probably observed because all cattle were fed an equal time on feed, with most rapid gains being obtained on the SFW treatments. No other significant differences in carcass merit were observed between treatments.

Influence of Grain Processing on Development of Subclinical Acidosis in Beef Cattle

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Story in Brief

When high concentrate rations are fed to beef cattle they are fermented rapidly with a concomitant rapid depression in rumen pH and occasionally an abnormal rumen lactic acid production. Following unusual over consumption these processes may result in a subclinical acidosis which could affect subsequent levels of feed consumption as well as general health of the animals. The three trials reported here were designed to evaluate the effects of grain processing on these rumen processes.

When the sorghum portion (84 percent) of a beef cattle ration was micronized, the depression in rumen pH following feeding was greater than following feeding of dry rolled sorghum. Lactic acid production peaked between 1 to 2 hrs. after feeding and was greater when micronized sorghum was fed. Lactic acid production was greater as the degree of micronizing was increased, the latter being indicated by decreasing bushel weights (32 to 18 lb/bu.). Depression in pH was not influenced, however.

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In trial 2, corn was fed in similar rations except the corn was either whole shelled (WSC), ground (GC), steamed flaked (SFC) or high moisture stored corn (HMC). On the test days, 150 percent of the normal half day feed was fed to simulate over consumption. The depression in pH was less with WSC than the other forms but was also more prolonged. GC, SFC and HMC feeding depressed the pH to the same level but recovery of initial pH was slowest with SFC. Lactic acid levels produced were not high but were greatest and most prolonged with SFC.

In trial 3, the same processed corns were used but were fed at both 150 and 200 percent levels. Again, pH depressions were much less with WSC than with the other forms of corn. Recovery of pH was very slow when SFC was fed, especially at the 200 percent level. Lactic acid levels produced were very high at both 150 and 200 percent levels of feeding but reached critical acidosis levels over 100 millimole per liter at the high feeding rate. Lactic acid levels were 2 to 7 times greater with the processed corns than with WSC. The levels attained at the low level of feeding were similar for GC, SFC and HMC but at the high level of feeding the highest peak lactic acid level (1 hr after feeding) was with HMC. After feeding SFC, lactic acid peaked at 4 hr. after feeding and was prolonged considerably more than with other forms.

These results show that beef cattle will certainly be more predisposed to acidosis conditions if the grain is processed. However, animals would need to eat at least 150 percent of a normal half days feed at one time to precipitate anything close to a clinical problem. A 200 percent level of feeding routinely produced dangerously high lactic acid levels in the rumen.

Introduction

Over the past two decades the level of concentrates in beef cattle finishing rations has been increased to between 85 and 100 percent to maximize gains and efficiency. In addition, numerous processing and storage techniques have been developed to increase the digestibility and utilization of the grain portion of these rations. While these changes increase rates of gain and improve feed efficiency, they also dispose the ruminant animal to digestive disturbances that manifest themselves in many ways. Acute clinical acidosis, for example, results when animals engorge themselves on such rations. These occurrences are only occasional in the feedlot but may result in serious illness or death.

In contrast, large numbers of animals may overeat to a lesser degree as a result of environmental influences, bad bunk management and other causes. Although the results of these circumstances are not always obvious

in the form of clinical signs, it is believed that they may be associated with other serious problems such as poor consumption of subsequent feeds, chronic rumen and liver lesions, and predisposition to other diseases. We classify these under the term "sub-clinical acidosis".

Subclinical acidosis is characterized by marked depression in rumen pH and moderate increases in rumen lactic acid production. It can be produced by over consumption of any high concentrate ration. However, since most processed grains are fermented more rapidly, the tendency is probably greater with these feedstuffs. The objectives of this study were to investigate the effects of grain processing on the indicators of rumen acidosis, i.e., rumen pH and lactic acid levels and to develop means to control these factors by dietary manipulation. Only the first phase is being reported here.

Materials and Methods

Three trials were conducted using essentially the same experimental design, the variations being primarily in the type of grain used and the level of feed. The ration utilized in all trials (Table 1) was 84 percent grain component, 6 percent protein and mineral supplement and 10 percent roughage (cottonseed hulls). Four rations were used in each of the three trials and fed to four rumen fistulated steers in a Latin square design. Four Hereford steers were used in trials 1 and 2 and four Holstein steers in trial 3.

During each of the four periods in each trial two sampling periods were conducted. The animals were fed twice a day and were trained to eat the offered feed in a short period of time by removing the feed after 30 minutes of exposure. On the day previous to a test day they were fed only 50 percent of a half-day feed in the p.m. feeding and then were fed either 100, 150 or 200 percent of a half-day feed on the following morn-

Table 1. Composition of Rations Used in Trials 1, 2 and 3.

Ingredient	%, as is basis
Grain component	84.0
Cottonseed hulls	7.0
Dehydrated alfalfa meal	3.0
Soybean meal	4.0
Urea	0.7
Salt, trace mineralized	0.5
Dicalcium phosphate	0.4
Calcium carbonate	0.4
Aurofac-50	225 g per ton
Vitamin A, (30,000 I.U./gm)	200 g per ton

ing. If they had not consumed all the feed in 30 minutes the remainder was poured directly into the rumen. These procedures were used to assure comparable consumption of all feeds and to have a concise starting time for rumen sampling. No additional feed was given until the termination of the test.

Samples of rumen contents were taken prior to the morning feed and at 0.5, 1, 2, 4 and 8 hrs. after feeding in trial 1 and at 1, 2, 4, 8, 12 and 24 hours after feeding in trials 2 and 3. The pH was determined immediately after withdrawing the sample. The sample was then squeezed through cheesecloth and an aliquot of the rumen liquor was frozen for subsequent analysis for lactic acid and volatile fatty acids. Only the pH and lactic acid data will be reported here.

Results and Discussion

When fed at the 100 percent level, all steers readily ate the total amounts of rations offered. When fed at 150 and 200 percent levels, animals occasionally did not consume all the ration, especially at the high level. Several occurrences of "off feed" were encountered in trials 2 and 3 (150 and 200 percent levels). The data collected on those days were discarded and the trial was repeated at a later date.

Trial 1.

In this trial the grain component consisted of either dry rolled sorghum or one of three micronized sorghums. The micronizing process was controlled to produce products with three bushel weights, namely, 32, 25 and 18 lb. per bushel. Previous studies with these products had shown that the degree of gelatinization of the starch, the *in vitro* digestibility of the grain and the gas production from the grain was inversely proportional to the bushel weight, or, in effect, directly proportional to the "degree" of micronizing. All rations were fed at the 100 percent level which averaged 8 lb. for the half-day feed.

Figure 1 illustrates the depression in pH following feeding. The pH was depressed considerably more when the micronized sorghum rations were fed than when the dry rolled form was fed. The difference at 1 and 2 hours post-feeding was sizeable, approximating 0.5 pH units. However, there were no differences between the degrees of micronizing.

Lactic acid levels determined at the same time are illustrated in Figure 2. All micronized grain rations produced higher lactic acid levels at 0.5, 1 and 2 hrs. post-feeding compared to the dry rolled control. Lactic acid peaked between 1 and 2 hrs. Furthermore, lactic acid levels were increased with each incremental decrease in bushel weight, agreeing with previous conclusions that the rates of fermentation were increased by

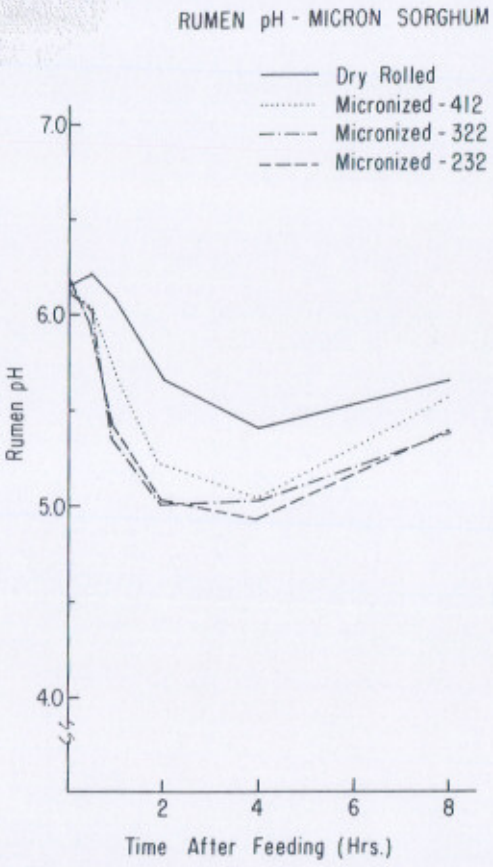

Figure 1. Changes in rumen pH after feeding rations containing dry rolled and micronized sorghums (Trial 1).

greater degree of micronizing. Although the levels of lactic acid were increased dramatically in this study to abnormal levels, they are still far from the levels characteristic of clinical acidosis which would be in the region of 100 mM per liter. Lactic acid returned to normal levels in all animals by 4 hrs. post-feeding.

Trial 2.

Corn provided the grain component in trial 2 and was fed as whole shelled (WSC), ground (GC), steam flaked (SFC), and high moisture corn (HMC). The WSC and GC were obtained from the O.S.U. feed

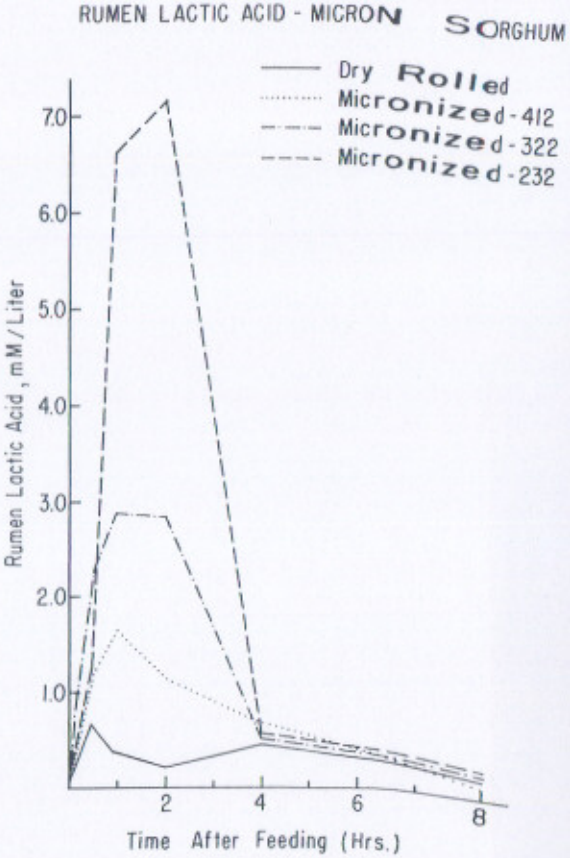

Figure 2. Changes in rumen lactic acid levels after feeding rations c taining dry rolled and micronized sorghums (Trial 1).

mill, the SFC through the courtesy of Texas County Feedlot, and tl HMC through the courtesy of the Hitch Feedlot, both of Guymon, Okl The 150 percent level of feeding was utilized.

Figure 3 illustrates the rumen pH levels observed in trial 2. The d pression in pH was greatest for the three processed forms of corn wit the lowest level at 4 hrs. After 4 hours the pH returned rapidly to norma levels with GC and HMC but much more slowly with SFC. When WSC was fed, the pH depression was much less but prolonged between 5.6 anc 5.7 for a considerable time. This indication of a more prolonged fermen tation with WSC agrees with earlier feedlot observations that acidosis was much less frequent with WSC.

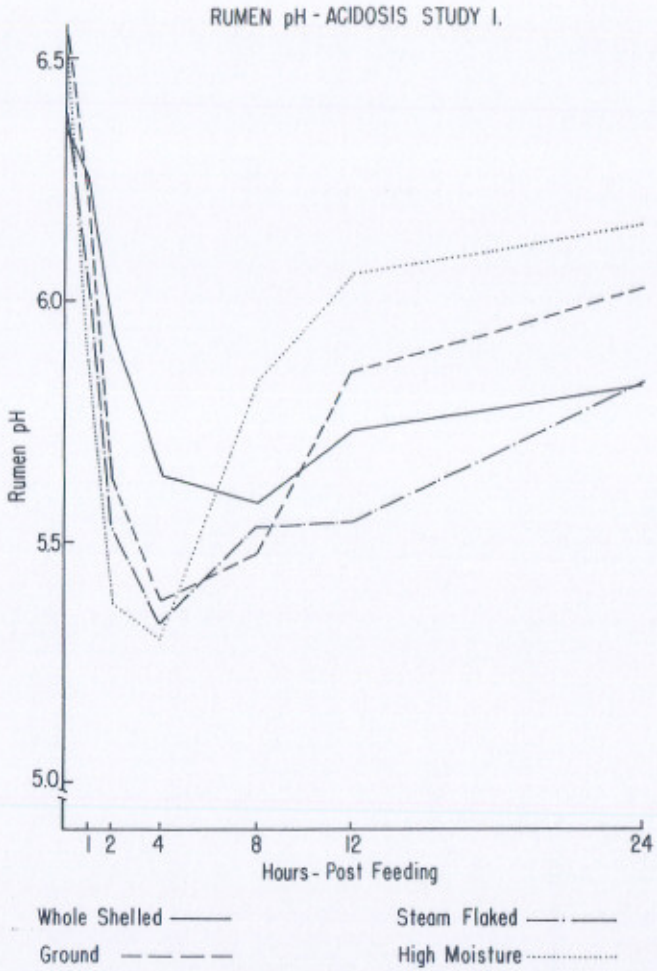

Figure 3. Changes in rumen pH after feeding rations containing whole shelled, ground, steam flaked or high moisture corn at the 150% level (Trial 2).

The lactic acid data shown in Figure 4 indicates that acid production was low with WSC, GC and HMC but somewhat greater with SFC. No explanation can be offered as to why the level continued to increase throughout the 24 hour period with SFC but, again, the levels are not in the acute range.

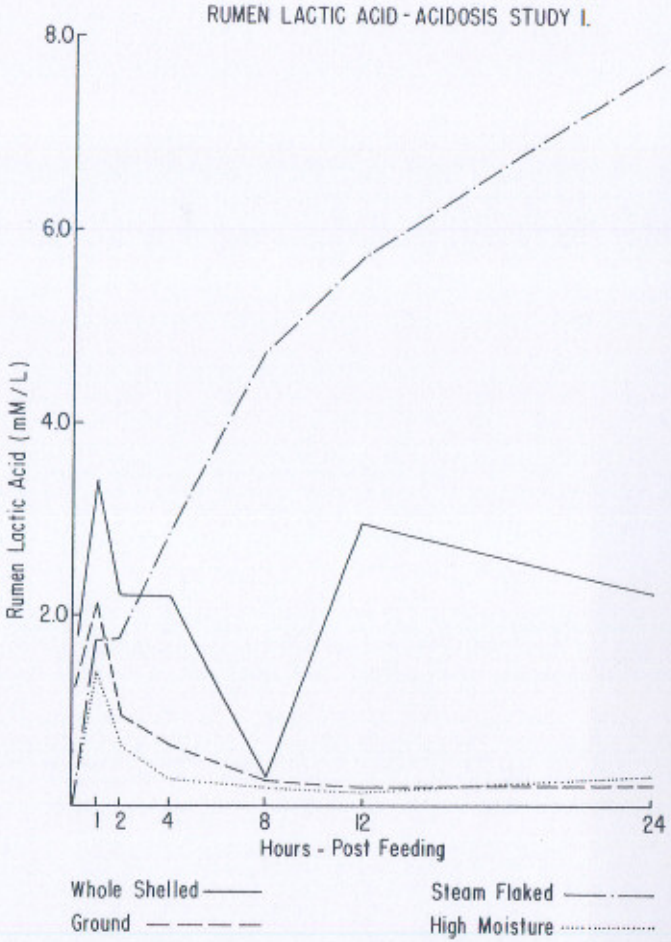

Figure 4. Changes in rumen lactic acid levels after feeding rations containing whole shelled, ground, steam flaked or high moisture corn at the 150% level (Trial 2).

Trial 3.

Trial 3 involved use of the same corn treatments as used in trial 2. However, Holstein steers were used. In addition, during each phase of the test 150 percent was fed on the first test day and 200 percent of a half-day feed on the second test day.

The pH data illustrated in Figure 5 confirm the findings in trial 2. Depressions in pH were much more marked with GC, SFC and HMC

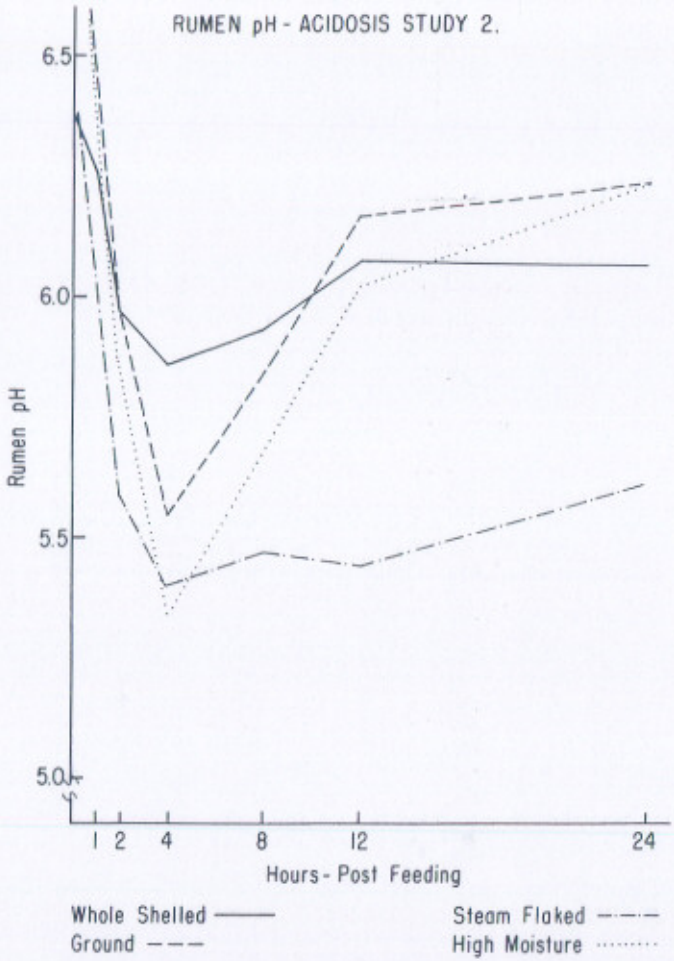

Figure 5. Changes in rumen pH after feeding rations containing whole shelled, ground, steam flaked or high moisture corn. Data are the averages of the 150 and 200% level of feeding (Trial 3).

than with WSC. The depression with SFC was prolonged below 5.5 for over 12 hours while it returned to levels above 6.0 with other forms of corn. Data presented in Figure 5 are averages of the 150 and 200 percent levels of feeding and a partial clarification can be seen in Figure 6 where the two are separated. With GC and even more with SFC, the pH changes were more dramatic at the 200 percent feeding level than at the 150 percent level.

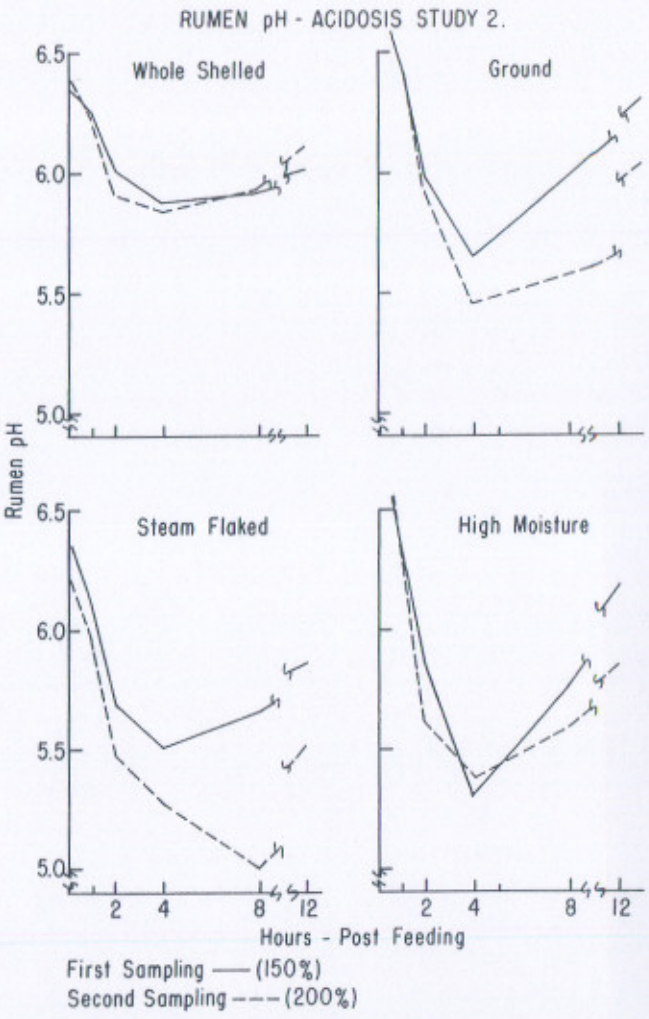

Figure 6. Comparison of rumen pH changes when corn rations in trial 3 were fed at the 150 and 200% levels.

Lactic acid levels observed at the two levels of feeding are shown in Figure 7. It should be noted first that the levels observed in this trial were considerably higher than those observed in earlier trials. In fact, they reached levels over 100 mM/liter at the 200 percent feeding level which is in the range observed in animals with clinical acidosis. Although this acute condition was not observed in this study, the animals were off feed numerous times.

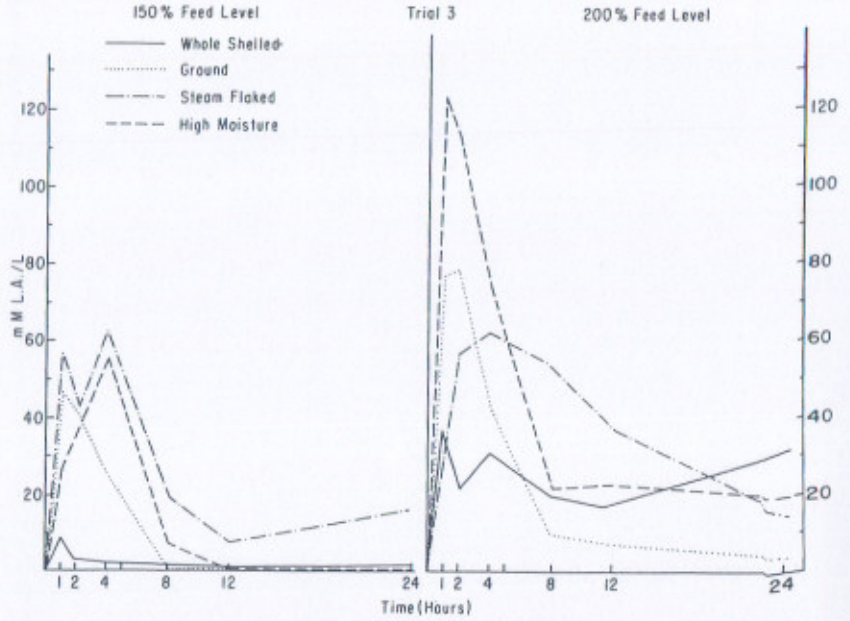

Figure 7. Changes in rumen lactic acid levels after feeding rations containing whole shelled, ground, steam flaked or high moisture corn at either the 150 or 200% levels.

At the 150 percent level of feeding, lactate production was low with WSC but quite high for the other three forms of corn (47-62 mM/liter). At the 200 percent level, lactic acid was markedly higher, especially for WSC, GC and HMC. The highest level was 123 mM/liter achieved 1 hour after feeding HMC but the level with this corn source fell rapidly by 8 hrs. post-feeding. The same was true for GC. SFC on the other hand did not produce the highest measured levels but they were prolonged at high levels up to 12 hrs. or more after feeding. Those produced with WSC were moderately high (20-30 mM/liter) but prolonged for the 24 hr. test period.

Some general conclusions may be drawn from these results. It should be noted first, however, that the data should not be taken as an endorsement or condemnation of any particular processing technique. The quality of product produced by most processing techniques can be varied as much as the variation between techniques shown here by simply altering processing conditions. Furthermore, the potential for using highly processed grains is controlled for a large part by the nutritional and bunk management being practiced in a feedlot.

All three forms of processed corn and the micronized sorghum obviously were fermented more rapidly in the rumen with resultant larger changes in pH and lactic acid levels. The effects with SFC appeared to be more prolonged than with GC or HMC. However, more care and management would be required with all of these forms compared to WSC. The delayed, more prolonged, fermentation of WSC is of considerable interest in light of the increased interest in feeding this form of corn in recent years. This is presumeably dependent, in part, on a greater lag time required for the starch in WSC to become available for fermentation by the microorganisms. Animals consuming WSC rations have been observed to ruminate considerably more than those consuming the processed forms of corn. This may well stimulate increased saliva flow which, because of its buffering function, may tend to keep the rumen pH higher. It is well known that observed advantages with WSC disappear as the roughage level of the ration is increased above 15 percent.

The physiological and pathological effects of levels of lactic acid between 5 and 20 mMole/liter are unknown. They are abnormal since they are considerably greater than the averages observed in random samples taken from feedlot animals. Nevertheless, they probably occur frequently and may be associated with sub-clinical problems. For example, if a second "load" of feed were added within 8 hrs. to the first one tested here, would the lactic acid levels increase rapidly to an acute level? This is conceivable considering the opportunistic nature of lactic acid producing bacterial. Does the irregular occurrence of such levels damage the rumen epithelium enough to induce parakeratosis and possible resultant liver abscesses? Does the pH and lactic acid condition predispose animals to respiratory diseases or other infections possibly because of acid-base changes in the blood? These questions have not been answered as yet. From a nutritional standpoint it will also be of interest to determine if the acid production can be modulated by the inclusion of buffers in the ration. This possibility is presently being tested.