will be profitable.

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