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EFFECT OF METHODS OF PROCESSING UPON
DIGESTIBILITY OF A NEW WHEAT
BY SHEEP AND CATTLE

by

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CHAPTER I

INTRODUCTION

Wheat is not generally considered a major feed grain, but because of the selection of new feed wheats with poor milling qualities by the Rockefeller Foundation in Mexico there is a potential for increased feeding of these wheats since they are not acceptable to the milling industry. These new high-yielding feed wheats, one of which is Maxigene 1877, are stiff-strawed, semi-dwarf varieties. There is very limited work concerning these wheats and their value as a feed grain for livestock and the necessity of extensively processing these grains. Eng (1970) reported that crude protein content of Maxigene 1877 was superior to several other varieties of wheat and barley. Lofgreen (1970) found that net energy (NE) values for maintenance (NE_m) and gain (NE_g) of another variety of feed wheat, Sonora 64, were superior to sorghum grain.

Other factors which favor wheat as a concentrate in finishing rations are market prices and world wheat supplies. Cash wheat prices were at the lowest level in 25 years in 1969 and exportation of wheat has decreased during the past several years because of increased wheat production in major importing countries (Nichols, 1970). One and one-half billion bushels of wheat were produced in the U.S. during the last three years. Two hundred million bushels were fed to livestock in 1969 (Askew and Comme, 1970).

Most available data regarding wheat as a feed grain deal mainly

with all types of wheat, many of which were not clearly defined. In addition, processing methods have resulted in somewhat less improvement in digestibility with wheat than with several other feed grains. Information is limited concerning the effect of various processing methods on the nutritive value of the new feed-type wheats. The experiments reported herein were conducted to study the effects of different grain processing methods upon the digestibility of feed-type wheat rations and grain portions by sheep and cattle.

CHAPTER II

LITERATURE REVIEW

There has been extensive research in the feeding of wheat in beef cattle finishing rations, but most of the work was conducted during the early part of the century under different feeding regimes than are used today. Interest in wheat feeding was again renewed in the 1950's and 1960's because of lower prices and surpluses which made wheat competitive with other feed grains. The development of new varieties of high-yielding feed wheats has stimulated an increased interest in the nutritive value and importance of these wheats. Because most of the previous studies were conducted with milling wheats, the results may not be directly applicable to the feed wheats. However, data from milling wheats are important since they represent the greatest amount of wheat grown.

Characteristics of wheat. The chemical composition of wheat varies with geographical location, fertilization rates, irrigation, and variety. The National Research Council (1969) gives the following chemical composition of wheat grain as percent of dry matter: protein, 14.3; nitrogen-free extract, 78.6; crude fiber, 3.4; ash, 1.8; and ether extract, 1.9. Sorghum grain is lower in protein and crude fiber and slightly higher in nitrogen-free extract. Corn follows a similar pattern, being higher in nitrogen-free extract. Barley is highest among the feed grains in crude fiber. Lofgreen (1970) reported the NE_m and NE_g of 84% grain rations consisting of corn, wheat, milo and

barley were expressed in Mcal/100 kg dry matter, 194, 152; 189, 143; 183, 134; and 178, 132, respectively.

The wheat kernel contains a glutenous-type starch with unique protein properties which are necessary for milling. These properties are not found in most other grains. Gluten comprises 80 to 90% of the protein in wheat grain (Oltjen, 1970). Whether the glutenous characteristic of wheat decreases acceptability to cattle is not definitely known, but there is a tendency for high gluten wheats to become pasty when eaten by livestock (Morrison, 1956). Possibly ruminal disorders such as ulceration and clumping of papillae which may lead to liver abscesses have also been associated with wheat feeding. However, Oltjen et al. (1966) indicated a trend toward less papillae clumping and darker rumen epithelium as wheat increased in the rations.

Comparison with other feed grains. Considerable research has been conducted comparing wheat with corn, primarily because corn is considered a standard among feed grains. Results of these comparisons have been somewhat variable. Dyer and Weaver (1955) and Oltjen et al. (1966) reported that steers fed corn rations made more rapid gains than those fed wheat rations, and that feed required per unit gain increased as the concentration of wheat increased. Animal performance was similar between wheat and corn during the first 70 days of a trial conducted by Oltjen et al. (1966). During the last 28 days, however, consumption of the wheat rations decreased with a resulting reduction in performance. Morrison (1956) stated that cattle fed wheat "go off feed" when subjected to these rations over long periods

of time. Gains were similar in a study by Baker and Baker (1960), with efficiency of feed utilization favoring wheat. Steers fed wheat in a trial by Ralston et al. (1964a) had higher gains with greater efficiency than steers fed corn in 60% concentrate rations containing 25% beet pulp.

Wheat has consistently produced similar gains with more efficient utilization than barley in steer finishing rations (Ralston et al., 1964b; Bris et al., 1966; Wood et al., 1966; Thomas and Geissler, 1968), primarily because of the higher energy content of wheat. Dahmen (1965) reported that wheat could replace barley if beet pulp was included in the ration. Excellent gains and increased feed efficiency resulted when wheat replaced 50% of the barley in all-concentrate rations, indicating that the feeding value of wheat was higher when mixed with barley (Brethour, 1966; Lofgreen, 1970).

Sorghum grain is the major feed grain in the Great Plains and Southwest. Therefore, comparisons of wheat with sorghum grain are important to feeders in this area. Again, as with corn, feeding results have been variable. Brethour and Duitsman (1965) and Hale et al. (1970b) reported that cattle fed 50% wheat gained slightly faster than cattle fed sorghum grain, with 1 kg of wheat replacing 1.14 kg of sorghum grain. However, in another trial (Brethour and Duitsman, 1966), intake was reduced 12% as compared to sorghum grain when wheat was fed as 50% of the air-dry intake with sorghum silage. Lower gains resulted, but efficiency of feed utilization was not affected. Gains were similar between wheat and sorghum grain in trials reported by Eng (1970) and Lofgreen (1970), but efficiency increased with higher

levels of wheat. Steers fed all wheat rations gained least efficiently when compared to those fed all milo, 50% wheat, and 75% wheat, in a study by Hale et al. (1970a). The 50% wheat rations were comparable to all milo rations with regard to feedlot performance. Richardson et al. (1967) reported similar results. Totusek et al. (1968) indicated that steers fed sorghum grain gained slightly faster than those fed wheat or combinations of both grains. Efficiency favored sorghum grain in studies by Totusek et al. (1968) and Hale et al. (1970b). McCloy et al. (1970), working with triticale (wheat x rye cross), found that gains were higher for cattle fed sorghum grain but that efficiency of feed utilization favored the triticale. Brethour (1966), Richardson et al. (1967), and Hale et al. (1970b) found that consumption and gains were higher when wheat was included as part of the grain in finishing rations. These results suggest that the most feasible method for feeding wheat is by blending with other feed grains up to levels of about 50% of the grain portion in the ration. Higher levels, however, may possibly be utilized without affecting performance. The addition of molasses to wheat rations to improve acceptability has shown inconsistent results. Baker and Baker (1960) and Brethour (1966) reported that intake and gain increased only slightly and feed efficiency remained unchanged with molasses added to wheat rations. McCloy et al. (1970) concluded that 5% molasses had little or no effect on acceptability and consumption of triticale rations.

Crude fiber may be a critical factor to consider in feeding high concentrations of wheat. Research has indicated that reduced performance was associated with low crude fiber content of diets containing

wheat (Gill, 1966). It was postulated that high crude fiber levels tended to slow the rate of passage through the digestive tract, stimulate rumination and increase digestion of the ration. Using 65% alfalfa pelleted rations, lambs fed wheat had higher gains and consumption with greater efficiency of feed utilization when compared to lambs fed corn, sorghum grain, rye or barley (Hillman et al., 1962). Ralston et al. (1964b) reported no significant differences between 10 and 20% roughage rations containing wheat, but indicated a slight benefit from the lower roughage level. Ralston and Taylor (1965) reported that gains were comparable between rations with wheat:beet pulp ratios of 85:15, 70:30 and 50:50, with efficiency of feed utilization slightly favoring the higher wheat concentrations. On high roughage rations made up of sorghum silage, wheat has proven to be superior to sorghum grain for cattle (Brethour, 1966; 1970).

Some experimental results have indicated a relatively high incidence of digestive disturbances when using wheat in rations. Oltjen et al. (1966) found that ruminal pH was lower ($P < .01$), ruminal ammonia concentrations greater ($P < .05$), and volatile fatty acid ratios similar for steers fed wheat as compared to those fed corn. Oltjen (1970) reported high ruminal lactic acid concentrations in steers fed high levels of wheat, but lactic acid concentrations were normal when rations contained only 50% wheat. Carcass characteristics have been similar in all the trials comparing wheat with other grains, but some researchers have found an increased incidence of liver abscesses in cattle finished with wheat (Baker and Baker, 1960;

Oltjen et al., 1966 and Thomas and Geissler, 1968) and in cattle fed triticale (McCloy et al., 1970).

Protein replacement value. Another factor to consider when feeding wheat is the protein replacement value in finishing rations, since wheat contains higher protein levels than most other feed grains. Ely and Duitsman (1967) investigated the possibility of replacing cottonseed meal with wheat in finishing rations for steers. The steers were fed 50:50 sorghum grain, wheat rations both with and without .34 kg of cottonseed meal per head daily. Cottonseed meal did not increase daily gains or alter feed intake. Less protein supplement was required in a trial by Baker and Baker (1960) using wheat. Brethour and Duitsman (1965) replaced 1 kg of cottonseed meal with 6.4 kg of wheat.

Effect of processing methods. Processing of other feed grains has received considerable attention and has been a major research endeavor during the last several years. Processing methods involving heat have improved efficiency of utilization of sorghum grain by finishing cattle. Similar benefits from comparable processing methods have been somewhat inconsistent with wheat. Brethour (1966) reviewed several studies concerned with processing wheat and reported no benefit from various processing methods. Dyer and Weaver (1955) compared shelled corn to ground and whole wheat and found that cattle fed whole wheat gained faster, but less efficiently than those fed ground wheat. Intake varied and digestive disturbances occurred in cattle fed the ground wheat. Steam rolled or pelleted wheat produced higher gains and efficiency of gain than dry rolled wheat (Eris et al.,

1966). The dry rolled wheat in this trial had the greatest amount of fines and intake was reduced. Wood et al. (1966) stated that fines in flaked wheat rations decreased feed intake and caused digestive disturbances and scouring.

In vitro gas production with ground wheat was greater than with ground milo, but similar between the two grains when flaked (Hale et al., 1969). Flaking increased gas production less for wheat than for sorghum grain. Hale et al. (1969; 1970b) reported that fines in steam flaked wheat reduced consumption. When poorly flaked, however, intake increased. Problems with fines appear to be associated with processing wheat and should be considered. If a poor flake is needed to decrease the percentage of fines and increase consumption, then steam processing would not appear to be beneficial. More economical processing methods such as dry rolling or coarse grinding may possibly be adequate for wheat.

Eng (1970) showed that processing wheat by steam flaking did not increase dry matter digestibility as determined by the nylon bag technique when compared with dry grinding. Untreated wheat starch was partially gelatinized and was altered very little when placed in boiling water. Water uptake was low for the wheat compared to other grains, which may offer an explanation for the lower rigidity of the wheat flake. Lofgreen (1970) reported no benefit from steaming wheat for 15 minutes and producing a 28 lb/bu flake compared to fine ground wheat and similarly flaked milo. Gains and efficiency of feed utilization were also comparable between dry rolled and steam flaked triticale (Nicholson, 1970).

Walden (1970) indicated that high moisture wheat was palatable for dairy cows and that performance was satisfactory after a short adjustment period on the ration. The same was true for popped wheat in a study at Davis, California, using steers (Walker, 1970). There appears a need for more work on some of the newer techniques of processing wheat, which may prove valuable in improving the utilization of wheat in finishing rations.

Types of wheat. As mentioned earlier, the type of wheat fed to livestock may also affect performance. Gaines, a soft winter wheat, has been studied considerably in the Pacific Northwest and found to be generally superior to a hard variety, Burt, in feedlot performance (Bris et al., 1966). Sonora 64 is a short-stemmed, poor milling variety introduced into Arizona from Mexico and has compared satisfactorily in feedlot performance with sorghum grain (Hale et al., 1969; 1970b). In comparing light and heavy hard red spring wheats, gains by cattle were similar in a study by Erickson et al. (1967), but lower for Durum wheat. Another soft wheat which has shown good response is Golden-50, a strong gluten wheat with high baking characteristics. Red Chief which has weak gluten and hard flinty starch has been shown to have a lower feeding value than other wheats (Brethour and Duitsman, 1970). A non-specified soft wheat provided greater responses than a hard wheat in nitrogen balance and feedlot studies (Oltjen, 1970). All of the major types of wheat and especially the new feed wheats need more extensive study in order to determine their feeding value and how they can best be included in a feeding program for ruminants.

CHAPTER III

EXPERIMENTAL PROCEDURE

The wheat (Maxigene 1877) used in this study was produced near Fresno, California during the 1969 crop season. Portions of the grain were processed by three different methods: dry rolled, steam flaked (steamed for 45 min under 2.8 kg per cm² pressure at 93° C and immediately rolled to produce a flat flake), and micronize flaked (exposed to gas-fired infra-red heat until approximately 5% of the kernels were popped, then rolled immediately). Grains from each processing treatment were incorporated into rations which contained in percent: grain, 78.2; cottonseed hulls, 20.0; molasses, 0.8; trace mineral salt, 0.5; calcium carbonate, 0.5; with 10.5 mg chlortetracycline and 4,400 I.U. vitamin A per kg ration. Chemical composition of the rations is given in table 1.

Eighteen Angus steers averaging 317 kg and 21 crossbred wethers averaging 44 kg were placed in metabolism stalls and randomly allotted six and seven per treatment, respectively, to the three treatments for digestibility trials involving 7-day adjustment periods followed by 7-day preliminary and collection periods. The procedure was identical for both the steers and wethers with the exception that fecal collection bags were used with the steers and urine was not collected. All animals were initially fed the respective experimental rations twice daily on a limited basis (1% of body weight daily). Intake was gradually increased during the adjustment period with maximum consumption

TABLE 1. CHEMICAL COMPOSITION OF RATIONS ^a

Processing method	Dry rolled	Steam flaked	Micronize flaked
Chemical analyses, DM basis, %			
Organic matter	97.7	96.8	97.1
Ash	2.3	3.2	2.9
Crude protein ^b	13.8	14.8	13.8
Calcium	0.27	0.27	0.27
Phosphorus	0.24	0.24	0.24
Gross energy, kcal/g DM ^c	4.490	4.460	4.445

^a All rations contained 10.5 mg chlortetracycline and 4,400 I.U. vitamin A per kg.

^b The wheat contained 15.7% crude protein on a dry matter basis.

^c Gross energy was 4.580, 4.565 and 4.523 kcal/g DM in the dry rolled, steam flaked and micronize flaked grains, respectively.

limited at 6.81 and 1.05 kg per head daily for the steers and wethers, respectively, fed in approximately equal portions twice daily. Feed intake was held constant at the level established for each animal during the remainder of the trial. Water and plain salt were available at all times. Rations were sampled at each feeding; total wet feces were weighed, sampled (10% aliquot) and the samples composited daily; and total daily urine (wethers only) diluted to a constant volume. A 100 ml aliquot was then composited for analysis. Fecal samples were frozen and urine samples refrigerated until analyzed. Proximate analysis of feed and feces, and urinary nitrogen analysis were conducted by A.O.A.C. (1965) methods. Gross energy determinations were made using an oxygen bomb, adiabatic calorimeter. Calcium and phosphorus were determined by atomic absorption spectrographic procedures (Warner, 1970). Nitrogen solubility of the grains was determined by the method given by Lyman et al. (1953). True protein digestibility was calculated using the value of 0.45 g metabolic fecal nitrogen per 100 g dry matter intake (Blaxter, 1964). Digestibility of the grain portions was calculated by difference using previously determined values for the cottonseed hulls. Total digestible nutrients were calculated using the value of 4.41 kcal digestible energy per g TDN (N.R.C., 1969). Statistical analyses were conducted according to standard analysis of variance techniques.

CHAPTER IV

RESULTS AND DISCUSSION

Digestibility data are presented in table 2. Crude and true protein digestibilities of the rations were not significantly different between treatments, although the steam flaked ration was somewhat lower in this respect than the other two rations. Digestibility of dry matter and gross energy were comparable between the dry rolled and micronize flaked rations and both were higher ($P < .01$) than the steam flaked ration. Organic matter digestibility followed similar trends with the steam flaked ration being lower ($P < .05$) in this regard than the other two treatments. There were no significant processing method X species interactions. In comparing species, digestibility of the energy components was comparable between sheep and cattle with the dry rolled and micronize flaked treatments, and somewhat lower ($P < .10$) with sheep compared to cattle on the steam flaked ration. Crude and true protein digestibilities were higher ($P < .01$) with cattle when the two species were compared with treatments combined. The largest differences in digestibility between sheep and cattle occurred within the steam flaked treatment, which might account for some of the reduction in digestibility when this treatment was compared to the other two treatments. Digestibility of the grain portions calculated by difference followed patterns similar to the rations in both the treatment and species comparisons.

These results indicate that the micronize flaked processing method did not alter and the steam flaked processing decreased digestibility

TABLE 2. EFFECT OF PROCESSING METHOD UPON DIGESTIBILITY OF WHEAT RATIONS AND OF THE GRAIN PORTIONS BY CATTLE AND SHEEP

Processing method Species	Dry rolled		Steam flaked		Micronize flaked		S.E.
	Sheep	Cattle	Sheep	Cattle	Sheep	Cattle	
Daily DM intake, kg	0.921	5.728	0.914	5.462	0.937	5.651	-----
Digestibility, total ration, DM basis, %							
Dry matter a,e	73.2	73.2	69.5	72.0	73.8	73.5	0.9
Organic matter b	74.0	73.8	70.5	72.8	74.6	73.8	0.9
Crude protein c,d,f	70.4	71.6	66.2	71.7	69.6	72.1	1.2
True protein c,d	90.8	92.0	86.2	91.8	90.0	92.4	1.2
Gross energy a	73.0	72.5	69.3	70.9	73.2	72.4	1.0
Daily nitrogen balance, g							
Nitrogen intake	20.36	-----	20.47	-----	20.72	-----	-----
Nitrogen in feces	6.03	-----	6.94	-----	6.29	-----	-----
Nitrogen in urine	10.82	-----	9.13	-----	10.25	-----	-----
Nitrogen retention g	3.51	-----	4.40	-----	4.18	-----	0.16
N retained, % intake	17.2	-----	21.5	-----	20.2	-----	-----

Continued on next page.

TABLE 2. CONTINUED

Processing method Species	Dry rolled		Steam flaked		Micronize flaked		S.E.
	Sheep	Cattle	Sheep	Cattle	Sheep	Cattle	
Digestible energy, kcal/g DM	3.278	3.255	3.091	3.162	3.254	3.218	----
TDN, DM basis, %	74.3	73.8	70.1	71.7	73.8	73.0	----
Digestibility, grain portion, DM basis, %							
Dry matter ^{b,e}	80.0	80.1	75.4	78.5	81.0	80.4	1.1
Organic matter ^b	80.9	80.7	76.7	79.4	81.8	80.9	1.2
Crude protein ^{b,c,d}	74.8	76.3	69.5	75.6	73.9	76.7	1.4
True protein ^{b,c,d}	92.7	94.2	87.5	93.5	91.9	94.6	1.4
Gross energy ^a	79.5	78.9	75.0	77.0	79.7	78.8	1.2
Digestible energy, kcal/g DM	3.641	3.614	3.424	3.515	3.605	3.564	----
TDN, DM basis, %	82.6	82.0	77.6	79.7	81.7	80.8	----

^a Steam flaked significantly ($P < .01$) lower than the other two treatments.

^b Steam flaked significantly ($P < .05$) lower than the other two treatments.

^c Significant ($P < .01$) difference between species.

Footnotes continued on next page.

TABLE 2. FOOTNOTES CONTINUED

- d Significant ($P < .01$) difference between species within steam flaked treatment.
- e Difference between species within steam flaked treatment approached significance ($P < .10$).
- f Difference between species within micronize flaked treatment approached significance ($P < .10$).
- g Dry rolled significantly ($P < .01$) lower than the other two treatments.

as compared with dry rolled wheat. Eng (1970) found that dry matter digestibility determined by the nylon bag technique was lower with this same variety of wheat when processed with methods involving heat similar to those reported herein. Walker (1970) found that in vitro enzymatic degradation of both a red and a white wheat was improved by processing with dry heat expansion. Pressure steaming and rolling a feed wheat decreased daily gain of steers by 0.11 kg, but slightly increased efficiency of feed utilization compared to atmospheric steaming. However, popping the wheat produced similar gains and increased the efficiency of feed utilization when compared to pressure steamed, rolled wheat. Intake of wheat rations was reportedly higher with the popped grain. This suggests that the micronize flaked treatment used in the present study might improve intake by finishing cattle as compared with the other processing methods since this process was similar to the popped treatment. Other investigators (Buchanan-Smith et al., 1968; Husted et al., 1968) have reported consistent improvements in digestibility of sorghum grain, particularly by cattle, with several different methods of processing. Parrott et al. (1969) found little or no improvement in digestibility of steam flaked barley compared with dry rolled barley.

Percentage of fine particles (table 3) was higher in the steam flaked wheat than in the micronize flaked grain, but lower in the dry rolled grain than either of the other two treatments. The steam flakes were extremely fragile and easily broken, which resulted in the higher percentage of fine particles in this treatment. Hale et al. (1969, 1970a) and Eng (1970) have also observed that flakes of steam flaked

TABLE 3. PARTICLE SIZE OF WHEAT PROCESSED BY DIFFERENT METHODS

Processing method	Dry rolled	Steam flaked	Micronize flaked
Screen size, mm	- - - -	% retained ^a	- - - -
6	0.0	5.4	24.6
5	45.7	7.3	37.0
4	75.1	15.3	59.8
3	79.2	26.8	63.2
2	87.1	32.7	73.2
1	99.1	72.2	83.2

^a Percent remaining on screen after sifting through screen sizes indicated. Different samples were used for each screening.

wheat were very fragile and resulted in excessive amounts of fines. Wood et al. (1966) reported that extreme care was necessary when steam rolling wheat to reduce shattering. Eng (1970) found that wheat did not absorb moisture as readily as other grains and proposed that this might account for the less rigid flakes and larger percentage of fines. He also found that unprocessed wheat starch was partially gelatinized with less further gelatinization during processing than was observed with other grains. Hale et al. (1969) noted that in vitro gas production increased less with steam flaked compared to unprocessed wheat than similar comparisons with sorghum grain primarily because gas production with unprocessed wheat was considerably higher. Gas production was similar when both grains were steam flaked. In the study reported herein, starch gelatinization values as determined by optical birefringence (Turner, 1970) were 10.0, 12.5 and 10.0% for the dry rolled, steam flaked, and micronize flaked wheat treatments, respectively. These results are in agreement with those given by Eng (1970), and offer evidence for a possible explanation of the lack of improvement in digestibility of wheat by these processing methods.

Balch (1950), Blaxter et al. (1956), Campling and Freer (1961) and Derrickson et al. (1965) reported that reduction of particle size increased the rate of passage of feed material through the digestive tract, thereby decreasing digestibility of the nutrient components. In the present study, the higher percentage of fine particles in the steam flaked wheat may have sufficiently increased the rate of passage through the digestive tract to decrease digestibility of the nutrient components. Also, some slight scouring was observed in the steam

flaked treatment group. This possible influence of rate of passage might also further explain the decrease in digestibility obtained with this treatment.

Buchanan-Smith et al. (1968) indicated that digestibility of ground sorghum grain was higher by sheep than cattle. Digestibility did not differ between these species, however, with reconstituted and steam processed sorghum grain. Keating et al. (1965) and McCloy et al. (1970) also reported that digestibility of dry rolled sorghum grain rations was higher with sheep. They obtained comparable digestibility data between sheep and cattle with dry rolled barley rations (Keating et al., 1965) and triticales rations (McCloy et al., 1970). In the present study, digestibility of the energy components was comparable between sheep and cattle with the dry rolled and micronize flaked wheat rations, but lower for sheep with the steam flaked ration. Crude and true protein digestibilities were lower for sheep on all rations with significant reductions within the steam flaked treatment, which probably accounted for the larger portion of the variance associated with the species comparison. Buchanan-Smith et al. (1968) also noted that protein digestibility by sheep was reduced with steam processed, rolled sorghum grain as compared to ground sorghum grain, whereas a slight improvement was observed in cattle with the steam processed grain. The results reported herein together with those of other investigators suggest that differences which may exist between sheep and cattle in digestibility of high concentrate rations are not consistent and may vary with different grains and different processing methods within particular grains.

Nitrogen retention by sheep (table 2) was higher ($P < .01$) with both processing treatments involving heat than with the dry rolled wheat. Similar responses were obtained when nitrogen retention was expressed as a function of nitrogen intake. Danke et al. (1966) reported that reduction of nitrogen solubility in protein supplements by heating improved nitrogen retention as long as increases in fecal nitrogen were compensated by decreased urinary nitrogen excretion. In the present experiment, soluble nitrogen was reduced by both processing methods involving heat and was 62.3, 51.8 and 53.2% of total nitrogen in the dry rolled, steam flaked and micronize flaked grains, respectively. Nitrogen retention increased primarily as a result of decreased urinary nitrogen excretion and both closely paralleled nitrogen solubility of the grains.

Feeding studies have shown little improvement in performance of finishing cattle fed processed wheat compared with dry rolled or coarse ground wheat (Brethour, 1966). Hale et al. (1970b) found some improvement in performance with poorly flaked wheat compared to flat flaked wheat, primarily due to a reduction in the percentage of fines in the poorly flaked wheat. Bris et al. (1966) reported somewhat higher performance with steam flaked and pelleted than with dry rolled soft winter wheat grown in the Pacific Northwest. They also attributed the reduced performance to excessive fines in the dry rolled wheat. Steam rolled wheat (Sonora 64), which made a 28 lb/bu flake, reduced gains slightly and decreased efficiency of feed utilization when compared to the same wheat fed finely ground; net energy values were similar for the wheat processed by the two methods, and for flaked milo (Lofgreen, 1970).

The data reported herein combined with results of other studies suggest that processing beyond dry rolling or coarse cracking does not improve digestibility of wheat, particularly the hard wheats. Thus, development of processing techniques other than those used for most other feed grains would appear necessary to improve flake quality, acceptability, and digestibility of wheat.

CHAPTER V

SUMMARY

Digestibility studies were conducted with steers and wethers to determine the effects of three different processing methods upon the nutritive value of a new feed-type wheat, Maxigene 1877. Portions of this wheat were dry rolled, steam flaked or micronize flaked and fed in rations containing 78.2% grain, 20.0% cottonseed hulls, 0.8% molasses, 0.5% trace mineral salt, and 0.5% calcium carbonate. All rations were fed at maximum levels of 6.81 and 1.05 kg per head daily for the steers and wethers, respectively. Percentage of fine particles was highest in the steam flaked wheat followed by the micronize flaked, and was lowest in the dry rolled treatment. Digestibility of the energy components was comparable between the dry rolled and micronize flaked rations. Both were superior in this regard to the steam flaked ration. Protein digestibility of the rations was not significantly different between treatments. The steam flaked ration, however, was somewhat inferior in this respect. Nitrogen retention by sheep was improved ($P < .01$) by both heat processing methods. There were no significant processing method X species interactions. In comparing species, digestibility of energy components was comparable in the dry rolled and micronize flaked treatments and somewhat lower in sheep on the steam flaked ration. Protein digestibility was higher ($P < .01$) with cattle when comparisons were made with treatments combined. The largest differences in digestibility between species occurred within

the steam flaked treatment for all nutrients. Digestibility of the grain portions calculated by difference followed similar trends as that of the rations in both treatment and species comparisons.

These results indicate that digestibility of the feed-type wheat used in this study was not improved by either steam flaking or micronize flaking methods when compared with dry rolling, suggesting that attention would need to be focused on the development of new processing methods in order to improve the acceptability and digestibility of these wheats.

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