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Amie Mass
University of Nebraska-Lincoln

Ryan Mass
University of Nebraska-Lincoln

Terry J. Klopfenstein
University of Nebraska-Lincoln, tklopfenstein1@unl.edu

D. J. Jordon
University of Nebraska-Lincoln

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Amie Mass
Ryan Mass
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Terry Klopfenstein[1]

Commercially produced hog hair meal can be improved by increasing the rigor of hydrolysis conditions. Properly processed hair meal has a protein value between soybean meal and feather meal.

Summary

A cattle growth trial, two lamb digestion trials and a lamb growth trial evaluated hog hair meal as a protein source for ruminants. Although no differences in protein efficiency were found in the cattle trial, hair meal tended to be lower in protein efficiency than feather meal and soybean meal and true nitrogen digestibility of hair meal was lower than both feather meal and soybean meal. Treatments of additional steam pressure and hydrolysis time were applied to raw hog hair. True nitrogen digestibility increased as hydrolysis time and steam pressure increased. Metabolizable protein supplied by hair meal was increased by added hydrolysis time.

Introduction

Keratin proteins are found in feather meal (FM) and hog hair meal (HM). Although these animal tissues are very high in crude protein concentration (80-100 percent), the protein is relatively unavailable to ruminants unless it is hydrolyzed (added steam pressure). Hydrolysis conditions have been optimized for FM to make it an excellent source of supplemental protein for ruminants. However, optimal hydrolysis conditions have not been defined for HM. The research objectives of this study were: 1) to evaluate the protein efficiencies of two commercially produced HM sources relative to FM and soybean meal (SBM); 2) to estimate true nitrogen digestibilities of these HM sources; 3) to test effects steam pressure and rendering time have on true nitrogen digestibility of HM; and 4) to evaluate protein efficiency of optimal HM treatments.

Procedure

Trial 1: Calf growth study

British crossbred steers (n = 120; 592 lb) were fed individually (at equal percentage of body weight) a diet containing 44 percent sorghum silage, 44 percent ground corncobs, and 12 percent supplement once daily using Calan electronic gates. Calves were assigned randomly to one of eight supplement treatments: urea control, SBM, FM, two HM (each from separate rendering facilities; HM1 and HM2) and each of the keratin proteins with added blood meal (FMB, HMB1 and HMB2, respectively; Table 1). The exact processing conditions of each HM were not known. Protein sources were fed at 30, 40, 50 and 60 percent of the supplemental CP, with urea providing the remaining CP necessary to balance each diet at 11.5 percent CP (DM basis). Weights were measured on three consecutive days at beginning and end of the 84-day trial. Protein efficiency, calculated as gain above the urea control versus natural protein intake, was calculated for each treatment using the slope-ratio technique.

Trial 2: Lamb digestion study

A lamb digestibility trial was conducted using 21 crossbred wether lambs to evaluate true nitrogen digestibility of keratin proteins from Trial 1 relative to a urea control diet. Lambs were fed individually (at equal percentage of body weight) a basal diet of ensiled corncobs and alfalfa pellets supplemented with one of the protein sources. The trial consisted of two 21-day periods. Each period included 10 days of diet adaptation, four days of crate adaptation and seven days of total fecal collection. Lambs were housed in individual pens during the 10-day diet adaptation phase. Lambs were reassigned randomly to another

Table 1. Supplements fed to growing steers (Trial 1)[a]

Ingredients	UREA	SBM	FM	FMB	HM1	HMB1	HM2	HMB2
Soybean hulls	73.8	17.8	47.3	47.4	27.7	32.1	12.9	21.2
Urea	14.5	6.9	6.9	6.9	7.0	7.0	7.0	7.0
Soybean meal	—	65.2	—	—	—	—	—	—
Feather meal	—	—	34.9	27.9	—	—	—	—
Hair meal 1	—	—	—	—	54.8	43.0	—	—
Hair meal 2	—	—	—	—	—	—	69.9	53.6
Blood meal	—	—	—	6.7	—	7.3	—	7.8
Dical[b]	7.2	5.6	6.3	6.5	5.9	6.1	5.5	5.9
Salt	2.3	2.3	2.3	2.3	2.4	2.3	2.4	2.4
Amm. sulfate	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Trace mineral[c]	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Vitamins[d]	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Se premix[e]	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Limestone	—	—	—	—	—	—	0.1	—

[a]Urea control (UREA), soybean meal (SBM), feather meal (FM), feather meal:blood meal (FMB), hair meal 1 (HM1), hair meal:blood meal (HMB1), hair meal 2 (HM2), and hair meal 2:blood meal (HMB2).
[b]Dicalcium phosphate.
[c]Premix contained 10 percent Mg, 6 percent Zn, 4.5 percent Fe, 2 percent Mn, .5 percent Cu, .3 percent I, and .05 percent Co.
[d]Premix contained 5,000 IU vitamin A, 3,000 IU vitamin D, 3.75 IU vitamin E per gram of premix.
[e]Premix contained .06 percent Se.

treatment at the end of each period. The amount of basal diet offered to each lamb was adjusted based on a weight taken at the beginning of each period. Feed, feces and orts were collected and analyzed for DM and nitrogen concentration.

Trial 3: Hydrolysis conditions and digestibility

Raw hog hair was hydrolyzed at different levels of steam pressure and time using a test cooker. Both internal and jacket steam were used to regulate the pressure. Six treatments (45-45, 45-90, 45-120, 45-150, 60-90 and 70-45 psi and minutes, respectively) were analyzed using the same procedures stated in Trial 2, with the exception of the basal diet of the digestion trial. Because of greater palatability, cottonseed hulls replaced ensiled corncobs.

Trial 4: Lamb growth study

Crossbred wether lambs (n = 60; 73 lb) were fed individually (at equal percentage of body weight) a diet consisting of 70 percent sorghum silage, 10 percent starch, 4 percent molasses, 2 percent Alifet® , 2 percent tallow and 12 percent supplement. Lambs were assigned randomly to one of six supplement treatments: urea control, FM, HM1 (from Trial 1), 45-120, 60-90 and 70-45 (from Trial 3). Keratin protein sources were fed at 30, 40, 50 and 60 percent of the supplemental CP, with urea providing the remaining CP necessary to balance each diet at 11.5 percent CP (DM basis). All supplements (except the urea control) contained blood meal. Initial and final weights were collected over three consecutive days at the beginning and end of the 60-day trial. Protein efficiency was calculated as in Trial 1.

The undegraded intake protein (UIP) concentration of proteins in each trial was estimated by the in-vitro ammonia release procedure. Rumen fluid was collected from a ruminally fistulated steer and strained through four layers of cheese cloth. A bicarbonate buffer solution was added to the rumen fluid and 30 ml of the fluid mixture were added to test tubes containing enough sample to provide 20 mg of nitrogen. Six tubes were incubated for each sample. Tubes were stoppered and incubated for two time periods (three for 18 hours and three for 24 hours) at 102°F. The ammonia concentration of the fluid in each tube was used to calculate UIP relative to standards whose *in vivo* UIP concentrations were measured.

Results

Trial 1: Calf growth study

Average daily gain and feed efficiency were similar among all protein sources (data not shown). Protein efficiency was highest for FMB (1.80), followed by FM (1.35), HMB1 (1.22), SBM (1.00), HMB2 (.67), HM1 (0.59) and HM2 (0.30; Table 2). No significant differences were detected among protein sources. However, numerical differences suggest FM, FB and HB1 have higher protein efficiencies than SBM, but HM alone is not as effective as either FM or SBM. This is because the amino acid profile of HM is not balanced and blood meal enhances that profile. The data also suggest not all sources of HM are equal in protein efficiency.

Trial 2: Lamb digestion trial

The lowest true nitrogen digestibility was found for HM2 (33.1 percent: Table 3). Soybean meal (90.6 percent) and feather meal (80.3 percent) were not different from each other but were higher in true nitrogen digestibility than both HM sources evaluated (*P* < .05). A difference (*P* < .05) was detected between HM1 (60.3 percent) and HM2 indicating that the hydrolysis method used for HM2 was not as effective as that used for HM1. The lower true nitrogen digestibilities of the two HM, compared with FM, suggest processing conditions for hair meal are not optimal.

Table 2. Efficiency of proteins fed to growing steers in Trial 1.

Treatment	PE[a]	SE[b]
Soybean meal	.95	.35
Feather meal	1.35	.53
FMB[c]	1.80	1.00
HM1[d]	.59	.35
HMB1[e]	1.22	.52
HM2[f]	.30	.39
HMB2[g]	.67	.39

[a]Protein efficiency (PE) calculated as the ratio of gain above the urea control over natural protein intake.
[b]Standard error of protein efficiency estimate.
[c]Feather meal:blood meal.
[d]Hair meal #1.
[e]Hair meal #1:blood meal.
[f]Hair meal #2.
[g]Hair meal #2:blood meal.

Although it had the highest UIP concentration (85.9 percent of CP), calculated MP was lowest for HM2 (19.0 percent of CP; Table 4). Feather meal had the highest MP (63.7 percent), followed by HM1 (38.0) and SBM (20.6). This indicates a high UIP concentration does not necessarily translate into a high degree of available protein for the animal.

Trial 3: Hydrolysis conditions and digestibility

True nitrogen digestibility of HM increased with both increased hydrolysis time and increased steam pressure (Table 4). On the other hand, UIP concentration of hydrolyzed HM decreased with additional pressure and time. The 70-45 treatment had the highest true nitrogen digestibility (81.1 percent) and the lowest

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Table 3. Crude protein, undegraded intake protein (UIP), true nitrogen digestibility (TND) and metabolizable protein (MP) concentrations of proteins tested in Trial 2.

Treatments	CP (percent of DM)	UIP (percent of CP)[a]	TND[b]	MP (percent of CP)[c]
Soybean Meal	48.0	30.0	90.6[d]	20.6
Feather Meal	95.6	83.0	80.4[d]	43.3
Hair Meal #1	90.3	77.6	60.4[e]	38.0
Hair Meal #2	87.2	85.9	33.1[f]	19.0

[a]Measured by the in vitro ammonia release procedure.
[b]Standard error of TND estimate = .13.
[c]MP = UIP - (100 - TND).
[d,e,f]Means with unlike superscripts differ (P < .05).

Table 4. Effect of steam pressure and time on undegraded intake protein concentration (UIP), true nitrogen digestibility (TND) and calculated metabolizable protein concentration (MP) of hog hair in Trial 3.

Pressure[a]	Time (min)	UIP (percent of CP)[b]	TND	MP[c]
45	45	77.4	63.7	41.1
45	90	75.9	68.9	44.8
45	120	72.5	72.4	44.9
45	150	63.7	77.9	41.6
60	90	54.5	79.4	33.9
70	45	52.8	81.1	33.9

[a]Pounds per square inch of pressure applied during hydrolysis.
[b]Measured by the in vitro ammonia release procedure.
[c]MP = UIP - (100 - TND).

Table 5. Efficiency of proteins fed to growing lambs in Trial 4.

Treatment	PE[a]	SE[b]
Feather meal	1.75[g]	.23
Hair meal #1[c]	.18[h]	.24
45-120[d]	.80[g,h]	1.35
60-90[i]	.32[h]	.25
70-45[f]	.13[h]	.21

[a]Protein efficiency calculated as the ratio of gain above the urea control over natural protein intake.
[b]Standard error of protein efficiency estimate.
[c]Commercially produced hair meal from Trial 1 (processing conditions unknown).
[d]Hair hydrolyzed at 45 psi for 120 min.
[e]Hair hydrolyzed at 60 psi for 90 min.
[f]Hair hydrolyzed at 70 psi for 45 min.
[g,h]Means with unlike superscripts differ (P < .05).

UIP concentration (52.8 percent of CP) of all treatments. Calculated MP supply was highest for both 45-90 and 45-120 (44.8 and 44.9 percent of CP, respectively). These data suggest optimal hydrolysis conditions for HM treated in this type of cooker are 45 psi of steam pressure for 90 minutes. Optimal conditions may vary in a commercial setting.

Trial 4: Lamb growth trial

Protein efficiencies measured in this trial are found in Table 5. The highest protein efficiencies were found for FM and 45-120. These values were not different (P < .05), suggesting HM protein can approach the protein quality of FM. Both 45-120 and FM were higher in protein efficiency than commercially produced HM1, 60-90, and 70-45 hair meals (P < .05). These data reflect findings of Trial 3, which showed 45-120 yielded the optimal calculated MP supply. The data also confirm the findings of Trial 1 in which HM1 tended to be lower in protein efficiency than FM.

The research demonstrates the range of protein quality found in HM currently available to livestock producers and begins to describe hydrolysis conditions necessary for optimal supply of MP to the animal. The MP values measured suggest HM, when properly processed, has a protein value between SM and FM when amino acid balance is corrected by addition of complementary protein sources such as blood meal.

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[1]Amie Mass, former graduate student, Ryan Mass and D.J. Jordon, research technicians , and Terry Klopenstein, professor, Animal Science, Lincoln.