North Dakota State University * Dickinson Research Extension Center
1089 State Avenue, Dickinson, ND 58601-4642 Voice: (701) 483-2348 FAX: (701) 483-2005

Hull-less Oats as a Feedstuff for Ruminants

Marc L. Bauer, Department of Animal and Range Sciences, North Dakota State University, Fargo

Introduction

A new variety (*Paul*) of hull-less or naked oats was released in 1994 by the North Dakota Crop Improvement Association. Hull-less oats are characterized by loosely attached hulls that are easily separated during harvesting subsequently increasing nutrient density of the final harvested product. *Paul* oats are very similar in nutrient content to oat groats (mechanically de-hulled oats) maintaining the high protein and lipid characteristics of hulled oat kernel. For this reason, *Paul* oats appears to be an energy-dense, protein-rich feedstuff for livestock. During the past three years NDSU research and extension personnel have conducted experiments feeding *Paul* oats to beef and dairy cattle, sheep, and hogs. The objectives have been to determine the energy and protein virtues of hull-less oats in the diets of these animals. The experiments involving beef and sheep have mainly involved determining the net energy of *Paul* oats in backgrounding or finishing diets.

Nutrient Characteristics

Average crude protein and fat in hull-less oats (Table 1) compared with oats are much higher because the hull is removed. Crude protein of hull-less oats is high compared to other grains and would appear to be advantageous to cattle and sheep producers as a "home-grown" protein source. However, if the characteristics of the protein have not changed from oats, the protein in hull-less oats is very degradable in the rumen and has very little ruminal bypass or escape characteristics. The fat concentration of hull-less oats is two to three times higher than other grains. The high fat content of hull-less oats should be advantageous to livestock producers because the energy content of fat is approximately 2.25 times higher than carbohydrates or proteins. But, feeding too much fat in ruminant diets has a negative impact on digestion of other nutrients in the rumen. Fiber of the hull-less oats appears to be quite variable and is probably related to the amount of hull left after threshing. Screened samples have NDF concentrations similar to corn. Starch characteristics of oats also need to be discussed here, although little information is available at this time. The rate which hull-less oat starch is digested in the rumen may be equal to or faster than barley and wheat. This may predispose cattle and sheep fed high hull-less oat rations to ruminal acidosis, reducing intake and performance.

Performance of cattle and sheep fed hull-less oats

In four separate experiments, hull-less oats has replaced or partially replaced barley and soybean meal (SBM) as the source of energy and protein in the diet. In the first experiment at the Dickinson Research and Extension Center, whole hull-less oats (Table 2) replaced ground barley and SBM. No statistical differences in cattle performance were detected between the two diets (Table 3). However, steers fed the hull-less oat diet ate .6 lb/d less than the steers fed the barley/SBM diet. In a second experiment at the Central Grasslands Research and Extension Center, hull-less oat were coarsely ground replacing ground barley and SBM (Table 2). In this experiment, calves fed hull-less oats gained faster with similar intakes (Table 3). The increased calf performance between the two experiments was attributed to the difference in processing (ground vs. whole hull-less oat). Subsequent experiments have thus used grinding or rolling to process the hull-less oats.

The second set of experiments at the Dickinson Research and Extension Center, hull-less oats again replaced barley and SBM (Table 4). The concentrate portion of these rations were 76 and 56%. When hull-less oats were fed, intakes decreased with no change in gain (Table 5). Feed efficiency improved when hull-less were fed in the first experiment but was not different statistically in the second experiment. In the second experiment, when field peas were fed with hull-less oats intakes were intermediate to the barley/SBM and hull-less oat treatments.

Hull-less oats were fed to steer calves at the Carrington Research and Extension Center, replacing barley and canola meal (Table 6). These calves were finished after the growing period with hull-less oats replacing barley in an 83.5% concentrate diet. The hull-less oats were rolled to produce a crimped product. Intake decreased as the percentage of hull-less oats increased in the diet (Table 7). Daily gain and feed efficiency improved from barley treatment (0% hull-less oats) to the 67% hull-less oat treatment.

At the Fargo experiment station, hull-less oats replaced corn in a 92.5% concentrate finishing diet (Table 8). This experiment was designed to evaluate the energy value of hull-less oats regardless of supplemental protein source. The performance of the cattle receiving hull-less oats in the diet decreased dramatically in terms of both intake and gain; feed efficiency was not affected (Table 9). During the study, the decision was made to quit processing the hull-less oats in the 100% hull-less oat treatment; dietary nutrient concentration would therefore be identical. The rolled oats were finer and dustier than the rolled product from the Carrington roller mill. After the change intakes increased and gains improved, but there was also a higher incidence of bloat within the first month after the change.

Whole hull-less oats replaced barley and soybean meal in an 88% concentrate lamb finishing diet (Table 10) at the Hettinger Research and Extension Center. The diets in this trial also had increasing levels of protein as hull-less oats increased. Again, intake and daily gain decreased with increasing hull-less oat in the diet; feed efficiency was unaffected (Table 11).

Decrease in intake

All of the reports (some were not significant) indicate when hull-less oats are fed a decrease in intake can be expected compared with feeding barley or corn. There are probably at least three factors contributing to this phenomenon -- acidosis, fat, and protein. Ruminal acidosis generally arises from rapid fermentation of grains in the rumen. Hull-less oats appear to ferment very rapidly in the rumen and may ferment faster than barley and wheat which ferment faster than corn. Acidosis generally leads to reduced and/or erratic intakes by cattle along with reduced gains.

Fat in the diet may also be a contributing factor. It is well recognized that low levels of added fat often increases energy density but levels above 6 to 7% may reduce digestibility of other nutrients (especially fiber) in the rumen which may decrease intake. Also fat itself will act as a restraint on feed intake because of its higher energy density in high grain finishing diets. However, only a few of the diets in this research exceeded this level of fat but it still may have been a contributing factor.

The third factor may be protein characteristics of oats. The 1996 Nutrient Recommendations for Beef Cattle estimates oat protein is 83% digested in the rumen (DIP) and only 17% escapes the rumen. As indicated in the tables (Tables 3,5,7,9) when hull-less oats were added to the diets, DIP balance increased. This indicates ruminal protein or N needs were met or exceeded. Generally, when cows are fed DIP deficient (negative balance) diets, adding DIP will increase intake through increased fiber digestion in the rumen. There were three instances where adding hull-less oats corrected an estimated deficiency in DIP of more than .2 lb/d (Table 3, 5, 7). In the backgrounding situations where hull-less oats replaced barley and SBM (Table 3 and 5) roughage made up less than half of the diet dry matter. Therefore, adding DIP to correct a deficiency may not improve fiber digestion in the rumen because of the negative effects of starch digestion on fiber digestion in the rumen. In the finishing trial (Table 7), gains improved when DIP from hull-less oats corrected the estimated deficiency. Also this was the largest estimated deficiency and therefore the cattle may have been actually more deficient than the cattle in the other experiments.

Metabolizable protein (MP) requirement and supply (microbial plus escape protein) were also estimated; MP requirement was estimated from actual ADG. It appears MP supply may have limited gains in a couple of instances. In the first experiment (Table 5), although there was a numerical increase in gain when hull-less oats replaced barley and SBM, gains may still have been limited by protein supply to the animal (MP). In the more extensive trials at Carrington (Table 7) and Fargo (Table 9) it also appears MP supply limited gains. At Carrington, gains and feed efficiency improved from the barley (0% hull-less oats) to the 67% hull-less oat treatment; DIP balance also went from negative to positive. From 67 to 100% hull-less oat treatment gain decreased while feed efficiency remained unchanged; estimated MP supply was at or below estimated requirement. Also in the Fargo finishing trial, estimated MP supply declined as hull-less oats increased in the diet and may have contributed to the decreased gains. This is also supported by the extensive lamb finishing experiment (Table 11) where gain declined as hull-less oats increased in the diet. In these finishing trials, MP supply may have been partially responsible for the decreased intake seen when feeding hull-less oats.

Hull-less oat processing

The question still remains: Do we grind, roll, or feed hull-less oats whole? The answer is not completely clear as there have been no head-to-head comparison of processed vs whole oats. As with any grain, processing increases the rate of fermentation in the rumen. With naked oats, because of the soft kernel and rapid rate of starch digestion in the rumen, processing may not be needed and may even be detrimental. An observation from the finishing trial in

Fargo, although not scientifically sound, indicates the cattle consumed more after switching from a rolled to a whole product. Gain and efficiency of the cattle after the switch also indicate the whole product was utilized by the cattle similarly to the rolled product. The difference was due solely to processing and probably reduced ruminal acidosis. The rolled hull-less oats fed at the Carrington Research and Extension center were crimped and not broken. Feeding this product was not detrimental to animal performance (Table 7) when compared with barley as was the rolled product fed in Fargo (Table 9) compared with corn. Although there are inherent differences in feeding barley and corn, the rolled oats fed in Fargo were too fine. In forage-based backgrounding diets the effect of processing may not be as great and probably is not needed. For example, the benefits of processing corn are less when fed in high roughage diets as compared to high-grain finishing diets. The reason it may not be as important is the calf or cow will spend more time ruminating when fed a high forage diet and, therefore, will chew (or re-chew) more of the grain. In addition, hull-less oat processing may not be needed in lamb finishing diets because lambs innately chew their food to a greater extent than cattle.

Conclusions

In backgrounding diets where naked oats have replaced barley and a protein source, intakes have decreased and gains have remained constant while feed efficiency improved from 3 to 16%. Feeding hull-less oats in this situation will decrease cost of gain if hull-less oats are equal to the cost of barley and protein supplement they replace. In these diets, hull-less oats have made up less than 50% of the diet and some of the imbalances and/or negative effects seen when feeding higher amounts of hull-less oats may not be substantial. Feeding higher levels of hull-less oats requires more scrutiny. High levels of fat in the diet and the rapid fermentation of hull-less oat starch may have deleterious effects in the rumen. In addition, DIP will be overfed and protein nutrition for the calf or lamb (MP) may limit gains.

Care must be taken to balance the protein of the complete diet. Because oat protein is readily digested in the rumen, very little protein escapes the rumen and may limit production. In situations where DIP is limiting production, the protein from hull-less oats may be very useful.

Table 1. Average nutrients in hull-less oats and other grains (dry matter basis).

Nutrient	Hull-less Oats[a]	Oats, 38 lb/bu	Barley, heavy	Corn
Crude Protein, %	17.2	13.6	13.2	9.8
DIP[b], % of DM	14.3	11.3	8.8	4.4
UIP[c], % of DM	2.9	2.3	4.4	5.4
Fat, %	9.9	5.2	2.2	4.1
ND Fiber[d], %	15.4	29.3	18.1	10.8

[a] *Paul* oats; average of 19 samples analyzed in 1996 and 1997. DIP and UIP are assumed to be equal to oats.
[b] Rumen degradable intake protein.
[c] Rumen undegradable intake or escape protein.
[d] Neutral detergent fiber.

Table 2. Ration and nutrient composition (dry matter basis) for backgrounding trials, Dickinson and Central Grasslands Research and Extension Centers.

Item	Dickinson REC		Central Grasslands REC	
	Barley/SBM	Hull-less Oats	Barley/SBM	Hull-less Oats
Ingredient, %				
Barley	34.1	--	49.8	--
Hull-less Oats	--	34.4	--	51.5
Corn Silage	--	--	26.9	29.1

Grass Hay	58.1	60.6	14.1	14.2
Soybean Meal	5.2	2.3	4.1	--
Supplement	2.6	2.7	5.1	5.2
Nutrient composition, %				
Crude Protein	11.6	12.1	13.2	13.7

Table 3. Effect of hull-less oats on performance and protein nutrition in backgrounding trials.

Ingredient	Dickinson REC		Central Grasslands REC	
	Barley/SBM	Hull-less Oats	Barley/SBM	Hull-less Oats
Initial weight, lb	448	443	681	680
DMI, lb/d	16.1	15.5	21.1	20.7
ADG, lb/d	1.97	1.98	2.92	3.48
F/G	8.19	8.03	7.2	6.0
MP requirement, lb/d	1.09	1.09	1.55	1.71
MP supply, lb/d	1.35	1.22	1.81	1.75
DIP balance, lb/d	-.10	+.06	-.19	+.06

Table 4. Ration and nutrient composition (dry matter basis) for backgrounding trials, Dickinson REC.

Item	Treatment, Experiment 1		Treatment, Experiment 2		
	Barley/ SBM	Hull-less Oats	Barley/ SBM	Hull-less Oats	Oats/ Peas
Ingredient, %					
Barley	63.6	22.6	29.8	--	12.9
Hull-less Oats	--	45.6	--	32.0	15.4
Field Peas	--	--	--	--	5.2
Corn Silage	--	--	39.1	39.0	38.6
Oat Hay	24.6	24.8	24.8	25.6	24.6
Soybean Meal	7.0	2.2	3.5	--	--
Supplement	4.8	4.8	2.8	3.4	3.3
Nutrient Composition					
Crude Protein, %	13.7	13.7	10.9	10.9	10.9
NE_m, Mcal/cwt	88	97	76	84	85
NE_g, Mcal/cwt	59	67	48	56	56

Table 5. Effect of hull-less oats on performance and protein nutrition in backgrounding trials, Dickinson REC.

Item	Treatment, Experiment 1		Treatment, Experiment 2		
	Barley/ SBM	**Hull-less Oats**	**Barley/ SBM**	**Hull-less Oats**	**Oats/ Peas**
Initial weight, lb	587	573	694	690	692
DMI, lb/d	17.2	15.5	25.1	21.2	22.9
ADG, lb/d	3.04	3.15	3.09	2.95	3.28
F/G	5.73	5.00	8.39	7.29	7.05
MP requirement, lb/d	1.52	1.54	1.60	1.56	1.65
MP supply, lb/d	1.68	1.41	2.18	1.73	1.92
DIP balance, lb/d	+.00	+.15	-.31	-.14	-.18

Table 6. Ration composition (dry matter basis) for cattle growing and finishing phases, Carrington REC.

Ingredient, %	Hull-less oats, % (Growing)				Hull-less oats, % (Finishing)			
	0	**33**	**67**	**100**	**0**	**33**	**67**	**100**
Barley	46.5	32.7	16.7	--	72.5	49.6	24.6	--
Canola Meal	4.2	2.3	--	--	--	--	--	--
Hull-less Oats	--	16.0	33.6	49.9	--	24.1	49.6	73.9
Corn Silage	31.1	30.8	30.9	30.8	17.4	16.0	15.3	15.5

Alfalfa/Brome Hay	16.4	16.2	16.8	17.2	--	--	--	--
Straw	--	--	--	--	8.2	8.3	8.4	8.5
Supplement	1.8	2.0	2.0	2.1	1.9	2.0	2.1	2.1

Table 7. Effect of hull-less oats on performance and protein nutrition in cattle growing/finishing experiment, Carrington REC.

Item	**Hull-less oats, %**			
	0	**33**	**67**	**100**
Overall Performance				
Initial weight, lb	634	634	635	635
DMI, lb/d	21.9	21.1	20.1	19.9
ADG, lb/d	3.33	3.45	3.51	3.43
F/G	6.58	6.10	5.73	5.81
Growing				
MP requirement, lb/d	1.58	1.62	1.57	1.60
MP supply, lb/d	1.85	1.72	1.67	1.61
DIP balance, lb/d	-.07	-.02	+.04	+.17
Finishing				
MP requirement, lb/d	1.67	1.69	1.74	1.69

MP supply, lb/d	2.04	1.91	1.74	1.66
DIP balance, lb/d	-.38	-.11	+.15	+.37

Table 8. Ration and nutrient composition (dry matter basis) for cattle finishing experiment, Fargo Experiment Station.

Item	**Hull-less oats, %**				
	0	**25**	**50**	**75**	**100**
Ingredient, %					
Corn	84.8	63.6	42.4	21.2	--
Hull-less Oats	--	21.2	42.4	63.6	84.8
Corn Silage	5.0	5.0	5.0	5.0	5.0
Alfalfa Hay	5.0	5.0	5.0	5.0	5.0
Supplement	5.2	5.2	5.2	5.2	5.2
Nutrient Composition					
Crude Protein, %	12.3	14.4	16.4	18.5	20.5
Fat, %	3.9	5.1	6.3	7.6	8.8
NDF, %	14.6	14.9	15.2	15.5	15.8
NE_m, Mcal/cwt	94.4	94.1	95.9	100.7	94.7
NE_g, Mcal/cwt	64.3	63.8	65.5	69.3	64.1

Table 9. Effect of hull-less oats on performance and protein nutrition in cattle finishing experiment, Fargo Experiment Station.					
Item	**Hull-less oats, %**				
	0	**25**	**50**	**75**	**100**
Initial weight, lb	621	621	622	624	620
DMI, lb/d	20.4	19.6	18.3	17.5	16.8
ADG, lb/d	3.30	3.13	2.98	2.87	2.62
F/G	6.19	6.23	6.14	6.05	6.36
MP requirement, lb/d	1.64	1.60	1.57	1.54	1.48
MP supply, lb/d	1.79	1.67	1.51	1.39	1.29
DIP balance, lb/d	-.06	+.31	+.64	+.95	+1.23

Table 10. Ration and nutrient composition (dry matter basis) for lamb finishing trial, Hettinger REC.				
Item	**Hull-less oats, %**			
	0	**33**	**67**	**100**
Ingredient, %				

Barley	76.0	50.5	25.5	--
Soybean meal	8.0	5.5	2.5	--
Hull-less Oats	--	28.0	56.0	84.0
Alfalfa Hay	5.0	5.0	5.0	5.0
Straw	7.0	7.0	7.0	7.0
Supplement	4.0	4.0	4.0	4.0
Nutrient composition, %				
Crude protein	16.6	17.1	17.3	18.1
Fat	2.2	3.6	5.3	7.3

Table 11. Effect of hull-less oats on lamb finishing performance, Hettinger REC.

Item	**Hull-less oats, %**			
	0	**33**	**67**	**100**
Initial weight, lb	78.6	78.8	78.3	77.5
DMI, lb/d	4.31	3.74	3.39	3.23
ADG, lb/d	.63	.60	.54	.49
F/G	6.80	6.24	6.28	6.64

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