ALKALINE HYDROGEN PEROXIDE TREATED ASPEN AS A RUMINANT FEED[1]

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Summary

Two experiments were conducted to evaluate the nutritive value of a diet containing 20% alkaline hydrogen peroxide(AHP) treated aspen sawdust for ruminants. In experiment 1, sheep fed treated aspen(treated) had higher ($p < 0.05$) average daily gain and improved feed/gain ratio compared to animals fed untreated aspen (untreated). Apparent NDF and ADF digestibilities of treated aspen were higher ($p < 0.05$) than for untreated material. A similar trend was observed for DM, organic matter and cellulose digestibilities coefficients. In experiment 2, the soluble and degradable DM and crude protein (CP) fractions tended to increase with AHP treatment. Treatment also increased ($p < 0.05$) the degradation rate of the degradable fraction.

Results of these experiment indicate that AHP treatment results in a substantial improvement in the extent of utilization of aspen sawdust by ruminants.

(Key Words: Alkaline Hydrogen Peroxide, Aspen, Sheep, Mobile Nylon Bag)

Introduction

In many countries forage is in scarce supply as the ruminant animal is unable to compete with man and non-ruminants for available land. With a growing world population the ruminant animal will face even more intense competition in the future. Under these circumstances the ruminant will have a greater dependence on agricultural by-products, wood residues and low quality forages as energy sources (Keith and Daniels, 1978). Although aspen contains 70 to 80% carbohydrate, its utilisation as an energy source by ruminants has been limited due to its high lignin content. The association of lignin with phenolic acid and/or other carbohydrates results in highly crystalline cellulose which microbial digestion in the rumen (Jung and Fahey, Jr., 1983).

Many workers (Butterbaugh and Johnson, 1978; Mellenberger et al., 1971; Millet et al., 1970; Wilson and Pidgen, 1964) have utilised chemical and/or physical treatment of aspen to increase its digestibility. However, the results of chemical treatment have not been sufficiently favorable to permit their widespread commercial use.

Since it has been demonstrated that alkaline hydrogen peroxide (AHP) degrades not only lignin but also phenolic lignin units in wood (Agnemo and Gellerstedt, 1979; Gellerstedt et al., 1980), this treatment has been successfully applied to agricultural by-products to enhance their nutritive value for ruminants (Keith and Daniels, 1978; Kerley et al., 1987).

In sacco studies (Myung et al., unpublished) have demonstrated that AHP treatment markedly improved rate and extent of ruminal digestion of aspen.

The object of these experiments was to further evaluate AHP treated aspen as a ruminant feed.

Materials and Methods

Aspen sawdust was obtained from a sawmill that cuts bark-free logs of Populus alba x Populus grandulosa. After air-drying for about 48 h, the sawdust was ground through a 2 mm sieve. Half of the sawdust was fed without treatment(untreated), while the remainder (treated) was treated by preparing a suspension of substrate and water (4% w/v) and water and H_2O_2 (1% w/v). The mix-

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ture was incubated for 100 h at 25°C, with stirring, at pH of 11.5 (Gould, 1984). After 100 h reaction time the insoluble material was collected by filtration, washed with water until the filtrate was pH > 8 and dried at 60°C in a forced-air oven for 48 h.

Experiment 1: Sheep growth and digestion trials.

Eight Suffolk lambs (mean BW, 35 kg) were assigned in a completely randomized design to two diets (table 1). Treated and untreated aspen sawdust were included at 20% of the diet (dry matter (DM) basis) at the expense of ground corn. Diets were balanced to meet NRC (1975) recommendations for finishing lambs (35 kg) and pelleted (0.6 cm).

Animals were tethered in elevated mesh-bottom metabolism crates in a temperature-controlled (16°C) room with constant fluorescent lighting. During the growth trial animals were fed ad libitum. During the digestion trial intake was restricted to 90% of ad libitum and animals were fed twice daily (07:30 and 19:30 h) during the digestion trial. Ad libitum and 90% of ad libitum intake were established prior to growth and digestion trials respectively. Water and trace-mineralized salt[4] were available continually.

Body weight and feed intake were measured weekly and daily, respectively, during the growth period. Total collections of feces were made over a 7-day period during the digestion trial. One-tenth aliquots of daily fecal collections were composited each day and stored at −20°C.

Experiment 2: Mobile nylon bag trial.

Two non-lactating Holstein cows were fed a 52:48 forage to concentrate diet (table 4) twice daily in equal portions at 07:00 and 17:00 h. The cows were fitted with rumen and duodenal cannulae. Nylon bags (5.5 x 7.0 cm) (de Boer et al., 1987) containing test diets (ground through 1 mm screen) were incubated in quadruplicate in the rumen for 0.1, 2, 4, 8, 12, 24 and 48 h. Two bags from 8, 12, 24 and 48 h incubation time were inserted into the small intestine through the duodenal cannula, using a pair of curved forcepts, at a rate of one bag per 20 min. Upon recovery from the rumen and feces, bags were washed prior determination of DM and CP. After drying at 60°C in a forced air oven for 48 h, bags plus contents were weighed and analyzed for protein content.

Fraction sizes and rumen degradation characteristics of diets were calculated (Orskov and McDonald, 1979). Whole tract DM and crude protein (CP) disappearance were calculated from the proportion remaining in the bag; where total disappearance is the sum of rumen plus intestinal disappearance for 8, 12, 24 and 48 h incubation. Gross energy of samples were measured in a Parr adiabatic bomb calorimeter, DM by AOAC method (1985), CP by the Kjeldahl procedure, and fibers according to methods of Robertson and Van Soest (1977) and Georing and Van Soest (1970). Differences between untreated and treated diets was tested by pair-T tests (Steel and Torrie, 1960).

Results and Discussion

Experiment 1: Sheep growth and digestion trials.

Chemical composition of diets is presented in table 1. Dietary concentrations of neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), cellulose and hemicellulose were influenced by AHP treatment. The diet containing AHP treated aspen sawdust tended to have higher concentrations of NDF, ADF and hemicellulose, and lower concentration of ADL than the untreated diet. The AHP treatment of aspen sawdust removes cell solubles, hemicellulose and ADL (Myung et al., unpublished). Lambs consuming the AHP treated diet gained significantly ($P < 0.05$) faster than lambs consuming the untreated diet (table 2). Lambs fed the treated diet consumed more ($P < 0.05$) DM daily than those fed the untreated diet. Less ($P < 0.05$) feed per kilogram of gain was required by lambs consuming the treated diet than those fed untreated aspen sawdust. In addition less ($P < 0.05$) non-wood DM per kg of gain was needed with the treated diet. Thus, the AHP treated diet supported maintenance and gain more efficiently than the untreated diet. These results are in contrast to that of Keith and Daniel (1978) who concluded that there were no significant ($P < 0.05$) differences in weight gains, feed intake and feed efficiency for cattle fed concentrates containing 25% of a 1% NaOH treated wood residue, compared to

[4] Containing 40 mg/kg Co, 70 mg/kg I and 99.9 % NaCl.

TABLE 1. FORMULATION AND CHEMICAL COMPOSITION OF EXPERIMENTAL DIETS

Item	Untreated[1]	Treated[2]
Formulation (% DM basis)		
Ground corn	66.3	66.3
Soybean meal	8.0	8.0
Molasses	5.0	5.0
Untreated aspen	20.0	–
Treated aspen	–	20.0
Calcium carbonate	0.5	0.5
Vitamin A,D and E[3]	0.2	0.2
Chemical composition (% DM basis)		
Gross energy (Mcal/kg)	3.5	3.0
Crude protein	11.85	11.46
Neutral detergent fiber	27.07	30.81
Acid detergent fiber	15.24	16.89
Acid detergent lignin	3.01	1.70
Cellulose	15.23	15.86
Hemicellulose	11.83	13.92

[1]Untreated aspen was added at 20% of the diet on a dry matter basis.

[2]Aspen delignified with alkaline hydrogen peroxide at 25°C for 100 h was added at 20% of the diet on a dry matter basis.

[3]Contained 1,200,000 IU of vitamin A, 120,000 IU vitamin D and 8,400 IU vitamin E/0.38 Kg.

TABLE 2. EFFECT OF ADDING 20% UNTREATED OR ALKALINE HYDROGEN PEROXIDE TREATED ASPEN (P.ALBA X P. GRANDULOSA) ON GROWTH AND FEED EFFICIENCY OF LAMBS

Item[1]	Untreated[2]	Treated[3]	SE[4]
No. of lambs	4	4	
Body weight (kg)	35.4	35.7	2.67
Weight gain (kg)	4.44	5.51	0.12
Avg. daily gain (kg)	0.22	0.26	0.01
Dry matter(DM) intake ($kg\ d^{-1}$)	1.62	1.82	0.06
DM intake/kg gain (kg)	7.62	6.92	0.06
Non-wood DM intake/kg gain (kg)	6.07	5.54	0.05

[1]Significant ($p < 0.05$) treatment effects for all items were observed.

[2,3]See table 1.

[4]Standard error of the mean.

those fed untreated wood residue. However they suggested that factors such as heat stress or physical characteristics of the cattle may have influenced their results.

Digestion coefficients for NDF and ADF were higher ($p < 0.05$) for diet containing AHP treated aspen than for diet containg untreated aspen (table 3). A similar trend was observed for DM, organic matter and cellulose digestibilities, although the differences were not significant ($p > 0.05$).

Results for DM digestibility are similar to those of Mellenberger et al. (1971) in which non-significant increases in DM, energy and carbohydrate digestibility were observed in response to sodium

TABLE 3. DIGESTION COEFFICIENTS FOR DIETS CONTAINING 20% UNTREATED OR ALKALINE HYDROGEN PEROXIDE TREATED ASPEN (P. ALBA X P. GRANDULOSA)

Item	Untreated[1]	Treated[2]	SE[3]
Dry matter	75.0	77.4	1.1
Organic mater	72.9	76.7	1.7
Crude protein	61.1	61.9	1.8
Neutral detergent fiber	28.1[a]	36.8[b]	1.4
Acid detergent fiber	24.1[a]	33.3[b]	1.5
Cellulose	36.1	38.3	1.6

[1,2]See table 1.

[3]Standard error of the mean.

[a,b]Means in the same row with different superscripts differ ($p < 0.05$).

TABLE 4. COMPOSITION OF DIET[1] FED TO HOLSTEIN COWS

Ingredients	%, DM basis
Oat silage	52.00
Rolled barley	45.01
Canola meal	0.57
Fish meal	0.36
Wheat shorts	0.55
Ground shell corn	0.90
Molasses	0.55
Monophosphate	0.01
Trace mineral[2]	0.05

[1]The diet contained 47.8% DM and 11.9% CP.

[2]Containing 25 mg/kg. Se, 40 mg/kg Co, 0.35% Mg, 25% Cu, 0.01% I and 0.75% Zn.

TABLE 5. FRACTION SIZES AND RUMEN DEGRADATION CHARACTERISTICS OF DIETS CONTA N-ING 20% UNTREATED OR ALKALINE HYDROGEN PEROXIDE TREATED ASPEN (P. ALBA x P. GRANDULOSA) AS ESTIMATED BY THE NYLON BAG PROCEDURE

Parameters[1]	Untreated[2]	Treated[3]	SE[4]
Dry matter			
Soluble (% of total)	35.6	36.2	0.2
Degradable (% of total)	39.9	40.7	0.1
Undegradable (% of total)	24.5	23.1	0.1
Degradation rate of the degradable fraction (h^{-1})	0.06[a]	0.08[b]	0.01
Lag time (h)	6.6[a]	0.8[b]	0.1
Crude protein			
Soluble (% of total)	37.5	36.7	0.2
Degradable (% of total)	29.7	34.4	0.6
Undegradable (% of total)	32.8	28.9	0.1
Degradation rate of the degradable fraction (h^{-1})	0.08[a]	0.04[b]	0.01
Lag time (h)	4.7[a]	4.2[b]	0.1

[1]See text for definition of parameters
[2,3]See table 1.
[4]Standard error of the mean
[a,b]Means in the same row with different superscripts differ ($p < 0.05$).

TABLE 6. WHOLE TRACT DISAPPEARANCE OF DRY MATTER AND CRUDE PROTEIN OF DIETS CONTAINING 20% UNTREATED OR ALKALINE HYDROGEN PEROXIDE TREATED ASPEN (P. ALBA X P. GRANDULOSA) AS ESTIMATED BY THE MOBILE NYLON BAG PROCEDURE

Item	Diets[1]	Site of disappearance	Rumen incubation time, (h)				SE[2]
			8	12	24	48	
Dry matter	Untreated						
		Rumen[3]	52.6	55.8	66.0	73.8	2.3
		Intestine[4]	24.4	23.2	14.7	7.8	0.1
		Total tract[5]	77.0	79.0	80.7	81.6	1.5
	Treated						
		Rumen[3]	50.0	52.3	66.3	76.0	1.0
		Intestine[4]	27.1	25.1	12.7	3.2	0.1
		Total tract[5]	77.1	77.4	79.0	79.2	2.7
Crude protein	Untreated						
		Rumen[3]	45.9	48.1	62.6	65.6	0.9
		Intestine[4]	44.9	43.2	30.2	31.1	1.1
		Total tract[5]	90.8	91.3	92.8	96.7	4.6
	Treated						
		Rumen[3]	42.2	47.1	57.3	66.5	1.9
		Intestine[4]	50.5	46.1	36.1	29.6	0.2
		Total tract[5]	92.7	93.2	93.4	96.1	3.5

[1]See table 1.
[2]Standard error of the mean.
[3,4,5]See text for the definition of disappearance.

hydroxide treatment of aspen sawdust incorporated at 20% of the concentrate diet for goats. These authors suggested that increased of NDF, ADF and cellulose, and decreased ADL with AHP treatment significantly ($P < 0.05$) improved NDF and ADF digestibilities of the treated diet by saponifying ester bonds of lignin and lignin-cellulose. Relatively low digestibilities of NDF, ADF and cellulose in this experiment may be related to their low concentration in the diet.

Experiment 2: Mobile nylon bag trial.

Fractional sizes and rumen degradation characteristics of diets are presented in table 5. While DM soluble and degradable fractions increased slightly, DM undegradable fraction tended to decrease with AHP treatment. Degradation rate of the degradable fraction was significantly ($P < 0.05$) faster and lag time considerably shorter ($P < 0.05$) with AHP treatment. Similar results were observed for CP except that degradation rate of the degradable CP fraction was significantly ($P < 0.05$) slower with AHP treatment. Results for ruminal degradation of DM and CP are consistent with more microbial colonization of the feed was due to AHP treatment (Kerley et al., 1985).

Whole tract disappearance of test diets as estimated by the mobile nylon bag procedure are shown in table 6. As the rumen incubation time increased, intestinal disappearance rate decreased for both DM and CP, due to more extensive ruminal digestion of nutrients. No differences in DM disappearance were observed for treated and untreated diets. Whole tract CP disappearance tended to be slightly higher for the treated diet.

Results of these experiments demonstrate that AHP treatment of aspen sawdust increases ruminal digestion, supporting the contention (Kerley et al., 1985) that the treatment of lignocellulosic material with AHP results in a feedstuff which is more efficiently utilised by ruminants.

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