KINETICS OF DIGESTION OF AMMONIATED WHEAT STRAW: SITES OF DIGESTION OF ORGANIC MATTER AND CONTRIBUTION OF MICROBIAL NITROGEN TO TOTAL NITROGEN REACHING THE SMALL INTESTINE OF STEERS

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Story in Brief

In order to fully understand the effect that the ammoniation of wheat straw has on its nutritive value for ruminants, data on digestion of organic matter (OM) within the rumen and the contribution of microbial protein in relation to the total protein available to the animal, is required. This study was conducted to bring some light on this topic. The percentage true disappearance of ruminal OM was 56.6 and 39.7 (SEM 4.8) for ammoniated straw and untreated straw, respectively. The total amount of true protein (lb/day) reaching the small intestine digestion was 1.28 and .79 (SEM .14) for ammoniated straw and untreated straw, respectively. Out of these amounts, .27 and .46 lb/day (SEM .06) were of microbial origin. A more balanced ruminal fermentation seemed to be achieved with ammoniated wheat straw. In addition to the chemical effect that ammoniation of straw had on digestibility of the cellulose fraction of the straw, the nitrogen added to straw resulted in an increased level of microbial protein available to the animal, reducing the need for supplementary conventional crude protein in the whole ration.

Introduction

The effect of alkali treatment of low quality roughages on voluntary intake and chemical composition is widely documented in the scientific literature. For an adequate understanding of the mechanisms by which ammoniation of wheat straw improves animal performance, it is essential to know its effect on ruminal digestion and utilization of the ammonia nitrogen added to the straw. The latter concept should be addressed in terms of microbial nitrogen and its total contribution to the animal. Understanding of these concepts will allow integration of more precise and economic protein supplementation programs for ruminants fed ammoniated crop residues. With these objectives in mind, the present experiment was conducted with rumen and duodenal cannulated steers fed untreated or ammoniated wheat straw.

Materials and Methods

Four mature Hereford x Angus steers (1205 lb) fitted with rumen and duodenal cannulae were used in a cross-over experimental design and fed stack ammoniated (40 g NH_3/kg DM) or untreated wheat straw plus 65 g of urea/head/day. The amount of urea fed to steers that received untreated straw was intended to be equivalent to the increased crude protein consumed by steers fed ammoniated straw. Ammoniated wheat straw was offered on the same DM basis as the ad libitum intake observed for

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steers fed untreated straw. Feed was offered twice a day, and consisted of either kind of straw and two sources of supplements. Composition and level of feeding for supplements employed is shown in Table 1. Supplement 1 was formulated to fulfill requirements for phosphorus, sulphur, magnesium, trace minerals and vitamin A, according to NRC Tables (1976). Supplement 2 was used as a vehicle for chromium oxide powder used as indigestible marker. Each of the two experimental periods conducted consisted of a 15-day adjustment period, followed by a 3-day collection period, during which rumen, duodenal digesta and fecal grab samples were collected three times (2, 6 and 10 hours after feeding). Duodenal samples were composited across collection times for each animal and were frozen prior to lyophilization. All or part of the following chemical analyses were conducted on feed, strained rumen fluid, duodenal and fecal samples: dry matter, ash, total nitrogen, pH, ammonia nitrogen, microbial nitrogen, fiber fractions, in vitro dry matter digestibility (IVDMD) and chromium.

Table 1. Supplement composition and level of feeding.

Ingredient	Percentage (as-fed)
Supplement 1 (fed at level of .88 lb/head/day)	
Corn	53.2
Dicalcium phosphate	22.7
Trace-mineralized salt	11.4
Sodium sulphate	8.8
Magnesium oxide	3.7
Vitamin A acetate	+[a]
Supplement 2 (fed at level of 1.1 lb/head/day)[b]	
Cottonseed hulls	93.2
Dry molasses	2.8
Chromium oxide	4.0

[a]To supply 30,000 IU/head/day.
[b]To supply 20 g chromium oxide/head/day.

Results and Discussion

Ammoniation of wheat straw improved its crude protein content, and digestibility in vitro, and reduced its cell wall constituents (Table 2). Effects of ammoniation of wheat straw on intake, site and extent of digestion of nutrients are summarized in Table 3. Similar intakes among straw sources were intended in order to isolate the effect of ammoniation in terms of extent of digestion of straw in the rumen and the nutritive value of the increased crude protein of ammoniated straw. This second effect was evaluated in terms of the contribution of microbial protein to the total protein available for intestinal digestion to the animal. An unexpected low intake of untreated straw by one steer during one period, was responsible for the numerical differences in the mean intakes of OM and N recorded among treatments. Because of this, it is expected that estimates on total protein reaching the small intestine and its microbial component were both favored by higher intakes as well as ammoniation. On the other hand, the apparent higher efficiency for synthesis of microbial protein per unit of OM

Table 2. Effect of ammoniation on chemical composition and in vitro dry matter digestibility (IVDMD) of wheat straw (% DM).

Item	Type of straw	
	Untreated	Ammoniated
Crude protein	4.0	11.8
Neutral detergent fiber	81.4	74.1
Acid detergent fiber	58.1	55.9
IVDMD	21.8	35.5

truly digested in the rumen for the untreated straw, is favorably biased for the same reason. Although this condition therefore precludes straight comparison among sources of straw, a general trend is apparent towards a higher proportion of OM of ammoniated straw being digested in the rumen, with a higher flow of microbial protein into the duodenum (Table 3). Whatever the origin of the increased protein reaching the small intestine of steers consuming ammoniated wheat straw was, the net benefit observed would allow for a reduction on the amount of conventional supplementary crude protein required in the diet to satisfy

Table 3. Nutrients intakes, sites of digestion and nutrients flows at the duodenum level.

Item	Type of straw	
	Untreated	Ammoniated
Organic matter, lb/day		
Intake	7.74	11.18
Duodenal flow	4.99	5.74
True rumen disappearance	3.28	6.34
Total tract apparent digestibility, %	37.5	58.1
True rumen digestibility, %	39.7	56.5
Nitrogen, lb/day		
Intake	.161	.231
Duodenal flow		
Total N	.141	.222
True protein (NAN[a]*6.25)	.788	1.278
Microbial nitrogen		
Duodenal flow, lb/day		
Total N (Nucl ac/.16)	.054	.088
True protein (Mic CP/.8)	.269	.461
Microbial N/total duodenal N	.38	.41
Microbial N/total duodenal NAN	.43	.45
g Microbial N/kg OM truly digested in rumen[b]	16.4	13.8

[a]NAN = non-ammonia nitrogen.
[b]Metric system units most commonly employed.

Table 4. Rumen ammonia-nitrogen (NH_3-N, mg/100ml) and pH values at various times after feeding.

	Hours After Feeding					
	2		6		10	
	NH_3-N	pH	NH_3-N	pH	NH_3-N	pH
Type of straw:						
Untreated	23.8	7.1	13.5	6.9	14.1	6.7
Ammoniated	19.3	7.0	3.0	6.6	2.8	6.7

animals needs. The higher intake attained with steers fed ammoniated wheat straw is a common response observed with the treatment of low quality roughages, and to some extent, responsible for the amount of nutrients digested in the rumen and flowing out of it, as measured in this trial.

Ruminal fluid pH values (Table 4) were typical of high roughage diets and not different with time after feeding, nor among straw treatments. Ammonia-N concentrations (Table 4) were higher for steers fed untreated straw at 6 and 10 hours after feeding, when effects of urea supplementation should not have been present. These high ruminal NH_3N concentrations may be an indication of reduced utilization of ammonia by ruminal microbes due to energy deficiency . Low ruminal ammonia values for the steers fed ammoniated straw on the other hand, may reflect a more synchronous release of dietary energy and nitrogen, allowing bacteria to transform a considerable amount of nitrogen into microbial protein. Ammoniation of wheat straw therefore renders the straw more nutritious as a result of increased ruminal digestion of OM and increased nitrogen for microbial synthesis of protein in a more synchronized and theoretically efficient fashion. The animal benefits from all these by obtaining a higher supply of energy as volatile fatty acids from the rumen, and more protein at the intestinal level.

Literature Cited

National Research Council. 1976. Nutrient Requirements for Domestic Animals. No.4. Fifth Ed. National Academy of Science. Washington DC.