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DIVISION OF DAIRY HUSBANDRY

Ground Versus Unground Grain for Lactating Dairy Cows

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS

T. O. WALTON, President

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Cows in these series of experiments consumed more grain when they were fed a concentrate mixture consisting of ground grains than when 50 to 75 per cent of the concentrate mixture was composed of whole grains. Less of the whole oats and barley was refused by the cows than of corn or milo fed as whole grain. Greater milk production, especially with high producing cows, was obtained in all of the experiments when ground grains were fed. Most of this greater amount of milk produced when ground grain was fed could be accounted for by the greater amount of grain consumed in each of the experiments with the exception of barley. However, since greater amounts of milk were obtained by feeding ground grains, even though more grain was required to produce this milk, and since the ratio of milk produced to grain consumed was practically unchanged, it seems advisable to grind grains for dairy cows in order to induce consumption of feed in proportion to their level of milk production.

There was found considerable variation between cows in the amount of whole corn or milo grain that was masticated. It was also found that more whole corn was masticated than whole milo, indicating that the size of the grain is a factor in the amount of whole grain masticated. Apparently very little, if any, food value was removed from the unmasticated whole grains passing through the cow's digestive tract.

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GROUND VERSUS UNGROUND GRAIN FOR LACTATING DAIRY COWS*

A. L. Darnell, Professor of Dairy Husbandry, and O. C. Copeland, Dairy Husbandman.

In Texas there is produced annually about 200,000,000 bushels of carbohydrate grains used principally for feeding livestock. These grains consist largely of corn, oats, barley, and many varieties of grain sorghums. With different feeders in this state, the method of preparing these grains for livestock feeding varies from feeding the entire plant cured in the shock to feeding the ground threshed grain. A number of livestock men feed large quantities of these feeds not only as whole threshed grain but as ear corn, grain sorghum heads, and sheaf oats. These methods of feeding are most commonly found in the sections where the facilities for the preparation of feedstuffs are limited.

Rather extensive research (4, 5, 6, and 8) has shown that the value of grinding roughages is not as great as was once believed. Most of these results indicate that there is very little advantage in grinding or chopping high quality roughage for dairy cows but that it sometimes pays to grind or chop poor quality roughages, in order to increase palatability and reduce waste, provided the cost of grinding is low.

Textbooks in general have advocated the grinding of grains for most classes of livestock. In studying the value of grinding grains for dairy cows, Wilbur (7) of the Indiana Station found that medium finely ground corn and oats were superior for milk production to the same grains when fed whole, coarsely ground, or pulverized. The cows produced 11.2 per cent less milk when fed whole grain, 5.8 per cent less milk when fed coarsely ground grain, and 5.4 per cent less milk when fed pulverized grain, than when fed a similar mixture containing medium ground grain.

It is known from observation that when cows are fed whole grain of almost any kind, a certain amount of it will pass through the digestive system of the cow and be voided in the feces as whole grain. Becker and Gallup (1) reported on the utilization of the grain of kafir and cane silage by dairy cows. They found that one-third of the cane seed and over two-fifths of the kafir grain contained in silage made from the two respective sorghums, were voided in the feces. They report that "chemical analyses showed little utilization of nutrients from these whole kernels during passage through the cow's digestive tract. Some ether extract was digested, whereas only a small percentage of the crude protein

*In cooperation with the School of Agriculture of the Agricultural and Mechanical College of Texas.

was utilized." Cave and Fitch (2) found that as high as 90 per cent of the seeds in sargo silage passed through the cow unmasticated.

The results of previous investigations seem to indicate that it pays to grind corn for dairy cows. There is practically no information available concerning the value of grinding the grain sorghums and other small grains, which are produced and fed extensively to livestock in Texas and the Southwest. The object of these experiments was to measure the value of grinding certain small grains as well as corn for milk production.

METHOD OF PROCEDURE

These experiments were conducted by the Department of Dairy Husbandry in cooperation with the Texas Agricultural Experiment Station. The double reversal method of feeding lactating dairy cows was used in comparing whole versus ground shelled corn, whole versus ground threshed oats, whole versus ground threshed milo, and whole versus ground threshed barley.

A total experimental period of 84 days divided into three periods of 28 days each was used in each experiment. The first seven days of each 28-day period was considered as a transition period from one ration to another and the data were disregarded, since the entire change from whole to ground grain feeding, or vice versa, was made in one feeding at the end of each 28-day period. The last 21 days constituted the true experimental period. Three to six purebred Holstein and Jersey cows were used in each group with the exception of the first oat experiment, in which one Ayrshire was also used in each group. These groups were balanced as nearly as possible as to breed, milk production, body weight, age, stage of lactation, and persistency of production. All the cows were fed their concentrate ration in the milking barn while they were being milked.

The grain mixture was fed at the rate of one pound for each two and one-half pounds of milk produced per cow per day by Jerseys, and one pound for each three pounds of milk produced daily per cow by Holsteins. The amount fed per cow each week was determined from the previous week's production. This grain mixture, balanced so as to properly supplement the nutrients supplied by the roughage, consisted of a variety of concentrates readily available in any of the feed markets of Texas. The analyses of these feeds are given in Table 1. The grain being tested in each of the experiments made up from 50 to 75 per cent of the total grain mixture. After the grain mixture was balanced, one per cent of salt and one per cent of either steam bone meal or oyster shell were added.

Table 1. Average Analyses* of Feeds Used in Experiments.

Name	No. of Analyses	Crude Protein %	Crude Fat %	Crude Fiber %	N.F.E. %	Water %	Ash %
Cottonseed meal	3	44.31	6.97	10.00	26.12	6.94	5.66
Wheat bran	3	16.91	4.11	9.25	53.33	10.46	5.94
Alfalfa hay	5	13.81	1.42	33.00	35.25	8.69	7.83
Barley	4	13.52	2.02	6.21	65.75	9.73	2.77
Oats	2	10.81	5.62	11.55	59.68	8.44	3.90
Corn	2	10.34	4.40	2.31	71.16	10.53	1.26
Milo	2	11.19	2.77	2.26	72.01	10.07	1.70
Hegari silage	1	2.45	0.94	6.31	18.75	67.22	4.33
Corn silage	1	2.07	0.56	6.86	12.29	76.28	1.94
Molasses—Beet pulp	1	9.01	0.31	17.16	59.99	8.97	4.56

*Analyses made by Division of Chemistry, Texas Agricultural Experiment Station.

The roughages consisted of either sorghum silage or wet beet pulp and alfalfa hay. Roughage was fed at the rate of one pound of alfalfa hay and three pounds of either silage or wet beet pulp per hundred pounds live weight per cow daily. The roughages were fed to each group separately in mangers in the feed barn, and the refuse was gathered and weighed after each feeding. Each group of cows was kept in a separate dry lot where water, block salt, shade, and shelter were available at all times.

The cows were weighed as nearly as possible at the same time each day for three consecutive days at the beginning and end of each 28-day period, and the average of the three weights was taken as the actual weight of the cows. The scale used for weighing the cows was graduated to one pound and was carefully balanced at each weighing period. In analyzing the results of body weight changes, only three-fourths of the actual weight differences were used because data concerning feed consumption and milk production were disregarded for the first seven days of each 28-day period.

The cows were milked three times daily by hand in the regular milking barn with the balance of the dairy herd and the milk was weighed on a regular milk scale graduated to one-tenth pound. The milk weights were kept on separate records as well as on the regular barn record.

All of the experiments were conducted with the College dairy herd under the direct supervision of the senior author. Senior and graduate students were in immediate charge of the experimental animals and responsible for weighing, milking, and feeding the cows.

In addition to the above experiments, tests were conducted to determine what per cent of whole corn and whole milo would pass unmasticated through the digestive system of the cow. It was found difficult to separate the masticated from the unmasticated whole grains of oats and barley, so that tests of mastication were discontinued.

EXPERIMENTAL RESULTS

The effect, if any, of grinding grain upon milk yield, changes in body weight, and feed consumption should be shown by the difference between

the average results of the first and third 21-day experimental period and those of the second 21-day experimental period. By employing the double reversal method of feeding experiments, involving two groups of cows, the influence of unfavorable climatic conditions and differences in inherited ability to produce milk were eliminated. Furthermore, in order to eliminate the possible influence of seasons of the year, the experiments were repeated at different periods during the year. In all of the experiments, group "A" was fed ground grain during the first and third periods and whole grain during the second period, whereas group "B" was fed the whole grain ration the first and third period and the ground grain ration the second period. Different cows were included in both groups for each experiment.

Results of Whole Versus Ground Corn

The first corn experiment was started in the spring of 1932. Six cows consisting of one Jersey and five Holsteins were used in each group. The second corn experiment was started in the fall of 1932, and again one Jersey and five Holsteins were used in each group.

The results from these two experiments of feeding whole versus ground corn were very unsatisfactory because of the extreme difficulty of securing consumption of the whole corn, so that there was a much greater consumption of grain during the periods the cows were fed the ground corn ration, as shown in Tables 2 and 3. This was especially true in the first corn experiment when whole corn comprised 75 per cent of the entire grain mixture. During the second corn experiment whole corn comprised only 50 per cent of the grain mixture; this resulted in more nearly equal consumption of whole and ground corn than during the first experiment, but with still a considerable difference in the total quantity of each consumed. Another method used in attempting to solve the problem of inducing the animals to eat whole corn was to raise heifer calves up to calving time on a mixture containing considerable whole corn, and then to place them on an experiment. However, once these animals were placed on the ground corn mixture, they showed the same dislike for the whole corn as the cows in the two previous experiments when changed from ground to whole corn, and the experiment was therefore discontinued.

Results of Milk Yield, Body Weight Changes, and Feed Consumption

The differences in milk yield, body weight changes, and feed consumption between the average of the first and third experimental period and the second period, as well as the combined results of both groups, are shown in Table 2. Average differences for each group are shown rather than total differences. The first two columns of the table represent the total consumption per cow for each group during the 21-day period of whole and ground corn feeding respectively, because whole and ground

Table 2. Ground versus Whole Corn. Average consumption of feed, production of milk, and changes in body weight in pounds during first and third 21-days minus consumption, production, and changes in weight during second 21-days.

	Whole Corn	Ground Corn	Ground Barley	Wheat Bran	Cottonseed Meal	Alfalfa Hay	Beet Pulp	Pounds Milk	Body Weight
Experiment 1.									
Group A (started on ground corn)	−110.8	+234.7	.....	+20.4	+20.4	+30.0	+7.0	+249.5	−49.7
Group B (started on whole corn)	+123.4	−207.8	.....	−14.1	−14.1	+118.5	+14.8	−132.2	−106.9
Difference A — B	−234.2	+442.5	.....	+34.5	+34.5	−88.5	−7.8	+381.7	+57.2
Experiment 2.									
Group A (started on ground corn)	−89.9	+109.3	+11.7	+3.9	+3.1	+6.5	+19.9	+23.6	−34.6
Group B (started on whole corn)	+95.6	−114.3	−11.2	−3.7	−3.0	+7.1	+20.4	−19.0	−27.1
Difference A — B	−185.5	+223.6	+22.9	+7.6	+6.1	−0.6	−0.5	+42.6	−7.5

	Whole Corn		Ground Corn		Ground Barley		Wheat Bran		Cottonseed Meal		Alfalfa Hay		Beet Pulp		Pounds Milk		Body Weight
From Experiment 1	234.2	=	442.5	+		+	34.5	+	34.5	−	88.5	−	7.8	−	381.7	−	57.2
From Experiment 2	185.5	=	223.6	+	22.9	+	7.6	+	6.1	−	0.6	−	0.5	−	42.6	+	7.5

corn were not fed at the same time to either group of cows. However, other concentrates in the grain mixture were being fed to both groups of cows at all times. Hence, the other columns represent actual average differences in consumption of other feeds, production of milk, and changes in body weight between the periods of ground and whole corn feeding. The average differences for group "B" were subtracted from the average differences for group "A" to obtain combined results for whole and ground corn for both groups of cows. In order to obtain for the 21-day experimental period the average differences per cow of milk produced, changes in body weight, and feed consumed, when the results of both groups of cows are combined, it is necessary to divide the figures obtained from the difference A-B by two. The lower section of the table represents an equation between whole and ground corn for each experiment when the results of both groups of cows are combined. Likewise, similar analyses were made of the results of the experiments with whole versus ground oats, whole versus ground milo, and whole versus ground barley, as shown in Tables 4, 6, and 8 respectively.

It will be observed from Table 2 that in both experiments the cows in both group "A" and group "B" produced more milk while they were being fed the ground corn ration. However, in Experiment 2 this difference was not as great as in Experiment 1. Likewise it will be observed that the cows in both groups consumed much more concentrates when they were being fed the ground corn ration. In the first experiment they consumed over twice as much concentrates when on ground corn as when they were on whole corn. There was a difference of 9.09 pounds of milk per cow daily favoring ground corn; however, this surplus milk yield on ground corn was accompanied by extra concentrate consumption amounting to 6.6 pounds per cow per day. In the second experiment there was a difference of only one pound of milk daily per cow favoring ground grain, with 1.78 pounds more concentrates consumed per cow daily on the ground corn ration.

Table 3 gives the total amount of milk produced and feed consumed by each group in both experiments, and the ratio of concentrates consumed to milk produced. It will be observed from this table that in both experiments the cows in each group produced considerably more milk per pound of grain consumed when fed the whole grain ration.

The results of changes in body weight in the two experiments were conflicting, as indicated by a difference of 28.6 pounds per cow in 21 days favoring grinding in the first experiment, whereas the difference was 3.75 pounds in favor of whole grain in the second experiment.

Table 3. Ground Versus Whole Corn.

Experiment 1.	Group A (6 cows)		Group B (6 cows)	
	Average of First and Third Period	Second Period	Average of First and Third Period	Second Period
Pounds Ground Grain Mixture Consumed..	1877.0	.....	.....	1662.5
Pounds Whole Grain Mixture Consumed...	.....	886.0	986.2	.....
Pounds Milk Produced.....	5532.8	4035.7	4140.0	4933.4
Grain Milk Ratio.....	1:2.95	1:4.55	1:4.20	1:2.97
Experiment 2.	Group A (6 cows)		Group B (6 cows)	
Pounds Ground Grain Mixture Consumed..	1335.3	.....	.....	1344.1
Pounds Whole Grain Mixture Consumed...	.....	1056.2	1123.7	.....
Pounds Milk Produced.....	3811.9	3633.6	3964.1	4083.8
Grain Milk Ratio.....	1:2.85	1:3.44	1:3.53	1:3.04

Results of Whole Versus Ground Oats

The first oat experiment was conducted during the winter of 1931-32. Two Holsteins and one Ayrshire were used in each group. The second oat experiment was conducted during the summer of 1933. Two Jerseys and four Holsteins were used in each group. The third oat experiment was conducted during the fall and winter of 1933; three Jerseys and two Holsteins were used in each group.

In the first oat experiment 60 per cent of the grain mixture consisted of oats, in the second 52.5 per cent, and in the third 52 per cent. In all of the oat experiments, the consumption of whole oats was much more satisfactory than the consumption of whole corn in the corn experiments.

Results of Milk Yield, Body Weight Changes, and Feed Consumption

It is shown in Table 4 that during the periods of ground grain feeding in the three oat experiments, the differences in milk production were consistent. The difference in milk production in the first experiment was 1.90 pounds, in the second 1.95 pounds, and in the third 1.80 pounds per cow daily, favoring ground oats. These differences in milk yields were accompanied by greater consumption of concentrates amounting to 1.25, 0.73, and 0.38 pounds per cow daily respectively for the three experiments.

Table 5 gives the total amount of concentrates consumed and milk produced by each group in all three experiments. It will be noted that between the periods of whole and ground grain feeding, the ratio of milk produced to concentrates consumed was very nearly equal, with the exception of group "A" in Experiment 1.

Table 4. Ground versus Whole Oats. Average consumption of feed, production of milk, and changes in body weight in pounds during first and third 21-days minus consumption, production, and changes in weight during second 21-days.

	Whole Oats	Ground Oats	Ground Barley	Wheat Bran	Cotton-seed Meal	Alfalfa Hay	Silage	Beet Pulp	Pounds Milk	Body Weight
Experiment 1.										
Group A (started on ground oats)	−100.0	+136.3	.....	+12.1	+12.1	−10.8	0	.....	+90.7	+23.85
Group B (started on whole oats)	+105.5	−100.6	.....	+1.6	+1.6	−11.8	0	.....	+10.8	+20.25
Difference A — B	−205.5	+236.9	.....	+10.5	+10.5	+1.0	0	.....	+79.9	+3.60
Experiment 2.										
Group A (started on ground oats)	−128.10	+140.35	+7.20	+2.59	+1.29	+5.56	.....	+15.2	+49.77	−12.37
Group B (started on whole oats)	+134.76	−138.50	−2.29	−0.76	−.38	+6.46	.....	+16.5	−31.52	−19.27
Difference A — B	−262.86	+278.85	+9.49	+3.35	+1.67	−0.90	.....	−1.3	+81.29	+6.90
Experiment 3.										
Group A (started on ground oats)	−112.67	+120.90	+4.24	+1.28	+0.99	+4.9	+6.35	.....	+77.02	+0.30
Group B (started on whole oats)	+106.61	−107.30	−0.39	−0.12	−0.09	+4.6	+2.45	.....	+1.54	−1.70
Difference A — B	−219.28	+228.20	+4.63	+1.40	+1.08	+0.3	+3.90	.....	+75.48	+2.0

	Whole Oats		Ground Oats		Ground Barley		Wheat Bran		Cotton-seed Meal		Alfalfa Hay		Silage		Beet Pulp		Pounds Milk		Body Weight
From Experiment 1	205.5	=	236.9			+	10.5	+	10.5	+	1.0					—	79.90	—	3.60
From Experiment 2	262.86	=	278.85	+	9.49	+	3.35	+	1.67	—	0.90			—	1.3	—	81.29	—	6.90
From Experiment 3	219.28	=	228.20	+	4.63	+	1.40	+	1.08	+	0.30	+	3.90			—	75.48	—	2.00

Average weight differences per cow in 21 days favoring ground grain ranged from one pound in the third experiment to 3.45 pounds in the second experiment. Weight differences between the periods of feeding whole and ground oats were much more uniform than those between the two experiments of whole versus ground corn.

Table 5. Ground Versus Whole Oats.

Experiment 1.	Group A (3 cows)		Group B (3 cows)	
	Average of First and Third Period	Second Period	Average of First and Third Period	Second Period
Pounds Ground Grain Mixture Consumed..	681.6	.....	.....	503.0
Pounds Whole Grain Mixture Consumed...	.....	499.7	513.0	.....
Pounds Milk Produced.....	1982.9	1710.8	1516.6	1483.1
Grain Milk Ratio.....	1:2.91	1:3.42	1:2.96	1:2.95
Experiment 2.	Group A (6 cows)		Group B (6 cows)	
Pounds Ground Grain Mixture Consumed..	1596.9	.....	.....	1580.5
Pounds Whole Grain Mixture Consumed...	.....	1462.4	1537.2	.....
Pounds Milk Produced.....	4875.6	4577.4	4646.3	4835.4
Grain Milk Ratio.....	1:3.05	1:3.13	1:3.02	1:3.06
Experiment 3.	Group A (5 cows)		Group B (5 cows)	
Pounds Ground Grain Mixture Consumed..	1135.4	.....	.....	1011.1
Pounds Whole Grain Mixture Consumed...	.....	1061.7	1004.6	.....
Pounds Milk Produced.....	3291.5	2906.4	2768.8	2761.1
Grain Milk Ratio.....	1:2.90	1:2.74	1:2.76	1:2.73

Results of Whole Versus Ground Milo

The first experiment comparing whole versus ground milo was conducted during the summer of 1932, with three Jerseys and two Holsteins in each group. The second experiment was conducted during the late winter and early spring of 1933, and the third experiment was conducted during the winter of 1934. There were two Jerseys and four Holsteins in each group in the second experiment and three Jerseys and two Holsteins in each group in the third experiment. In each of the three experiments the grain mixture included 60 per cent of milo.

Results of Milk Yield, Body Weight Changes, and Feed Consumption

Table 6 shows the average differences in feed consumption, milk production, and changes in body weight between the periods of whole and ground milo feeding for the three experiments. During the first experiment there was a difference of 2.12 pounds of milk per cow daily favoring ground milo, while in the second and third experiments the

Table 6. Ground versus Whole Milo. Average consumption of feed, production of milk, and changes in body weight in pounds during first and third 21-days minus consumption, production, and changes in weight during second 21-days.

	Whole Milo	Ground Milo	Ground Barley	Wheat Bran	Cottonseed Meal	Alfalfa Hay	Beet Pulp	Pounds Milk	Body Weight
Experiment 1.									
Group A (started on ground milo)	−131.4	+148.8	+5.7	+2.9	+2.9	−29.9	+1.4	+95.7	+12.3
Group B (started on whole milo)	+104.0	−104.1	−.08	−.06	−.06	−32.5	−4.0	+6.5	+32.9
Difference A — B	−235.4	+252.9	+5.78	+2.96	+2.96	+2.6	+5.4	+89.2	−20.6
Experiment 2.									
Group A (started on ground milo)	−142.4	+165.3	+7.6	+3.8	+3.8	+9.6	+28.8	+106.8	−54.97
Group B (started on whole milo)	+164.9	−178.6	−4.4	−2.3	−2.3	+9.7	+28.8	−86.4	−48.88
Difference A — B	−307.3	+343.9	+12.0	+6.1	+6.1	−0.1	0	+193.2	−6.09
Experiment 3.							Silage		
Group A (started on ground milo)	−126.48	+145.18	+6.24	+3.11	+3.11	+9.7	−12.4	+98.34	+36.63
Group B (started on whole milo)	+129.54	−141.14	−3.89	−1.95	−1.95	+12.2	−2.4	−55.28	+16.00
Difference A — B	−256.02	+286.32	+10.13	+5.06	+5.06	−2.50	−10.0	+153.62	+20.63

	Whole Milo		Ground Milo		Ground Barley		Wheat Bran		Cottonseed Meal		Alfalfa Hay		Beet Pulp		Pounds Milk		Body Weight
From Experiment 1	235.4	=	252.9	+	5.78	+	2.96	+	2.96	+	2.6	+	5.4	−	89.2	+	20.6
From Experiment 2	307.3	=	343.9	+	12.00	+	6.10	+	6.10	−	0.1	+	0	−	193.2	+	6.09
From Experiment 3	256.02	=	286.32	+	10.13	+	5.06	+	5.06	−	2.5	−	10.0	−	153.62	−	20.63

differences were greater, amounting to 4.60 and 3.66 pounds respectively for the two experiments. The consumption of concentrates was greater during the periods of ground milo feeding, amounting to 0.70 pounds per cow daily in the first experiment and 1.45 and 1.20 pounds per cow per day respectively during the second and third experiments. It can be seen from Table 7 that the ratio of concentrates fed to milk produced was practically the same between whole and ground milo feeding for all three experiments.

From Table 6 it will be observed that the changes in body weights were rather inconsistent, ranging from 10.3 pounds per cow in 21 days favoring whole grain in the first experiment to a similar change of 10.3 pounds favoring ground grain in the third experiment.

Table 7. Ground Versus Whole Milo.

Experiment 1.	Group A (5 cows)		Group B (5 cows)	
	Average of First and Third Period	Second Period	Average of First and Third Period	Second Period
Pounds Ground Grain Mixture Consumed..	1239.9	.....	.....	867.3
Pounds Whole Grain Mixture Consumed...	.....	1094.8	865.7	.....
Pounds Milk Produced.....	3722.1	3243.4	2488.5	2455.8
Grain Milk Ratio.....	1:3.08	1:2.96	1:2.87	1:2.83
Experiment 2.	Group A (6 cows)		Group B (6 cows)	
Pounds Ground Grain Mixture Consumed..	1651.7	.....	.....	1785.2
Pounds Whole Grain Mixture Consumed...	.....	1423.4	1649.0	.....
Pounds Milk Produced.....	4786.0	4145.3	4832.8	5351.4
Grain Milk Ratio.....	1:2.90	1:2.90	1:2.93	1:3.00
Experiment 3.	Group A (5 cows)		Group B (5 cows)	
Pounds Ground Grain Mixture Consumed..	1209.7	.....	.....	1176.1
Pounds Whole Grain Mixture Consumed...	.....	1053.9	1079.1	.....
Pounds Milk Produced.....	3303.2	2811.5	2921.9	3198.3
Grain Milk Ratio.....	1:2.73	1:2.67	1:2.71	1:2.72

Results of Whole Versus Ground Barley

The first barley experiment was conducted in the winter of 1934-35; three Jerseys and two Holsteins were used in each group. The second experiment was conducted during the spring of 1935, with three Jerseys and three Holsteins in each group. In both of these experiments the concentrate mixture fed included 50 per cent of barley.

Results of Milk Production, Body Weight Changes, and Feed Consumption

Table 8 shows the average differences of milk yield, feed consumption, and changes in body weight between the periods of feeding whole and ground barley for the two experiments. The differences in milk

Table 8. Ground versus Whole Barley. Average consumption of feed, production of milk, and changes in body weight in pounds during first and third 21-days minus consumption, production, and changes in weight during second 21-days.

	Whole Barley	Ground Barley	Ground Corn	Wheat Bran	Cottonseed Meal	Alfalfa Hay	Beet Pulp	Pounds Milk	Body Weight
Experiment 1.									
Group A (started on ground barley).....	−128.7	+143.4	+5.5	+3.7	+3.7	−48.6	+3.4	+97.81	+34.4
Group B (started on whole barley).....	+133.0	−144.6	−4.2	−3.7	−3.7	−37.0	+5.8	−65.38	−30.1
Difference A — B.....	−261.7	+288.0	+9.7	+7.4	+7.4	−11.6	−2.4	+163.19	+64.5
Experiment 2.									
Group A (started on ground barley).....	−103.8	+125.5	+8.0	+6.6	+6.6	−5.7	−1.9	+110.4	+29.0
Group B (started on whole barley).....	+113.1	−119.9	−2.4	−2.0	−2.0	−1.6	−4.1	−72.0	−0.25
Difference A — B.....	−216.9	+245.4	+10.4	+8.6	+8.6	−4.1	+2.2	+182.4	+29.25

	Whole Barley		Ground Barley		Ground Corn		Wheat Bran		Cottonseed Meal		Alfalfa Hay		Beet Pulp		Pounds Milk		Body Weight
From experiment 1.....	261.7	=	288.0	+	9.7	+	7.4	+	7.4	−	11.6	−	2.4	−	163.19	−	64.5
From Experiment 2.....	216.9	=	245.4	+	10.4	+	8.6	+	8.6	−	4.1	+	2.2	−	182.40	−	29.25

production favoring ground barley were 3.89 and 4.34 pounds per cow daily for the first and second experiment respectively. The consumption of concentrates while the cows were on the ground grain ration for the two experiments was 1.20 and 1.33 pounds greater per cow per day respectively. It can be seen from Table 9 that the ratio of concentrates fed to milk produced was practically the same between the periods of whole and ground barley feeding for both experiments.

Table 9. Ground Versus Whole Barley.

Experiment 1.	Group A (5 cows)		Group B (5 cows)	
	Average of First and Third Period	Second Period	Average of First and Third Period	Second Period
Pounds Ground Grain Mixture Consumed..	1404.9	.....	.....	1417.2
Pounds Whole Grain Mixture Consumed...	.....	1260.6	1303.7	.....
Pounds Milk Produced.....	3918.4	3429.3	3680.4	4007.3
Grain Milk Ratio.....	1:2.79	1:2.72	1:2.82	1:2.83
Experiment 2	Group A (6 cows)		Group B (6 cows)	
Pounds Ground Grain Mixture Consumed..	1476.3	.....	.....	1409.8
Pounds Whole Grain Mixture Consumed...	.....	1220.1	1329.3	.....
Pounds Milk Produced.....	4164.9	3501.8	3702.9	4134.6
Grain Milk Ratio.....	1:2.82	1:2.87	1:2.79	1:2.93

The average of body weight changes for the two experiments showed a difference of 23.4 pounds per cow in 21 days favoring ground barley.

Effect of Feeding Whole versus Ground Grains on High versus Low Producing Cows

In analyzing the results of milk production in the several experiments on whole grain, it was observed that there was a greater decrease in that of the higher producing cows in the experiments than in that of the lower producing cows. Therefore, the cows in the several experiments were divided into two groups on the basis of their milk production for the first 21-day period of each experiment. Cows producing an average of 34.4 pounds or four gallons or more of milk daily were placed in the High Producing group and the cows producing less than four gallons daily were placed in the Low Producing group; the results were analyzed as shown in Table 10. The lowest producing cows used in any experiment produced not less than one and one-half gallons per cow daily.

It can be seen from Table 10 that in every experiment comparing whole versus ground grains, the effect on milk production was much greater on the high producing cows than on the cows classified as low producers. The average differences for all experiments concerning any particular grain showed that the greatest differences in milk production between high and low producing cows was found for barley and the smallest dif-

ference for oats. The difference in favor of the ground grain ration was greater by approximately one-half gallon per cow daily for the high producing than for the low producing cows in both the corn and barley experiments, whereas the difference between the high and low producers in the oats and milo experiments was only about one quart per cow daily.

Table 10. Effects of Feeding Ground versus Whole Grain on High versus Low Producing Cows.

Experiment Numbers	High Producing Cows	Low Producing Cows	Difference Average between High and Low Producing Cows		Average Difference per Day for All Experiments
	Av. Lbs. Milk Produced in 21 days favoring ground grain	Av. Lbs. Milk Produced in 21 days favoring ground grain	Lbs. in 21 days	Lbs. per Day	
Corn Experiment No. 1.....	252.30	104.88	147.42	7.02	.....
Corn Experiment No. 2.....	38.33	11.33	27.00	1.29	4.15
Oat Experiment No. 1.....	92.65	13.58	79.07	3.76	.....
Oat Experiment No. 2.....	52.43	17.08	35.35	1.68	.....
Oat Experiment No. 3.....	72.48	22.85	49.63	2.36	2.60
Milo Experiment No. 1.....	86.72	16.52	70.20	3.34	.....
Milo Experiment No. 2.....	107.12	44.20	62.92	3.00	.....
Milo Experiment No. 3.....	101.00	66.44	34.56	1.65	2.66
Barley Experiment No. 1....	115.49	47.70	67.79	3.22	.....
Barley Experiment No. 2....	147.40	34.97	112.43	5.35	4.28

Productive Values of Whole Grains

Because different feedstuffs, milk, and body weight, each have different energy values, these three items have been reduced to a common term, "Productive Energy," in the analysis of these data. The productive energy of the feeds used was calculated from the analyses of the feeds as shown in Table 1 by the Division of Chemistry as illustrated in Texas Station Bulletin No. 329 (3). The productive energy of the milk and gain in weight was also calculated by the Division of Chemistry on the basis of the estimated therms of energy required to produce one pound of average milk and one pound of average gain in body weight. The calculated productive value of the ground grains was multiplied by the pounds of ground grain fed to obtain the total productive energy supplied by the ground grains. Similar calculations were made for the other feeds, milk productions and changes in body weights on the basis of the differences between the periods of whole and ground grain feeding. These differences in productive energy were added to or subtracted from the productive energy contained in the ground grain. Finally, this remainder of productive energy was divided by the total amount of whole

grain consumed per cow to obtain the productive value for the whole grain expressed as "therms per hundred pounds."

There was a wide variation and often much inconsistency in change in body weight in the experimental animals in these experiments as shown in Tables 2, 4, 6, and 8. Because of this inconsistency, calculations of the productive values were made including and omitting the changes in body weights.

The productive values of the whole grains used in the various experiments are given in Tables 11 to 14 inclusive. Each table includes the results of all experiments conducted with any one grain. Table 15 gives the average of all experiments pertaining to each of the whole grains tested, as well as the calculated values for the ground grains. It can be seen from Table 15 that the calculated energy value of whole corn was high; this was probably caused by the wide difference in the amounts of whole and ground grain consumed. In the two barley experiments the calculated productive values were practically the same. There was considerable variation in calculated productive values of whole oats between the three experiments with a difference of about 10.75 therms per one hundred pounds between the first and third experiments. There was very close agreement between the second and third milo experiments. However, the first milo experiment showed a productive value of whole grain about 3.5 therms per one hundred pounds greater than that of the other two experiments.

Table 11. Calculation of Productive Value of Whole Corn in Therms (from equations in Table 2.)

	Factor	Pounds	Productive Value	Pounds	Productive Value
Whole Corn		234.2		185.5	
Ground Corn	.871	442.5	385.42	223.6	194.76
Wheat Bran	.490	+34.5	+16.91	+7.6	+3.72
Cottonseed Meal	.744	+34.5	+25.67	+6.1	+4.54
Ground Barley	.794	.....	.....	+22.9	+18.18
Alfalfa Hay	.330	—88.5	—29.21	—0.6	—0.20
Beet Pulp (Dry)	.629	—7.8	—4.91	—0.5	—0.31
Body Weight	1.10	—57.2	—62.92	+7.5	+8.25
Milk Lbs.	.30	—381.7	—114.51	—42.6	—12.78
Total +	.....	.....	428.00	.....	229.45
Total —	.....	.....	211.55	.....	13.29
Remainder	.....	.....	+216.45	.....	+216.16

	Total Thermal Value of Whole Corn		Pounds of Whole Corn	Therms per 100 lbs. of Whole Corn
Changes in Weight Included				
1	216.45	÷	234.2	92.42
2	216.16	÷	185.5	116.52
Disregarding Weight Changes				
1	279.37	÷	234.2	119.29
2	207.91	÷	185.5	112.08

Table 12. Calculation of Productive Value of Oats in Therms (from equations in Table 4).

	Factor	Pounds	Productive Value	Pounds	Productive Value	Pounds	Productive Value
Whole Oats		205.5		262.86		219.28	
Ground Oats	.722	236.9	171.04	278.85	201.33	228.20	164.76
Cottonseed Meal	.744	+10.5	+7.81	+1.67	+1.24	+1.08	+0.80
Wheat Bran	.490	+10.5	+5.15	+3.35	+1.64	+1.40	+0.69
Ground Barley	.794	.....	.....	+9.49	+7.54	+4.63	+3.68
Alfalfa Hay	.330	+1.0	+0.33	−0.90	−0.30	+0.30	+0.10
Silage	.249	0	0	.....	.....	+3.90	+0.97
Beet Pulp (Dry)	.629	.....	.....	−1.30	−0.82	.....	.....
Body Weight	1.10	−3.60	−3.96	−6.90	−7.59	−2.00	−2.20
Milk (Lbs.)	.300	−79.90	−23.97	−81.29	−24.39	−75.48	−22.64
Total +	.....	.....	184.33	.....	211.75	.....	171.00
Total −	.....	.....	27.93	.....	33.10	.....	24.64
Difference	.....	.....	+156.40	.....	+178.65	.....	+146.16

	Total Thermal Value of Whole Oats		Pounds of Whole Oats	Therms per 100 lbs. of Whole Oats
Changes in Weight Included				
1	156.40	÷	205.5	76.11
2	178.65	÷	262.86	67.96
3	146.16	÷	219.28	66.65
Disregarding Weight Changes				
1	160.36	÷	205.5	78.03
2	186.24	÷	262.86	70.85
3	148.56	÷	219.28	67.75

Table 13. Calculation of Productive Value of Whole Milo in Therms (from equations in Table 6).

	Factor	Pounds	Productive Value	Pounds	Productive Value	Pounds	Productive Value
Whole Milo		235.4		307.3		256.02	
Ground Milo	.857	252.9	216.74	343.9	294.72	286.32	245.38
Ground Barley	.794	+5.78	+4.59	+12.00	+9.53	+10.13	+8.04
Wheat Bran	.490	+2.96	+1.45	+6.10	+2.99	+5.06	+2.48
Cottonseed Meal	.744	+2.96	+2.20	+6.10	+4.54	+5.06	+3.76
Alfalfa Hay	.330	+2.60	+0.86	−0.10	−0.03	−2.50	−0.83
Beet Pulp (Dry)	.629	+5.40	+3.40	0	0	.....	.....
Silage	.249	.....	.....	.....	.....	−10.0	−2.49
Body Weight	1.10	+20.6	+22.66	+6.09	+6.70	−20.63	−22.69
Milk (Lbs)	.30	−89.2	−26.76	−193.2	−57.96	−153.62	−46.09
Total +	.....	.....	251.90	.....	318.48	.....	259.66
Total −	.....	.....	26.76	.....	57.99	.....	72.10
Remainder	.....	.....	+225.14	.....	+260.49	.....	+187.56

	Total Thermal Value of Whole Milo		Pounds of Whole Milo	Therms per 100 lbs. of Whole Milo
Changes in Weight Included				
1	225.14	÷	235.4	95.64
2	260.49	÷	307.3	84.76
3	187.56	÷	256.02	73.26
Disregarding Weight Changes				
1	202.48	÷	235.4	86.01
2	253.79	÷	307.3	82.59
3	210.25	÷	256.02	82.12

Table 14. Calculations of Productive Value of Whole Barley in Therms (from equations in Table 8).

	Factor	Pounds	Productive Value	Pounds	Productive Value
Whole Barley		261.7		216.9	
Ground Barley	.794	288.0	228.67	245.4	194.85
Ground Corn	.871	+9.7	+8.44	+10.4	+9.06
Cottonseed Meal	.744	+7.4	+5.51	+8.6	+6.40
Wheat Bran	.490	+7.4	+3.63	+8.6	+4.21
Alfalfa Hay	.330	−11.6	−3.83	−4.1	−1.35
Beet Pulp (Dry)	.629	−2.4	−1.51	+2.2	+1.38
Body Weight	1.10	−64.5	−70.95	−29.25	−32.17
Milk (Lbs)	.30	−163.19	−48.96	−182.40	−54.72
Total +	.....	.....	246.25	.....	215.90
Total −	.....	.....	125.25	.....	88.24
Remainder	.....	.....	+121.00	.....	+127.66

	Total Thermal Value of Whole Barley		Pounds of Whole Barley	Therms per 100 lbs. of Whole Barley
Changes in Weight Included				
1	121.00	÷	261.7	46.24
2	127.66	÷	216.9	58.86
Disregarding Weight Changes				
1	191.95	÷	261.7	73.35
2	159.83	÷	216.9	73.69

Table 15. The Average Productive Values of Whole Grains in each Experiment.

Experiment and Feed	Total Calculated Productive Value of Whole Grain		Pounds Whole Grain Fed		Therms per 100 lbs. Whole Grain
Corn					
Experiment 1	234.20	÷	279.37		119.29
Experiment 2	185.50	÷	207.91		112.08
	Ground Corn 87.10			Average =	115.68
Oats					
Experiment 1	160.36	÷	205.50		78.03
Experiment 2	186.24	÷	262.86		70.85
Experiment 3	148.56	÷	219.28		67.75
	Ground Oats 72.20			Average =	72.21
Milo					
Experiment 1	202.48	÷	235.40		86.01
Experiment 2	253.79	÷	307.30		82.59
Experiment 3	210.25	÷	256.02		82.12
	Ground Milo 85.70			Average =	83.57
Barley					
Experiment 1	191.95	÷	261.70		73.35
Experiment 2	159.83	÷	216.90		73.69
	Ground Barley 79.40			Average =	73.52

Mastication of Grain by Dairy Cows

Immediately following the first experiment with milo, two Holstein cows used in that experiment were kept in box stalls for six consecutive days and fed a ration containing 60 per cent of whole milo, and the unmasticated grain was recovered from the feces daily by washing

through a screen. The recovered grain was then dried to an air dry basis and weighed. One cow consumed 36 pounds of milo, of which 17.4 pounds were recovered in the feces; therefore 51.7 per cent was masticated. The other cow was fed 15 pounds of whole milo, of which 13.1 pounds was recovered, so that 12.7 per cent was masticated.

A similar test was conducted with two Holstein cows at the close of the first corn experiment, with a ration containing 75 per cent of whole corn. One cow consumed 40.65 pounds of whole corn and 9.1 pounds was recovered in the feces, showing that 77.6 per cent was masticated. The other cow consumed 55.5 pounds of whole corn and 21.5 pounds were recovered in the feces, showing that 61.3 per cent was masticated. A second trial was conducted with two Holstein cows following the second corn experiment. In this trial the ration consisted of only 50 per cent of whole corn instead of 75 per cent as in the first trial. One cow consumed 26.8 pounds of whole corn and 17.7 pounds were recovered in the feces, so that 24.0 per cent was masticated. The other cow was fed 14.6 pounds of whole corn and 8.5 pounds were recovered in the feces, so that 41.8 per cent was masticated. Table 16 shows the chemical analyses of the corn and milo grain as fed and as recovered.

Table 16. Analysis of Corn and Milo Grain as Fed and as Recovered.

	Crude Protein %	Crude Fat %	Crude Fiber %	N. F. E. %	Water %	Ash %
Corn as Fed	9.97	4.40	2.15	71.12	11.05	1.31
Corn Recovered	10.72	4.61	2.53	71.56	8.77	1.81
Milo as Fed	11.17	2.73	2.28	72.24	9.68	1.90
Milo Recovered	11.07	2.41	2.47	70.30	11.56	2.19

DISCUSSION

Experiments are reported in this bulletin on the results of feeding whole as compared with ground grains to dairy cows, using the double reversal method of feeding. These tests were conducted in triplicate to compare whole threshed milo with ground milo and whole threshed oats with ground oats, and in duplicate to compare whole shelled corn with ground corn and whole threshed barley with ground barley.

The ground grains used in these investigations were ground to a medium fineness. In all of the experiments greater milk yields were obtained from the cows when they were fed the ground grain ration. At the same time these cows consumed more grain than when fed the whole grain ration. It was found that much more whole corn was refused by the cows than any of the other whole grains tested; especially

was this true in the first corn experiment. Whole milo grain was second to corn in the amount refused, with barley third and oats fourth. Corn was the largest in size of the whole grains tested and possibly the hardest to crack or crush, whereas milo was the smallest grain and would possibly rank close to corn in crushing strength. Oats was much the softest grain and of intermediate size. Thus it would seem that hardness as well as size of the whole grains had an influence on the palatability of the grains as indicated by the relative amounts of the various whole grains refused by the cows. There were two reasons why the groups of cows consumed more total concentrate feed during the periods of ground grain feeding, namely, less ground grain refused and greater milk production on the ground grain ration. No doubt a part of the greater milk yields obtained during the periods of ground grain feeding was due to the fact that more concentrate feed was consumed. In fact, nearly all of the higher milk yields obtained on ground grain could be accounted for by the greater consumption of concentrate feed except in the case of the barley experiments, as shown in Tables 11 to 14 inclusive. Therefore, it seems advisable to grind such grains for dairy cows, especially high producing animals, in order to increase the palatability of the grains to the extent of obtaining consumption of such feeds in proportion to their level of milk production.

It was intended at the outset of these experiments that approximately equal amounts of ground and whole grains would be fed to the cows. However, it can be seen from the results of feed consumption and milk yields shown in Tables 2, 4, 6, and 8 that greater differences in feed consumption and milk production were always shown in group "A," which group was started on the ground grain mixture in each experiment and therefore had two periods on ground and one on whole grain feeding. The reverse procedure applied to group "B." Perhaps a better method for this type of experimental feeding would be to use four periods instead of three. This would give each group of animals an equal number of periods on the two types of rations, which we believe would help to eliminate differences in feed consumption by either group of cows when changed from the more palatable to the less palatable ration.

It was found by analyzing the results of milk production between the high and low producing cows in these experiments that the low producers did not decline as much in milk production as the high producers when fed the whole grain mixture. The high producing group, because the total amount of grain refused was greater in proportion to milk production, naturally showed a greater reduction in milk yield than did the low producing group when on whole grain.

The differences in changes in body weight between the periods of whole and ground grain feeding were wide and inconsistent, especially in the experiments with corn, milo, and barley. These extreme variations between one experiment and another on the same feed indicate that other factors than the difference between whole and ground grain feeding influenced changes in body weights. It can be observed from Tables 11

to 14 inclusive that the results, expressed in therms of energy per one hundred pounds of whole grain, were more uniform when body weight changes were disregarded. Hence it is the opinion of the authors that the energy values calculated when body weight changes were disregarded more nearly represent the actual values of the whole grains. The productive energy value of ground and whole oats were the same. The productive energy value of ground milo was 2.13 therms greater per one hundred pounds than that of whole milo, or 100 pounds of ground milo was equal to 102.55 pounds of whole milo. The productive energy value of ground barley was 5.88 therms greater per one hundred pounds than whole barley, or one hundred pounds of ground barley was equal to 108.0 pounds of whole barley.

Tests were conducted to determine mastication of whole shelled corn and whole threshed milo by dairy cows. The results indicate that there was a wider variation between individual cows in the mastication of grain than there was between the mastication of different grains by the same cow. However, there was a greater percentage of corn than of milo masticated by the cows in these tests, indicating that the smaller grains are more likely to escape mastication than the larger grains. According to the chemical analysis of the grain before and after feeding, as shown in Table 16, the cows obtained very little, if any, energy from the unmasticated grain as it passed through the digestive tracts of the cows.

SUMMARY AND CONCLUSIONS

Experiments were conducted with dairy cows to compare the value of whole versus ground corn, whole versus ground oats, whole versus ground milo, and whole versus ground barley for milk production.

In all experiments there was a greater consumption of concentrates by both groups of cows during the periods they were on ground grains. This difference in consumption was probably due to the fact that the ground grains were more palatable than the whole grains.

Greater milk production was obtained during the periods of ground grain feeding.

When the results of whole versus ground grain feeding were analyzed on the basis of productive energy, considering the results of milk production and feed consumption, it was found that with the exception of barley the greater amount of milk produced during the period of ground grain feeding was probably due to greater consumption of concentrates.

The results of this series of experiments indicate that ground grain when mixed with other concentrates is more palatable than the same grain unground in a similar mixture of concentrates, and in these experiments the cows ate more of the concentrate ration containing the ground grain. This indicates that the greater palatability of the ground grains

has a great influence upon the results of feed consumption and milk production in these experiments.

The analysis of the results of feed consumption and milk production indicate that it is more profitable to grind feed for high producing cows than for low producing cows.

The amount of whole grain masticated by the cows in these experiments was influenced more by the individuality of the cows than by the kind of whole grain fed. However, the cows in these experiments masticated a greater per cent of the whole corn than of the whole milo. Unmasticated grain yielded very little if any energy while passing through the digestive tract of the cows.

LITERATURE CITED

1. Becker, R. B., and Gallup, Willis D.
   1927. Utilization of the Grain in Kafir and Cane Silage by Dairy Cows. Jour. of Agri. Res. 35:3.

2. Cave, H. W., and Fitch, J. B.
   1925. Ground Sargo Seed as a Feed for Dairy Cows. Kans. Agri. Exp. Sta., Circ. 110:8.

3. Fraps, G. S.
   1925. Energy-Production Coefficients of American Feeding Stuffs. Texas Agri. Exp. Sta. Bul. 329.

4. Hayden, C. C., Monroe, C. F., and Perkins, A. E.
   1932. Preparation of Feeds for Dairy Cows. Ohio Agri. Exp. Sta., Bul. 502.

5. Morrow, K. S., and LaMaster, J. P.
   1929. Ground Hay for Milk Production. S. C. Agri. Exp. Sta., Bul. 255.

6. Reed, O. E., and Burnett, J. E.
   1926. Grinding Alfalfa Hay for Dairy Cows. Mich. Agri. Exp. Sta., Bul. Quarterly Bul. 9:3.

7. Wilbur, J. W.
   1933. Grinding Grains for Dairy Cows. Purdue Univ. Agri. Exp. Sta., Bul. 372.

8. Wilson, James W.
   1930. Value of Grinding Grains and Roughage for Livestock. S. Dak. Agri. Exp. Sta., Bul. 252.