Metabolic Aspects of Feeding Wheat to Beef Cattle

R. R. Oltjen

Until recently, wheat had not been used to any extent as a normal ingredient in ruminant diets primarily because of the economic advantage of its use for human consumption. Because of this relatively little research has been conducted to determine the nutritional value of wheat compared to the other cereal grains in ruminant finishing diets. Other factors which may have contributed to the reluctance of cattle feeders to use wheat are the widespread uncertainty concerning the feeding of wheat to ruminants and also the selection of wheat to demonstrate the acidosis syndrome. It is the purpose of this paper to review the general influence of feeding wheat on certain metabolic aspects of the ruminant.

Rumen microbial patterns: The end products of rumen microbial fermentation supply the ruminant animal with 70-80% of its total energy supply (Warner, 1964). The microbial population also extensively degrades dietary protein to peptides, amino acids, carbon skeletons and ammonia. These protein precursors are then used by the microbes to synthesize their own cellular protein which becomes available to the host animal in the lower gut. It is readily apparent that the performance of the ruminant is *directly* dependent on what occurs in the rumen.

R. R. Oltjen is Leader of Nutrition Investigations, Beef Cattle Research Branch, ASRD, ARC,* Beltsville, Maryland 20705.

Ruminants fed high or all-concentrate rations normally have ruminal conditions conducive to rapid growth of the lactic acid-producing bacteria, *Streptococcus bovis* and *Lactobacillus sp.* (Hungate *et al* 1952). Under normal feeding conditions the numbers of these microbes are relatively small compared to the concentration of other microbes.

Slyter *et al* (1970) studied the rumen microbial patterns in steers fed *ad libitum* all-concentrate diets of 90% cracked corn, 90% cracked soft red winter wheat and 60:30 combinations of the two grains and found that steers fed all the diets had similar but elevated bacterial concentrations and very low concentrations of ruminal protozoa. The loss of protozoa (primarily due to the low ruminal pH) may be of major significance because they store polysaccharides and this slows down the rapid degradation of the readily available energy. Steers fed corn had greater concentrations of *Lactobacilli* and other aciduric bacteria but *Streptococcus bovis* was found in greater concentrations in steers fed wheat than corn. There were cellulose hydrolyzing bacteria in the ruminal ingesta of all of the steers but they were not present in sufficient numbers to be detected among any of the 526 strains of bacteria isolated from the higher dilutions of ruminal contents using non-selective roll-tube medium. In a second study the microbial population of twin steers fed *ad libitum* the 90% corn or 90% wheat diets were studied and it was found that the steers fed the 90% wheat diet had the greatest concentrations of *Lactobacilli* and other aciduric bacteria. In a third study, corn, soft wheat, barley and milo were compared in all-concentrate diets with steers. All the grains were coarsely cracked. It was found that the ruminal ingesta of steers fed wheat had the lowest pH, lowest protozoal concentrations and the greatest concentration of *Lactobacillus* and other aciduric bacteria. Each steer in this study was restricted fed an amount of feed equal to 1.5% of body weight daily.

Carbohydrate metabolism: The carbohydrate portion of wheat is readily degraded to the volatile fatty acids (VFA) in the rumen. In studies conducted at Beltsville (Oltjen *et al*, 1966) it was determined that the VFA pattern in the ruminal ingesta of steers fed *ad libitum* all-concentrate diets of 90% cracked corn, 90% cracked wheat or 60:30 combinations of the two grains for 98 days were somewhat different. Steers fed the 90 and 60% wheat diets had lower (5.15 vs. 5.65) pH and greater concentrations (164 vs. 135 mmole/liter) of the ruminal VFA than did steers fed the 90 and 60% corn diets. As the amount of wheat increased in the diet the molar percentage of propionic acid decreased while the molar percentage of butyric acid increased. A follow-up study indicated similar VFA trends. Steers fed all diets gained similarly until 70 days. However, after 70 days steers fed the high wheat diets seemed to go "off feed" and

their feed consumption was reduced resulting in a difference ($P<.05$) in daily gains (1.15 vs. 1.35 kg) in favor of the high corn diets for the entire study. It is interesting that the pH was lower and VFA concentration higher in the cattle fed the high wheat diets because their feed consumption was lower than that of cattle fed the high corn diets at ruminal sampling time.

Wheat was compared to corn, milo and barley in metabolism trials in a later study (Oltjen *et al*, 1967). Steer calves were fed (two times daily; 1.5% of body weight) the grains in all-concentrate diets. The VFA concentrations (four hours after feeding) were higher ($P<.05$) in steers fed wheat (150 mmole/liter) and barley (148 mmole/liter) than in steers fed corn (99 mmole/liter) and milo (105 mmole/liter). Ruminal pH was lowest when steers were fed wheat (5.3) followed by barley (5.7) corn (6.0) and milo (6.1). Wheat-fed steers had the highest molar percentage of butyric acid. Ruminal lactic acid was not determined.

Totusek *et al* (1968) fed finishing diets containing 45% wheat, milo or combinations of these grains to beef cattle and reported that the type of grain had very little effect on the pattern or concentration of the VFA. Chou and Walker (1964a,b) fed sheep a limited diet of corn or wheat once daily and reported similar VFA patterns and concentrations for both grains. Allison *et al* (1964) studied the influence of preadaptation of sheep to a wheat diet on ruminal parameters and the overfeeding response and found that unadapted sheep receiving wheat in the rumen had a shift in the VFA pattern shortly after wheat was administered. The most pronounced shift was the lowering of acetic acid and the elevation of butyric, valeric and caporic acids. Rumen pH decreased as lactate increased. The molar percentage of butyric acid seemed higher than normal in sheep not showing acidosis.

Ryan (1964) studied the low molecular weight acids in the rumen following the addition of wheat to the rumen and reported that there was an increase in the ruminal concentration of lactic acid and glucose accompanied with a very marked decrease in the concentration of acetic, propionic, and butyric acids. However, these VFA were in greater accumulation in the first phases and decreased as acidosis became more severe. In many respects it appears that the feeding of large quantities of wheat to ruminants under normal conditions yields a ruminal VFA pattern similar to the feeding of sucrose in a purified diet (Orskov and Oltjen, 1967). The molar percentage of butyric and higher VFA may be indicative of the rate of fermentation.

Overloading the rumen with wheat or other cereal grains results in low pH (5.0) and an accumulation of lactic acid. Particular significance is attached to the accumulation of the D (-) enantiomorph of lactic acid which is more slowly metabolized by animal tissues (Turner and Hodgetts 1949-1959; Ryan, 1964) and may be a bottleneck in ruminal fermentation and utilization of end products. Uhart and Carroll (1967) studied acidosis in steers and reported that steers stopped eating within two or three days after an abrupt shift from alfalfa to a high-grain diet. This was attributed to a high ruminal lactic acid concentration (100 mmole/liter) and acidity (4.8 pH) which developed. The results of Tremere *et al* (1968) indicate that when wheat was fed as the only concentrate to dairy heifers, high lactic acid (14-75 mmole/liter of ruminal fluid) resulted but when the concentrate mixture was only 50% wheat lower (< 4 mmole/liter) levels occurred. High rumen acidity did not appear to be the only factor causing an animal to go off feed, since buffers administered either by intraruminal infusion or feeding did not prevent off feed. Dowden and Jacobson (1960) reported that lactic acid infused intravenously did not depress ruminant appetite, suggesting other factors are involved with the depression.

Haskins *et al* (1969) reported that the lactic acid concentrations in the ruminal fluid of steers fed all concentrate corn based diets *ad libitum* were low and averaged 0.2 mmole/liter of ruminal fluid. Steers receiving hay had higher concentrations. Eadie *et al* (1967) fed high barley diets to steers and reported that under normal feeding conditions the lactic acid concentrations were low and averaged about 0.1 mmole/liter of rumen fluid.

Ethanol concentrations are higher in the ruminal contents of sheep and cattle receiving large quantities of readily fermentable carbohydrate (Allison *et al* 1964; Orskov and Oltjen, 1967). Ethanol accumulation appears to be associated with the synthesis of longer chain acids in the rumen (Orskov *et al* 1967).

Protein metabolism: Gluten forms 80-90% of the total protein in wheat. This component is insoluble in water and neutral salt solutions. The rest of the protein is water soluble and chiefly constitutes the enzyme complex of wheat. Gluten has a high glutamic acid and proline content and a low lysine and arginine content. Metabolism results (Oltjen *et al* 1967) of feeding all-concentrate diets comprised of 91% corn plus 1% urea, 92% wheat, 92% barley or 92% milo to growing steer calves indicated that the protein in wheat was digested to a similar extent (77%) to that in corn (74%) and barley (78%). The protein digestibility for all 3 grains was greater ($P<.1$) than for milo (43%). Adding 1% urea to the milo diet increased digestibility to 57%. Removal of 1% urea from the corn diet resulted in a 59% protein digestibility. Morrison (1956) reported protein digestibilities of 77, 84, 79 and 78% for wheat, corn, barley and milo, respectively. Nitrogen retention (% of intake) was similar for corn with urea (43%), wheat (43%) and barley (38%) but

all were greater than milo without urea (24%). Corn without urea and milo with urea resulted in similar retention. Dry matter digestibilities for corn with urea, wheat, barley, milo, corn without urea and milo with urea were 83, 88, 84, 72, 75 and 73%, respectively. These data demonstrate the high nutritional value of the protein and carbohydrate in wheat compared to other grains. Ruminal ammonia concentrations (four hours after feeding) were low (3-6 mg/100 ml fluid) from steers fed the different diets and were not significantly different.

Annison (1956) studied the *in vitro* degradation of casein, zein, wheat gluten and soybean protein and reported that casein and soybean protein were readily degraded while zein and wheat gluten were less extensively and similarly degraded by ruminal microbes. Klosterman *et al* (1956) studied the nutritional value of a hydrolysate of wheat protein in which 80% of the glutamic acid was removed and reported that its over-all feeding value judged by metabolism and feeding trials with cattle and sheep was approximately 95% that of soyeban meal .

Ely *et al* (1970) compared the nitrogen utilization of two varieties of wheat with lambs. One variety (Red Chief) had weak gluten properties while the other variety (Golden 50) had strong gluten properties. Two rations were composed of the two varieties of rolled wheat as the only grain source while cracked corn replaced one-half of each of the wheats in two additional rations. The grains comprised 91% while cottonseed hulls comprised 9% in each of the four diets. Preliminary results indicate that nitrogen digestibility was slightly greater while the percent of digested nitrogen retained was significantly greater with Golden 50. When one-half of the wheat was replaced with corn, nitrogen digestibility was not affected but nitrogen retention was improved in both cases. Brethour and Duitsman (1970) reported that Golden 50 was superior ($P<.05$) to Red Chief in finishing diets with beef cattle. The wheat varieties comprised 38% of the experimental diets. Bris and Dyer (1967) reported that a hard variety of wheat (Burt) was inferior ($P<.05$) to a soft variety (Gaines) when these grains comprised 60% of the diet in feedlot studies with finishing steers.

The blood plasma amino acid patterns of the metabolism steers before feeding (Oltjen *et al* 1967) were similar. Steers fed wheat had the greatest concentrations of plasma glycine, isoleucine and lysine compared to the other grains. Although wheat contained more than twice the amount of glutamic acid as did corn the plasma levels were actually lower in steers fed these grains. The plasma lysine concentration was greater ($P<.01$) in wheat fed steers compared to steers fed the other diets. In general, there seemed to be little relationship between dietary amino acid intake, nitrogen retention and the blood plasma amino acid pattern. This emphasizes the fact that the rumen microbial population

degrades the ingested protein to a large extent (Hungate, 1966) and that the resulting plasma amino acid patterns were probably more a reflection of hydrolyzed microbial protein than of dietary ntirogen.

Other observations: Other factors which may be pertinent in determining the nutritional value of wheat are observations that the salivary flow of steers fed wheat (Oltjen *et al* 1967) was greater than that for milo but less than that for corn and barley. Particle size, however, was the smallest for the milo and wheat diets and this may have contributed to the lower flow rates. The weight of ruminal ingesta and dry matter was similar for all grains.

The feeding of the 90% corn or 90% wheat diets on an *ad libitum* basis resulted in similar feeding patterns (Oltjen *et al* 1966). Steers fed wheat spent 86 min/day while steers fed corn spent 96 min/day eating. More than 80% of the time at the feeding occurred from 6 AM to 9 PM.

Ruminal bypass of wheat may occur when steers are fed high levels of grain because of the rapid rate of passage through the rumen. If this does occur, it should be beneficial to the ruminant in terms of carbohydrate utilization because less would be fermented in the rumen (Karr *et al* 1966) but possibly detrimental to protein utilization because of its resistant nature to digestion (Annison, 1956) and its similarity to zein (Little and Mitchell, 1967).

Summary

The feeding of moderate to large quantities of wheat to beef cattle in finishing diets results in a rumen microbial population which has a moderate percentage of *Streptococcus bovis* and *Lactobacillus*. The bacterial patterns of steers fed wheat were, in general, similar to the patterns found in steers fed the other cereal grains. Rumen protozoa are either absent or found in low concentrations under *ad libitum* feeding conditions. Protozoa were found in lower concentrations when steers were fed restricted levels of wheat compared to corn, milo or barley.

The carbohydrate portion of wheat appears to be more rapidly fermented in the rumen than the carbohydrate from other cereal grains and results in lower ruminal pH values and greater VFA concentrations. The molar percentage of butyric and longer chain acids is greatest on wheat diets. Lactic acid concentrations are low under normal feeding conditions.

Metabolism results indicate that the dry matter and protein in soft wheat was utilized similarly to that in corn and barley. Blood plasma amino acid patterns of steers fed wheat were similar to those of steers fed corn and barley. Soft wheat was superior to hard wheat in a feedlot study. Ruminants fed wheat exhibiting weak gluten properties had

greater feedlot performance and nitrogen retention than ruminants fed wheat exhibiting strong gluten properties.

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