PROCESSED GRAINS: DISAPPEARANCE OF DRY MATTER AND STARCH FROM MOBILE DACRON BAGS

Hector Anzola[1], Beth Doran[1] and F.N. Owens[2]

Story in Brief

Site and extent of disappearance of dry matter and starch from 14 different combinations of grains and processing methods were measured using calves equipped with ruminal and intestinal cannulas and ileorectal anastomoses. Digestion in the rumen was estimated from disappearance after 15 h of incubation. For postruminal digestion, bags were incubated for 3 h in pepsin-HCl, inserted into the duodenal cannula and recovered when defecated. Rolling whole corn or oats increased disappearance of dry matter and starch both in the rumen and in the small intestine. Compared with rolled grain, steam flaked grain had greater disappearance of DM in the rumen for corn and milo grains. Ruminal starch disappearance was increased by flaking each of the grains. Ensiling rolled corn, especially at 35% moisture, increased disappearance of dry matter and starch in the rumen and in the intestines. As corn and milo were more extensively processed, intestinal supply of digestible starch tended to increase. Changes in site of starch digestion with processing of wheat, barley and oats were minor as compared with corn and milo.

(Key Words: Mobile Dacron Bag, Starch Digestion, Grains, Processing, Ruminal Bypass.)

Introduction

Starch digestion in the rumen and intestines for various grains was reviewed recently (Owens et al., 1986). Corn and milo grains are processed routinely to increase total tract digestion of starch. Effects of various methods of processing of cereals remain poorly defined regarding quantitative changes in ruminal escape and in small intestinal digestion of escape starch.

The objective of this experiment was to determine the impact of grain source and grain processing on the extent of disappearance of dry matter and starch in the rumen and the small intestine of calves.

Materials and Methods

Experimental methods for measuring ruminal and intestinal disappearance of dry matter and starch are described in a companion paper (Anzola et al., 1988). In addition, feed samples and bags containing residues were subjected to dry matter and starch analyses.

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[1]Graduate Assistant [2]Regents Professor

Results and Discussion

Dry matter disappearance at various sites of the digestive tract for the 14 feeds are presented in table 1. Processing drastically increased ruminal and total tract disappearance of dry matter. Ruminal, total tract and postruminal DM disappearance of whole corn and whole oats were very low; digestion at each site was increased ($P<.05$) by dry rolling. Compared to rolling of the grain, steam flaking increased ($P<.05$) ruminal digestibility for corn and milo but not for wheat or barley. Steam flaking also increased ($P<.05$) intestinal disappearance of DM from corn, milo and wheat but not for barley. Ensiling rolled corn to form the high moisture corn tended to increase ruminal, intestinal and total tract disappearance of DM. Though ruminal and total tract disappearance were changed less by fermentation than by steam flaking, amounts of dietary DM disappearing in the small intestine from these two processing methods were virtually identical.

Total tract dry matter disappearance in pigs of ground barley from mobile nylon bags was studied by Sauer et al. (1984). Their values exceeded ours, probably due to the fine grinding which they used plus fermentation in the large intestine of their pigs which was avoided by our anastamoses. Fine grinding usually increases extent of disappearance in the rumen and the small intestine.

Table 1. Effect of processing grains on dry matter disappearance from mobile dacron bags.

	Mobile bag disappearance of protein			
Feedstuffs	Ruminal (15 h) %	Total tract %	Small intestine by difference %	% of supply
Corn				
Whole shelled	3.8^{g}	4.8^{g}	1.0^{g}	1.0
Dry rolled	19.1^{ef}	46.1^{e}	27.0^{e}	33.4
25% moisture	19.4^{ef}	56.7^{d}	37.3^{cd}	46.3
35% moisture	27.2^{cd}	66.3^{c}	39.1^{cd}	53.7
Steam flaked	49.1^{a}	86.5^{a}	37.4^{cd}	73.5
Milo				
Dry rolled	16.9^{ef}	49.5^{e}	29.0^{e}	34.9
Steam flaked	33.8^{bc}	82.0^{ab}	48.2^{b}	74.3
Oats				
Whole	.1^{g}	4.1^{g}	4.0^{g}	4.0
Dry rolled	15.2^{f}	30.4^{f}	15.2^{f}	17.9
Wheat				
Dry rolled	46.1^{a}	79.9^{b}	33.8^{ed}	62.7
Steam flaked	27.3^{cd}	86.5^{a}	59.2^{a}	81.4
Barley				
Dry rolled	23.3^{cd}	67.9^{c}	44.6^{bc}	58.1
Steam rolled	22.7^{cd}	68.3^{c}	45.6^{bc}	59.0
Diet	35.0^{b}	68.4^{c}	33.4^{de}	51.4
SE[h]	2.0	2.0	3.0	

[abcdefg]Means with similar superscripts in a column do not differ ($P<.05$).

[h]Standard error of the means.

Rolling of whole corn or oats increased (P<.05) extent of starch disappearance in the rumen, small intestine and total tract (table 2). Compared to rolling the grain, steam processing increased (P<.05) starch disappearance from the rumen, small intestine and total tract for all four grains tested (corn, milo, wheat, barley). However, extent of starch digestion in the rumen was not changed by ensiling of rolled corn at 25% moisture; ensiling at 35% moisture increased extent of ruminal and total tract starch disappearance (P<.05) and tended to increase intestinal disappearance of starch. Ruminal starch disappearance at 15 h ranked these 13 combinations of grains and processing methods corn as: 1) steam flaked corn, 2) steam flaked wheat, 3) steam flaked milo, 4) rolled oats, 5) rolled wheat, 6) steam rolled barley and 7) high moisture corn (35%). These rankings are reasonably similar to their ranking in acidosis potential (Britton and Stock, 1986) except that ruminal starch disappearance of high moisture grain was considerably lower than expected. Perhaps a digestion time shorter than 15 h would more accurately predict acidosis potential. Alternatively, higher moisture feeds may increase acidosis by reducing the time which ruminants spend chewing and salivating.

The quantity of starch disappearing in the small intestine (% of supply) within each grain increased as particle size was reduced except for steam flaking of corn. Across feedstuffs, particle size was poorly

Table 2. Effect of processing grains on starch disappearance from mobile dacron bags.

	Mobile bag disappearance of protein			
Feedstuff	Ruminal (15 h) %	Total tract %	Small intestine by difference %	% of supply
Corn				
Whole shelled	0.0^{h}	7.4^{g}	7.4^{b}	7.4
Dry rolled	9.4^{f}	20.4^{f}	11.0^{b}	12.1
25% moisture	4.0^{h}	11.6^{g}	7.6^{b}	7.9
35% moisture	21.7^{e}	56.3^{a}	34.6^{b}	44.2
Steam flaked	49.4^{b}	82.5^{a}	33.1^{b}	65.4
Milo				
Dry rolled	3.5^{h}	15.0^{f}	11.5^{b}	11.9
Steam flaked	36.5^{d}	56.9^{b}	20.4^{b}	32.1
Oats				
Whole	18.8^{f}	21.2^{f}	2.4^{c}	3.0
Dry rolled	26.4^{e}	31.6^{e}	5.2^{c}	7.1
Wheat				
Dry rolled	24.7^{e}	56.6^{b}	31.9^{b}	42.4
Steam flaked	44.3^{c}	87.6^{a}	43.3^{a}	77.7
Barley				
Dry rolled	17.1^{f}	38.8^{d}	21.7^{b}	26.2
Steam rolled	21.8^{e}	47.4^{c}	25.6^{b}	32.7
Diet	82.6^{a}	95.0^{a}	12.4^{b}	71.3
SE[i]	8.5	4.6	10.5	

^{abcdefgh}Means with similar superscripts in a column do not differ (P<.05).

[i]Standard error of the means.

related to intestinal starch digestion. Intestinal starch digestion was quite low for rolled oats (2096 um) and for several forms of corn (2329-4758 um) and rolled milo (1482 um), intermediate for barley (2418-2644 um) and flaked milo (1333 um) and highest for wheat (1865-2245 um) and processed corn (2430-3388 um; see table 1 of Anzola et al., 1988 for particle sizes). This ranking probably reflects differences in starch structure or accessibility among these grains and quite closely parallels expected rates of gain of feedlot cattle fed these grains.

Processing to increase the surface area of the cereal for contact with the ruminal microbes and enzymes presumably is responsible for the extensive disappearance of starch from steam flaked corn and milo. The higher the amount of corneus endosperm (corn, milo) the greater the response to starch gelatinization and fine grinding.

In summary, rolling whole grains increased disappearance of dry matter and starch both in the rumen and in the small intestine. Steam flaking further increased disappearance of DM and starch in the rumen for corn and milo grains. Ruminal starch disappearance was increased by flaking each of the grains. Ensiling rolled corn, especially at 35% moisture, increased disappearance of dry matter and starch in the rumen and in the intestines. Changes in site of digestion starch digestion with processing of wheat, barley and oats were minor as compared with corn and milo. Supply of starch disappearing from the small intestine ranked the grains as: Low: rolled oats, whole, rolled or 25% moisture corn, rolled milo; Intermediate: barley and flaked milo; Highest: wheat and steam flaked or 35% high moisture corn grain. Within grains, particle size appeared to limit starch digestion though effects of and need for processing of wheat and barley were limited. Though the mobile dacron bag procedure shows promise for evaluating site of digestion, further verification with in vivo measurements is needed. Of primary concern are appropriate ruminal incubation times and particle size of feedstuffs. Effects of chewing and rumination on the grain particles are avoided by using mobile dacron bags; this may explain why disappearance values are much lower than in vivo estimates of intestinal and total tract digestion (Owens et al., 1986) even though rankings of grains and effects of processing appear realistic.

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