UTILIZATION OF MICRONIZED SORGHUM

GRAIN BY DAIRY CALVES

By

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CHAPTER I

INTRODUCTION

Cereal grains provide the major source of protein and calories for the monogastric and ruminant livestock populations. Some great variations in protein content and quality exist among the cereals, but all tend to have an imbalance of the essential amino acids necessary for full protein utilization. There are numerous recent reports that some kinds of processing of cereal grains increase efficiency of utilization. The digestibility of processed grain and the rate of gain in some instances showed great improvement compared to nonprocessed grain. The feeding value of sorghum grain is improved more by some processing methods than is the feeding value of wheat and corn.

Some methods of processing sorghum grain may produce desirable results in different species of animals by improving digestibility, feed efficiency and performance.

Acceptance and utilization of sorghum grain by dairy animals may be enhanced by grinding, steam processing and flaking, micronizing or by pressure cooking followed by proper flaking. These processes appear to render the starch fractions more readily available to enzyme degradation and rumen fermentation than the starch in the raw grain.

Processing sorghum grain by some methods, such as expansion-extrusion, steam processed and flaked, soaked pelleted, reconstituted and popped, has been observed to improve the performance and feed efficiency in fattening steers. Also, acceptance and utilization of sorghum grain by young dairy calves may be enhanced by these processing methods.

CHAPTER II

REVIEW OF LITERATURE

Sorghum grain is widely used as the major component in concentrate mixtures for ruminant animals in the southwest area. It is one of the most commonly produced cereal grains in that area, because of its ability to resist drought and diseases.

Composition and Nutritive Value of Sorghum Grain

Research has been reported in many articles about the value of feeds for animal nutrition. Ross and Wall (1970) and VanSoest (1967), proposed that the digestibility, consumption, and energy value for productive purposes are the three main components of feed nutritional value. Others such as Maynard and Loosli (1956) and Barnes (1973) suggested the percentage of non nutritive constituents of the feed as another quality component. However, all these researchers agree that the important factors influencing the feeding value of grain are its nutrient content and digestibility.

Sorghum Starch

Cereal grains including sorghum are valued for their high content of energy in the form of starch (Rooney and Clark, 1968; Greenwood, 1970). Sorghum grain is particularly rich in starch, containing about 70% nitrogen-free extract, nearly all of which is starch. Starch comprises 83% of the endosperm, 13.4% of germ and 34.6% of the bran obtained by hand dissection of sorghum grain (Hubbard et al., 1950). Different types of starches are found in sorghum and other cereals. A major one is amylose; it is a polymer of glucose units, united exclusively by α-1,4 linkages to give a linear chain and it dissolves with difficulty in water. The other fraction of starch is amylopectin. Amylopectin is more soluble in water, and has in addition to α-1,4 linkages, about 5% of α-1,6 bonds that give a branched or bushy structure (French, 1973).

Crude Protein

Being so rich in starch, sorghum grain is naturally low in protein. Pond et al. (1958) found that sorghum grain protein is among the poorest of the cereal grains in biological value, and its primary amino acid deficiency is in lysine. The correlation between the protein percentage in sorghum grain and lysine percentage in protein was found to be -0.34 by Collins and Pickett (1972). Waggle et al. (1966) confirmed that when fed in isonitrogenous rations, the sorghum protein from low-protein strains promotes growth of chicken and rats faster than that from high protein strains. Deyoe and Shellenberger (1965) found that for chickens tyrosine and phenylalanine also may be deficient in sorghum grain protein.

The availability of different amino acids in sorghum grain is different from one variety to another. Stephenson et al. (1971) found large differences in amino acid composition of sorghum grain lines and even greater differences in amino acid availability for rats and chickens. Collins and Pickett (1972) found out from analyzing sorghum hybrids, that protein varied from 11.3 to 15.3 percent of the grain and lysine varied from 1.3 to 2.0 percent. All these studies suggest that the possibility of improving sorghum grain as a protein source, of course, will depend upon the genetic variation available in different species.

The most promising idea for improving sorghum grain as a source of protein has come from Virupaksha and Sastry (1968), who discovered one sorghum line, 160 Cerum, that had high protein (17.7 percent) and high lysine content (2.1 percent) of the protein. But, this protein lysine relationship was caused by 160 Cerum having a low prolamine and high gluteline content. The protein from this grain is considered to be deficient in lysine when it is compared to the opague-2 oats or corn, both of which have more than 40% lysine availability. Therefore, we can see that there is not a genetic type of sorghum which has the same composition and availability of amino acid of opague-2 corn or oats. The other alternative to improving the sorghum grain protein and its amino acid availability is by mixing it with another rich source of protein like soybean meal or cottonseed meal, or by processing (Ross and Wall, 1970).

Vitamins of Sorghum Grain

Compared to corn, sorghum grain contains approximately the same quantity of riboflavin and pyridoxine, but more pantothenic acid, nicotinic acid and biotin (Tanner et al., 1947; Ross and Wall, 1970). All the varieties of sorghum grain, even those which are yellow in color, are apparently low in Vitamin A, resembling white corn and small grains in this respect. Sorghum grain is deficient in Vitamin D, the same as all other cereal grains (Maynard and Loosli, 1956).

TABLE I

AVERAGE VITAMIN COMPOSITION OF WHOLE SORGHUM GRAIN
AND FRACTIONAL VITAMIN CONTENTS
ug/g

Fraction	Niacin	Pantothenic Acid	Riboflavin	Biotin	Pyridixine	Thiamine	Choline
Whole grain	45.3	10.4	1.3	0.20	4.7	3.3	420.0
Endosperm	43.7	8.7	0.9	0.11	4.0	---	-----
Germ	80.7	32.2	3.9	0.57	7.2	---	-----
Bran	40.0	10.0	4.0	0.35	4.4	---	-----

From Ross and Wall (1970).

Minerals of Sorghum Grain

The level of minerals in sorghum grain and plant parts depends upon a number of variables, such as variety, soil condition, temperature, rainfall and fertilizer.

Wall and Ross (1970) indicated that phosphorus, magnesium, potassium and silicon are the major minerals in sorghum grain with lesser amounts of calcium, phosphorus and sodium also present (Table II). Although sorghum is a good source of phosphorus, most ration formulations will require additional phosphorus even though the ration contains high levels of grain.

TABLE II

MAJOR MINERALS IN SORGHUM GRAIN

Element	Average concentration %
Ci	0.20
Na	0.02
K	0.40
Ca	0.02
Mg	0.18
P	0.49
Total	2.2

From Ross and Wall (1970).

Digestion of Sorghum Grain

The chemical composition of sorghum grain indicates that it has the potential energy of any other cereal grain. However, it is not utilized in as efficient a way as the other grains like barley, corn and wheat. This probably is because the sorghum grain has a dense, hard endosperm and waxy bran cover, which makes it relatively unavailable for rumen bacterial fermentation (Hale _et al_., 1966).

Buchanan-Smith _et al_. (1968) found out that sheep digested more dry rolled sorghum grain than cattle. When cattle are fed high levels of dry rolled grain, many particles of the grain can be found in the feces, however, this is not true with sheep. Saba _et al_. (1964) indicated that the total digestible nutrients for milo and barley where 75.3% and 84.9%, respectively, in the case of beef cattle.

The lower digestibility of the milo nitrogen-free extract (NFE) was apparently due to the lower digestibility of milo starch. With sheep, the digestibility of NFE and gross energy were significantly greater for milo than for barley, this being contrary to the results obtained with cattle. This suggests that digestibility value for sheep and cattle are not intrachangeable for high grain rations (Keating _et al_., 1965). Brown _et al_. (1968) and Totusek _et al_. (1963) have shown that the digestibility of the organic matter and protein of sorghum grain with steers is lower than for barley and corn. Also, they indicated that feed requirements for cattle were lower on a corn ration compared to a sorghum grain ration.

Processing of Sorghum Grain

With modern day fattening rations for beef cattle which may be as much as 60 to 85% concentrate, the grain will supply up to 90% of the usable energy of the ration, so any improvement in the efficiency of utilization of the sorghum grain will be reflected in improved gain and reduced feed requirements.

This improvement of sorghum grain could be achieved by processing, which causes certain physical and chemical changes in the grain that lead to increased digestibility and utilization by ruminant animals.

Shaw et al. (1960) reported that the feeding of pelleted alfalfa hay plus steam flaked corn and linseed meal to Holstein calves resulted in increased gains and reduced feed requirements as compared to a similar corn and linseed meal.

Hale et al. (1966) and Keating et al. (1965) suggested that a moist heat treatment of milo grain improved the digestibility of protein and NFE and decreased the feed requirement. Hale and Theurer (1972) suggested the following methods by which sorghum grain may be processed for ruminant animals: grinding, dry rolled, soaked, steam rolled, pelleted, steam processed and flaked, pressure cooked flaked, reconstitution, early harvested, popped and micronized. The main purpose of all these methods is to increase the efficiency of grain utilization by ruminant animals, increasing their performance with the minimum amount of cost.

The Feeding Value of Processed Sorghum Grain

The unprocessed grain is poorly utilized by cattle, but it seems to be improved by several processing methods. Hale et al. (1966) reported that steam processing and flaking milo increased performance and reduced the feed requirement of fattening steers. Additional studies indicated that utilization of sorghum grain could be improved as much as 15% by steam processing and flaking (Newsom et al., 1968).

White et al. (1969) found that very fine ground milo (1/16 inch screen) is more efficiency utilized by steers than fine (1/8 inch screen) or dry rolled grain.

Bush et al. (1973) found that cows fed coarse ground sorghum grain produced less milk than cows which consumed finely ground sorghum grain. McGinity et al. (1967) proposed that the digestion coefficients for dry matter, organic matter and non-protein organic matter in reconstituted sorghum grain were higher than in dry rolled grain. Gains were highest for cattle fed micronized grain followed closely by those fed flaked, reconstituted and dry ground grains in that order. The NE_{mp} value was highest for steam flaked followed by reconstituted, micronized and ground grain (Richard et al., 1969).

Wagner and Croka (1974) indicated that micronized grain has a higher ME ($P < .01$) and NE_{m+g} ($P < .05$) than dry rolled sorghum grain which suggests that the micronized grain has a small effect on the efficient utilization of energy. There was very little difference in milk yield of cows fed rations containing sorghum grain processed by fine grinding, steam rolling, or micronizing (Bush et al., 1973).

Riggs et al. (1970) reported an increase in nitrogen free extract digestibility when sorghum grain was processed by micronization. They reported no effect on protein digestibility.

Partially popped or 100% popped sorghum grain fed to finishing steers caused reduction in feed intake and increases in efficiency of feed utilization, better than non-heated dry rolled. Also it decreases the rate of gain, dressing percent, carcass grade and fat thickness (Riggs et al., 1970).

Schake et al. (1970) indicated that steam processed flaked was superior to micronized sorghum grain in case of average daily gain and feed intake under commercial feedlot conditions.

Daniel et al. (1972) indicated that expanded extructed sorghum grain for young dairy calves tended to give a higher digestible energy utilization than non-processed sorghum grain. Hale and Theurer (1972) reported that pressure cooking and steam processing and flaking sorghum grain gave similar results when fed to young dairy calves.

Although there were no significant ($P > .05$) effects due to grain processing, the steam processing and flaking of milo and barley tended to improve the weight gains and feed efficiency of dairy calves over the steam rolled grains (Schuh et al., 1970).

Gelatinization and Digestion of the Starch

Proper processing of cereal grains, particularly sorghum and corn, improves the digestibility of starch by ruminants. The rumen is where the greatest increase in starch digestion occurs. The processing technique has some effect on the composition of the grain itself. The starch granules undergo gelatinization or disruption of their internal organization; in other words, gelatinization is defined as a damage to the starch granules by pressure, heat, and moisture. Leach and Schock (1961) suggested that the gelatinization temperature of sorghum starches is from 68^{o} to $76^{o}C$, which causes complete gelatinization to the all granules of the starch. Gelatinization temperature depends on sorghum variety, granule, diameter, density and amount of absorbed substances, Hale (1973). Novellie and Schutte (1961) suggested that the breakdown of starch granules by enzymes is more rapid when the granule is gelatinized.

The change in starch due to gelatinization makes the starch more available either to rumen microorganisms or animal, or both, and this change is responsible for improvements noted with fattening cattle (Trei et al., 1970). Hinman and Johnson (1974) have shown that the degree of gelatinization was greater for the micronized and steam flaked, with small differences between the dry rolled and ground sorghum. The micronized and steam flaked grain were digested by rumen microorganisms at a faster rate than the non-treated sorghum grain. Mudd and Perry (1969), and Salsbury et al. (1961) proposed that the cooking and flaking of maize produced a higher amylase potency in the rumen of sheep, when consumed, than unflaked maize. Ruminal digestion of starch was greater in steers fed reconstituted and steam flaked sorghum grain than in steers fed on ground or micronized sorghum grain (McNeill et al., 1971).

Utilization of Processed Sorghum Grains

It is well known that the amino acid composition of sorghum grain protein is decidedly poor relative to essential amino acids requirements for ruminant tissue and protein synthesis, containing low levels of lysine and high levels of leucine. Therefore, ruminal conversion of grain proteins into microbial proteins of a higher biological value is necessary for maximum tissue utilization of ingested grain protein. Increased biological value through ruminal conversion is achieved by proper processing of sorghum grain (Bressani and Ross, 1962).

Potter et al. (1969) found that reconstituting or steam flaking sorghum brain resulted in enhanced ruminal conversion of sorghum protein to bacterial protein thereby increasing its biological value. However, the micronized sorghum grain resulted in decreased ruminal conversion compared to dry ground grain, so the biological value of the grain protein was decreased by micronizing. The abomosal protein from steers fed reconstituted grain contained more lysine, arginine, valine, methionine, serine and glycine, but less leucine, phenylalanine, glutamic acid, alanine and tyrosine than protein from steers fed dry ground grain. Abomosal protein from steers fed on micronized grain was lower in lysine, threonine, valine, aspartic acid and glycine, but higher in leucine, phenylalanine and glutamic acid, than protein from steers fed on dry ground grain.

Histological studies with reconstituted sorghum grain shown a disorganization of the protein matrix of the endosperm. It may be that certain processing techniques cause marked disruption of the protein matrix, which enhances overall utilization of the grain by animals (Sullins et al., 1971).

VFA Changes Due to Grain Processing

Many workers (e.g., Topps et al., 1968) have indicated that there is an increase in the proportion of propionate acid in the rumen fluid of animals fed high concentrate rations. Moreover, it is clear that rumen VFA levels and proportions are changed with consumption of processed cereal grains.

Phillipson (1952) reported that flaking of corn reduced the ratio of acetate to propionate in the rumen. Total VFA concentration was lower on dry rolled sorghum grain than on micronized -18 and micronized -25 grain. A lower acetate to propionate ratio also was noted on micronized sorghum grain (Hinman and Jhonson, 1974).

In one trial, some depression in milk fat test where micronized grain was fed was consistent with observed changes in proportions of rumen VFA. In particular there was lower acetic acid and increased propionic acid than in rumen fluid of cows fed dry rolled grain (Bush et al., 1973). However, in later work (Bush et al., 1974) a depression in fat test was not observed. Riggs et al. (1970) found that acetic and isovaleric acids were significantly higher but propionic acid was less in rumensamples from cattle fed dry rolled milo as compared with popped milo.

Micronizing cereal grains for ruminant animals has received considerable attention in recent years, especially from the management point of view. However, reports of the nutritive value of micronized rations have indicated possible advantages under certain conditions. Previous studies at Oklahoma State University and other places had shown that the dry heat treatment, micronization, tended to increase the digestibility of dry matter and starch, resulting in higher energy value, thereby improving the utilization of grain sorghum by finishing beef cattle (Croka, 1974).

The objectives of this study were to compare the effects of sorghum grain processed by micronization versus dry rolled sorghum grain. The criteria of evaluation were comparative digestibilities of nutrients and growth of dairy calves.

CHAPTER III

MATERIALS AND METHODS

Trial I

Forty-two dairy heifers (18 Ayrshires and 24 Holsteins) at eight weeks of age were used in this trial. Starting when the calves were three days of age they were fed a calf started ration which consisted of a mixture of cereals such as corn and sorghum grain plus soybean meal, alfalfa hay and other required minerals. In addition, each calf was fed whole milk at the rate of 8% of body weight. They were weaned at six weeks of age onto the calf starter ration mentioned above.

Heifers within each breed were assigned at random to three experimental treatments as follows: (a) control (dry rolled), (b) micronized (380 g/ℓ) and (c) micronized (230 g/ℓ). A feed mixture having 60% sorgum grain comprised the entire ration for the heifers. Sufficient soybean meal was included to give a ration with approximately 14% total protein content. Ground alfalfa hay was used at a 15% level to provide bulk, prevent an excessive increase in rumen acidity, and to promote development of the desired rumen microbial population (Table II).

TABLE II

INGREDIENT COMPOSITION OF THE RATION

Ingredient	Percent
Sorghum grain	60.0
Soybean meal (44%)	16.0
Alfalfa ground	15.0
Liquid molasses	7.5
Dicalcium phosphate	1.0
Salt	0.5

Ration Preparation

Dry rolled grain was prepared by cleaning the whole grain and then passing it through a set of rollers set to crack all the kernels. The micronized grain was prepared after cleaning by vibrating the sorghum grain on a slopping metal plate under gas-fired infra-red heaters, and then passing it through rollers under pressure to produce a minimum micronized (380 g/ℓ) and a maximum micronized (230 g/ℓ) product.

The only difference in preparation on techniques between the dry rolled ration and the two micronized rations was the treatment with heat.

Management and Feeding System

Each heifer was kept in an individual pen and bedded on sawdust. The feed was provided twice a day, once in the morning and once in the afternoon. Water was available in each pen all the time.

Feed consumption was recorded every day and feed weighbacks were taken every week. The feed weighbacks of all calves were very low most of the time. The heifers were weighed one day prior to and on the beginning day of the experiment. These two weights were averaged. Weights were recorded throughout the experiment on Friday of each week until the final week when they were taken on Thursday and Friday, and the averages calculated. During the fourth week of the trial, five hours after the morning feeding and shortly before the afternoon feeding, rumen liquor was drawn by stomach tube from the rumen of each heifer. Then, samples were strained through cheesecloth and 2 ml of saturated mercuric chloride was added per about 200 ml of rumen fluid to stop microbial action. The VFA were separated by gas chromatography by using the method of Erwin, Macro and Emery (1961).

With few exceptions, feed samples were taken on Friday of each week for chemical analysis. One of the Ayrshire heifers which was fed on dry rolled grain got sick and was excluded from the experiment. For statistical analyses, the missing values were estimated by using the missing data technique from Snedecor and Cochran (1967).

Trial II

Nine dairy steers (6 Holsteins and 3 Ayrshires) with uniform weights and ages from 4 to 6 weeks (Table III) were used in this trial to determine digestibility of the three rations which were used in the previous heifer experiment. A 3 x 3 Latin Square design was used. Animals were placed on the rations one week before the experiment and were fed *ad libitum* in order to determine the feed intake for each calf. Later, each steer was randomly assigned to one of the three rations mentioned in the previous trial. The intake was restricted to 1.5 times the maintenance requirement for fifteen days. Feces samples were collected during the last five days of this period. This was followed by a seven day adjustment period before beginning the next sequence of the experiment. The same design was followed for the third period.

Feed allowances for the young steers were carefully calculated according to size of the calf using the NRC digestible energy system for growing steers.

Digestible energy of the ration was calculated to be about 1.5 MCal DE/kg. For example, the daily feed allowance for a calf weighing 73.6 kg was 1.86 kg/day of the appropriate ration (Table IV).

The bulls were kept in separate pens and provided with water all the time. The feeding system was two times per day, once in the morning and once in the afternoon. Feces were collected by using sheep harnesses during each of the three five-day collection periods for each calf. Careful consideration was given to the collection to make sure to collect all the feces from each calf. Feces were weighed and sampled. Samples were then dried at about 75°C for two days, then ground through a 2mm screen in a Wiley Mill. Then, the samples were stored in glass containers for later analysis.

Feed samples were collected almost every week throughout the experiment for chemical analyses. Feed and feces starch were determined as α-linked glucose polymers by the procedure of Macrae and Armstrong (1968). Feed and feces crude protein were determined by Kjeldhal procedures. Dry matter analysis was by drying the samples in an oven for 24 hours at 105°C. Ash was determined by igniting the samples in an

TABLE IV

FEED ALLOWANCES FOR 9 DAIRY CALVES DURING THE FIRST PERIOD OF THE DIGESTIBILITY TRIAL

Wt. of Calves (kg)	Maintenance requirement (MCal)	1.5 Maintenance requirement (MCal)	Feed allowance (kg)
73.6	3.68	5.52	1.86
68.2	3.41	5.11	1.73
61.8	3.09	4.63	1.59
69.5	3.47	5.20	1.77
57.7	2.88	4.32	1.45
59.1	2.95	4.42	1.49
86.2	4.31	6.46	2.17
95.3	4.76	7.14	2.40
74.8	3.74	5.61	1.91

ashing oven for 12 hours at 600°C.

Statistical analyses of data were determined according to procedures outlined by Snedecor and Cochran (1967).

One of the Ayrshire steers died after he finished the second period of collection. Values for the third period of collection were estimated by using the missing data formula according to Snedecor and Cochran (1967).

CHAPTER IV

RESULTS AND DISCUSSION

Trial I

Feed Intake and Growth Data

Neither of the micronized treatments had any significant effect ($P > .05$) on feed intake, average weight gain, or feed efficiency (kg feed/kg gain) as compared to the dry rolled sorghum grain (Table V).

The average weight gain was 46.9, 46.0 and 43.6 for heifers fed dry rolled, minimum micronized (380 g/ℓ) and maximum micronized (230 g/ℓ) sorghum grain, respectively. As noted, the micronized rations did not have any significant effect ($P > .05$) on average weight gain as compared to dry rolled ration. Also there was not any significant difference ($P > .05$) between the two micronized rations. Similar results were reported by Riggs *et al.* (1970), Schake *et al.* (1970), and Croka (1974), for cattle fed on dry heated sorghum grain. The average feed consumption during the whole trial was highest in the group of heifers fed the dry rolled grain ration, i.e., 164.7 compared to 149.9 and 142.3 kg for heifers fed on micronized (380 g/ℓ), and micronized (230 g/ℓ), respectively. Differences among these values approached significance ($P < .09$).

Although these were no significant differences ($P > 0.05$), feed efficiency favored the micronized treatment over the dry rolled treat-

TABLE V

WEIGHT GAIN, FEED CONSUMPTION AND FEED EFFICIENCY OF HEIFER CALVES

Item	Dry rolled	M(380 g/ℓ)	M(230 g/ℓ)	S.E.[a]
<u>All Calves</u>				
No. of Heifers	13	14	14	
Weight gain kg	46.9	46.0	43.6	1.15
Feed intake kg	164.7	149.9	142.3	3.58
Feed efficiency, kg	3.5	3.2	3.3	0.01
<u>Holsteins</u>:				
No. of Heifers	8	8	8	
Weight gain, kg	49.1	51.8	44.2	2.01
Feed intake, kg	174.8	169.4	141.7	4.11
Feed efficiency, kg	3.6	3.3	3.2	0.01
<u>Ayrshires</u>:				
No. of Heifers	5	6	6	
Weight gain, kg	42.5	38.2	41.7	1.41
Feed intake, kg	148.6	123.9	143.3	3.97
Feed efficiency, kg	3.5	3.2	3.4	0.02

a = standard error.

ment (i.e., 3.2 and 3.3 vs. 3.5, respectively). There was only a small difference between the micronized treatments, i.e., 3.2 and 3.3 kg for micronized (380 g/ℓ) and micronized (230 g/ℓ), respectively. Croka (1974) reported similar results with large steers fed micronized and dry rolled sorghum grain, thus indicating that age might not be a variable factor in utilization of micronized grain rations.

Hinman (1973) and Riggs et al. (1970) noted an increase in digestion of starch in micronized sorghum grain. This may be a factor for improvement of feed efficiency.

Intake of all three rations increased by nearly regular increments during the whole trial, as shown in Figure 1. Feed intake of calves within each ration group varied considerably. An example of this may be shown by two calves fed the dry rolled ration. One of these calves consumed 28.6 kg whereas another consumed only 16.9 kg during the fifth week of the trial. These differences may be attributed to a multiple number of factors. Considered may be differnces in appetite due to health, management and environmental differences.

During the first four weeks of the trial there was a consistent increase in weight gain. This was attributed to progressive rumen development and fill. Wide fluctuation occurred after the first four weeks (Figure 2). Presumably, larger rumen capacity at this stage allowed a large amount of variation in water and feed. Weights taken without a prior period of feed and water withdrawal tended to fluctuate widely. In future trials, some effort to eliminate variation in weights due to body fill and use of a longer feeding period should be considered.

The average weight gain of the heifers on each ration was deter-

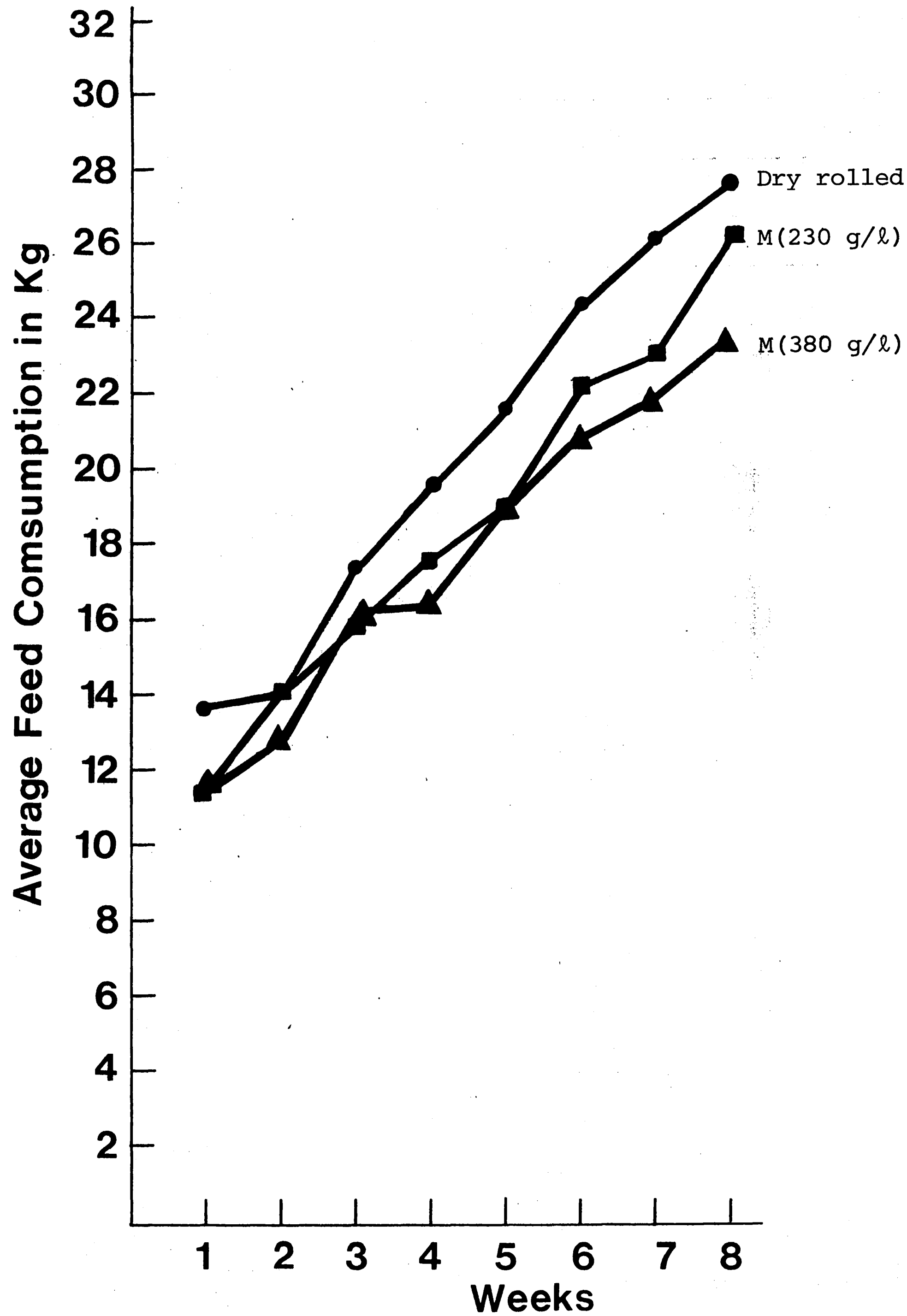

Figure 1. Average Feed Consumption on Dry Rolled, M(380 g/ℓ) and M(230 g/ℓ) Rations

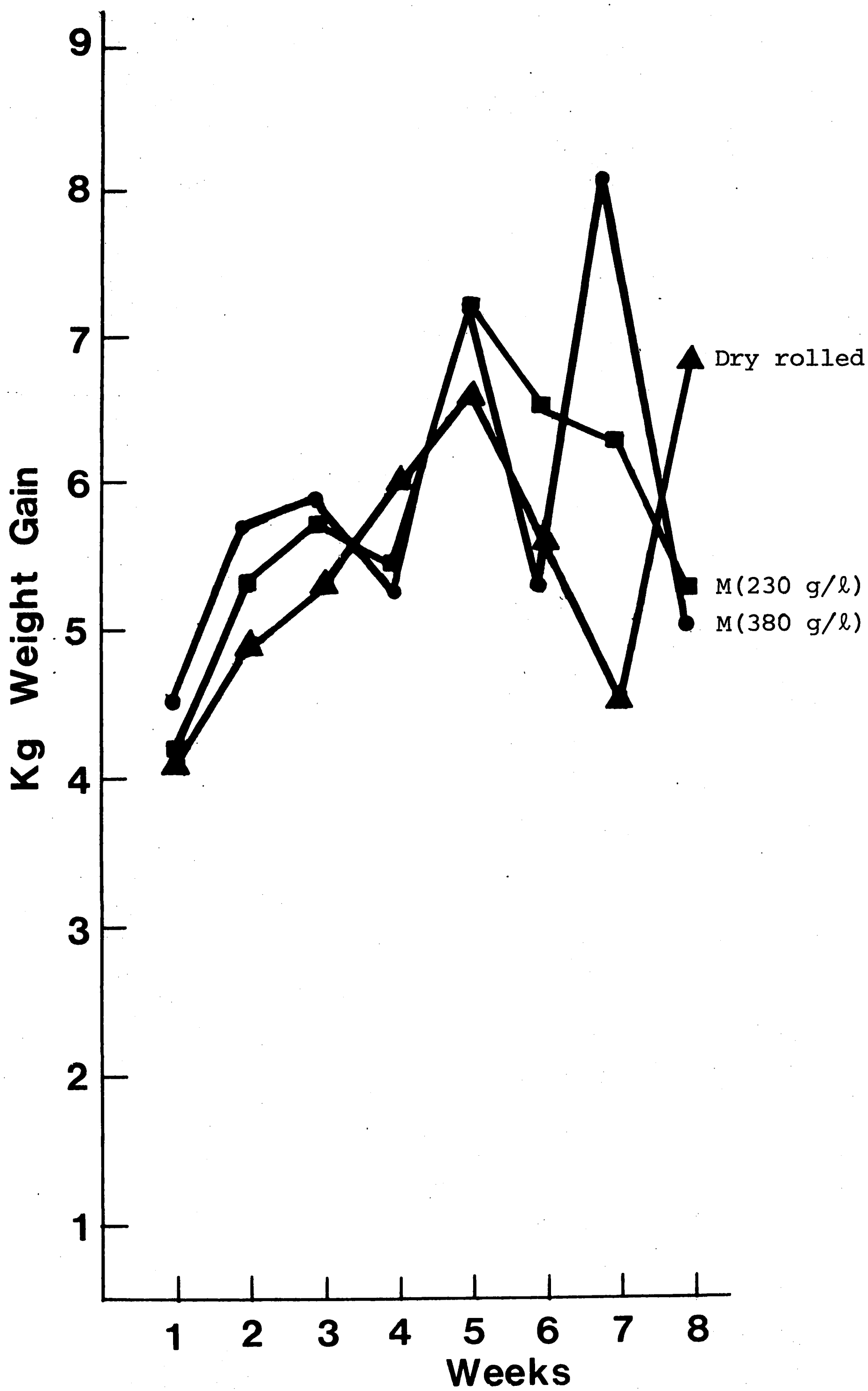

Figure 2. Average Weight Gain of Calves Fed on Dry Rolled M(380 g/ℓ), and M(230 g/ℓ) Rations

mined by two methods. One method was by the difference between the individual initial average weight and the final average weight of each heifer on each ration. The disadvantage of this method was that accurate estimation of weight gain in ruminant animals is complicated by variability in rumen fill. The second method used simple regression analysis in order to minimize the effect of rumen fill on the average weight gain. Thus, a regression coefficient was determined for each calf using weight of the calf as dependent variable and weeks of trial as an independent variable. Then, the difference in beginning and ending weight determined by this procedure was taken as the weight change for each calf. This method was similar to what Bath et al. (1966) reported. A more accurate estimation of tissue gain in dairy cows was obtained by using the simple regression analysis.

The average weight gain of the Holstein breed of 48.5 kg was higher than that of the Ayrshire breed at 40.4 kg (Table VI). The difference between these two was statistically significant ($P < 0.01$). The feed consumption was 161.9 kg and 138.0 kg for the Holsteins and Ayrshires, respectively (Figure 3). The difference in feed consumption between the two breeds was statistically significant ($P < .05$). The difference in feed efficiency between the two breeds approached statistical significance ($P < 0.1$), thus indicating that Holstein heifers utilized sorghum grain more efficiently than Ayrshire heifers.

There was variation in feed consumption within each breed on each ration, and it was greater in the Holsteins than the Ayrshires. This caused a great variation in the average weight gain within each breed on each ration. There was not any significant interaction ($P > .05$) between breeds and treatments.

TABLE VI

WEIGHT GAIN, FEED CONSUMPTION AND FEED EFFICIENCY BY BREEDS

Item	Holstein	Ayrshire	S.E.[a]
No. of animals	24	18	
Weight gain, kg	48.5[b]	40.4	1.15
Feed intake, kg	161.6[c]	138.0	3.58
Feed efficiency	3.3	3.4	0.06

a = Standard error.

b = $P < .01$

c = $P < .05$

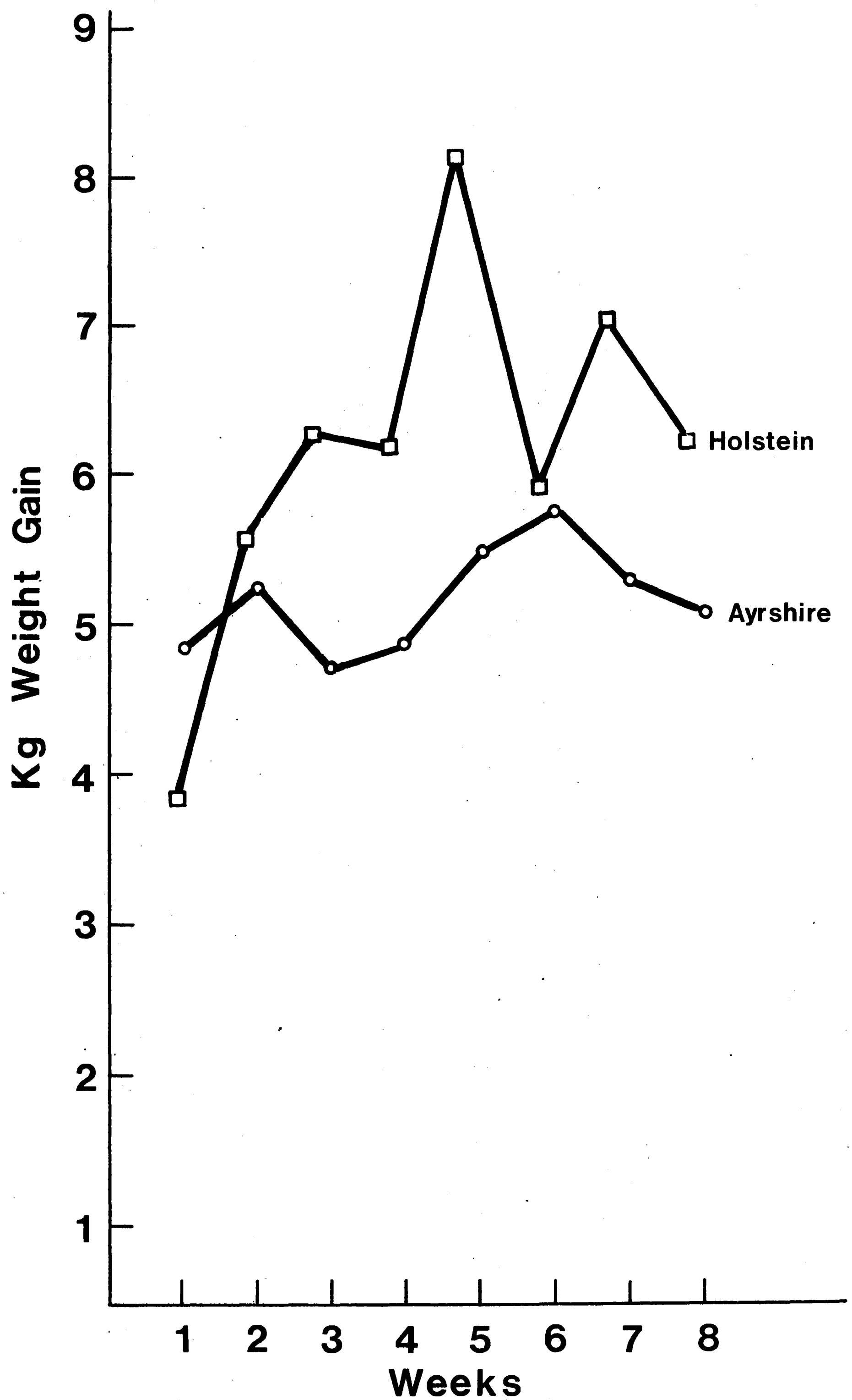

Figure 3. Average Weight Gain of Heifers by Breeds (8-16 Weeks of Age)

Rumen Molar Percentage of VFA

No significant differences (P > .05) were found in total valatile fatty acid concentration in rumen fluid of heifers fed on dry rolled or micronized grain rations (Table VII). There were no significant differences between concentration of VFA in the rumen fluid of heifers fed on sorghum grain micronized to two different degrees. There was a non significant (P > 0.05) decrease in acetic and isovaleric acids on both micronized treatments, and an increase in propionic acid in rumen fluid of heifers fed on micronized grain. These results agreed with what Croka and Wagner (1973) and Riggs *et al*. (1970) indicated. These researchers noted decreased acetic and increased propionic acid levels in cattle fed on micronized sorghum grain. This means that the rations fed to the calves in this trial produced results similar to those which other researchers have reported.

Trial II

There were some differences in chemical composition of both micronized grain rations as compared to dry rolled sorghum grain ration (Table VIII). These differences are probably due to some variable factor or factors like, treatment with heat, handling, and sampling method where the small particle size ingredients tended to separate from the grain portion of the mixture. The use of standard deviation in (Table VIII) is to describe the variation among individual samples of each ration.

Processing of sorghum grain by micronization had no significant effect (P > .05) on ration digestibility (Table IX).

The dry matter digestibility was slightly, but not significantly, higher for the micronized (380 g/ℓ) and micronized (230 g/ℓ) than for

TABLE VII

MOLAR PERCENTAGE OF RUMEN VFA

Acid	Ration: Dry rolled	Ration: M(380 g/ℓ)	Ration: M(230 g/ℓ)	S.E.[a]
	Molar %			
Acetic	45.8	45.6	45.1	1.70
Propionic	30.4	35.9	30.8	2.11
Isobutyric	3.5	1.6	2.1	0.55
Butyric	10.4	9.6	10.9	1.21
Isovaleric	3.5	2.7	2.9	0.69
Valeric	8.8	6.4	6.7	1.23

a = Standard error.

TABLE VIII

CHEMICAL ANALYSIS OF RATION (% D.M. BASIS)[a]

Item	Dry rolled	M(380 g/ℓ)	M(230 g/ℓ)
Crude protein	20.4 ± 1.48[b]	19.0 ± 1.99	19.7 ± 1.56
Organic matter	91.8 ± 1.08	91.6 ± 2.08	92.2 ± 1.22
Starch	35.5 ± 4.08	31.2 ± 4.99	33.4 ± 2.51

[a]Each value represents the average of eight samples of each ration.

[b]S.D.

TABLE IX

APPARENT DIGESTIBILITY OF RATION COMPONENTS

Components	Control	M(230 g/ℓ)	M(380 g/ℓ)	S.E.
	%			
Dry matter	79.9	83.0	82.9	0.45
Crude protein	80.7	80.7	82.0	0.44
Organic matter	80.2	83.2	83.4	0.43
Starch	98.6	99.0	98.6	0.22

the dry rolled sorghum grain. The dry rolled ration had 79.9% DM digestibility compared with 82.9% and 83.0% for micronized (380 g/ℓ) and micronized (230 g/ℓ), respectively. This agreed with what Riggs et al. (1970) reported. Their cattle fed the dry heat treated grains showed significantly higher digestibility of dry matter as compared to the cattle fed on non-heated grain.

Protein digestibility was 80.7%, 80.8% and 82.0% for dry rolled, micronized (380 g/ℓ) and micronized (230 g/ℓ), respectively. This suggested that the dry heat treatment, micronization, did not produce a sufficient protein denaturation to depress protein digestibility. Potter et al. (1970) reported some depression in rumen conversion of sorghum protein to microbial protein with micronized sorghum grain, but there was not any change in total protein digestion. The digestibility of organic matter was 80.2%, 83.4% and 83.2% for dry rolled, micronized (380 g/ℓ) and micronized (230 g/ℓ), respectively. This shows both micronized rations had higher values than dry rolled ration, but not significant degree ($P > .05$).

Riggs et al. (1970) reported an increase in digestibility of some popped grain fractions, e.g., organic matter, might be due to slightly lower feed intake. However, Bush et al. (1973) and Croka (1974) did not mention any depression of feed intake on micronized rations. Moreover, Reid and Tyrrell (1964) has presented an extensive amount of data supporting the concept that level of intake of many rations has no bearing on the extent of ration digestibility.

About 98.6% of starch of the dry rolled milo ration was digested compared to 98.6% and 99.0% for micronized (380 g/ℓ) and micronized (230 g/ℓ), respectively. This slightly, but not significantly, higher for micronized rations than for the dry rolled. Hinman and Johnson (1973) suggested that a dry rolled milo ration was significantly ($P < 0.05$) lower in starch digestion than a micronized grain ration.

It is noticeable here that starch digestibility is slightly high in all three rations but this is not unusual in case of these types of rations. The results from the digestibility trial agreed with the results of the growth data in case of the dry rolled sorghum grain ration, which indicated that although the heifers fed on dry rolled ration consumed more feed than those fed on micronized rations, they did not utilize it as much as the others.

In general, the micronized sorghum grain had slightly, but not significantly, higher digestion values in case of protein, organic matter, starch and dry matter than the dry rolled grain. This agreed with the improvement in feed efficiency (kg feed/kg gain) noted in the heifer trial. This also agreed with Wagner and Croka (1974) and Riggs et al. (1970) who reported increased dry matter digestibility on micronized sorghum grain. And, increased starch digestibility of micronized sorghum grain was reported by Hale (1973) and Johnson and Hinman (1973).

The use of sheep harnesses as a method to collect feces from young dairy calves has some disadvantages. The sheep harnesses were too small as the calves became larger. Calves appeared to be in obvious discomfort because they always tried to take the harnesses off, so they needed to be watched consistently. In addition to these things, the harnesses must be kept clean and dry all the time. Volcani et al. (1973) suggested that the use of liquid paraffin as a digestibility indicator in young calves gives more precise results in determining digestibility coefficients than the use of chromium oxide as an indicator or total collection with sheep harnesses.

CHAPTER V

SUMMARY AND CONCLUSIONS

The objectives of this study were to compare the feeding value of sorghum grain processed by different degrees of micronization with dry rolled sorghum grain. The criteria of evaluation were comparative digestibilities of nutrients and growth of dairy calves. Forty-two heifers (18 Ayrshires and 24 Holsteins) at eight weeks of age were used to compare the utilization of dry rolled and micronized sorghum grain. Calves within each breed were randomized to three groups as follows: a) control (dry rolled), b) micronized (230 g/ℓ) and c) micronized (380 g/ℓ). During an eight-week period, feed intake and body weights were recorded weekly. Rumen samples for VFA determination were taken 4-5 hours after feeding during the fourth week of the experiment.

Nine bull calves (6 Holsteins and 3 Ayrshires) were used in a 3 X 3 Latin square design to determine the digestibility of the rations used in the heifer trial. The feed intake of each calf was restricted to 150% of his maintenance requirement for ten days. Feces were collected for the next five days followed by a ten-day adjustment period before beginning the next sequence of the experiment.

The average weight gain was 46.9, 46.0 and 43.2 for heifers fed dry rolled, micronized (380 g/ℓ) and micronized (230 g/ℓ) sorghum grain, respectively. Average feed consumption was 164.7, 149.9 and 142.3 for heifers fed on dry rolled, micronized (380 g/ℓ) and micronized (230 g/ℓ), respectively.

Feed efficiency (feed/gain) was 3.5, 3.2 and 3.3 for dry rolled, micronized (380 g/ℓ) and micronized (230 g/ℓ), respectively. No significant differences among rations were observed in digestibility of dry matter, crude protein, starch, and organic matter. No differences were detected among ration treatments with respect to propionic acid, acetic acid, butric acid and the other VFA. Method of processing had no significant effect on production of rumen VFA, nutrient digestibility, or growth by dairy calves from 8 to 16 weeks of age. However, there was a trend toward more efficient feed utilization and digestibility by calves fed micronization grain. Micronized grain was accepted as readily by dairy calves as was dry rolled sorghum grain.

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