

EFFECTS OF RUMINAL UNDIGESTED FIBER ON INTESTINAL STARCH DIGESTION IN SHEEP FED DIFFERENT RATIONS AND WITH STARCH INFUSION INTO THE ABOMASUM

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Introduction

The capacity for starch digestion by the small intestine in ruminants is inferior to that in non-ruminants. Many factors which limit starch digestion in the small intestine of ruminants have been indicated (Owens *et al.*, 1986). However, there have been few studies on the effect of fiber in the intestinal tract on intestinal starch digestion. Its effect cannot be disregarded, because the ruminant diet contains more fiber than that of non-ruminants. The fiber fractions are digested in the rumen by microorganisms to some extent, but a considerable quantity of ruminal undigested fiber still reaches the small intestine and therefore may interfere with intestinal starch digestion. The aim of the present study was to investigate the effect of fiber on small and large intestinal digestion of starch infused into the abomasum of sheep fed rations with different ratios of roughage and concentrate.

Materials and Methods

Four castrated male Suffolk sheep, averaging 49 kg, were fitted with an abomasum cannula and a re-entrant cannula in the distal ileum (approx. 15 cm from ileocecal valve). Animals were fed rations and dosed with Cr_2O_3 twice daily. The rations consisted of 30% concentrate and 70% chopped hay (about 5 cm in length; HH) or 70% alfalfa meal pellets (HA), and 70% concentrate and 30% chopped hay (LH) or 30% alfalfa meal pellets (LA) on a digestible energy basis. The concentrate contained mainly ground corn and soybean meal. These rations were supplied at the energy level for maintenance requirement and at an isonitrogen level by adjusting the content of soybean meal in the concentrate. The digestion trials for each ration were conducted twice per animal; in the first trial, animals were fed the ration alone and in the second were given the same

ration, but also with continuous infusion of purified corn starch (SIA) into the abomasum, averaging 113 g per day equivalent to 0.2 times maintenance energy. The experimental design adopted was the 4 x 4 Latin-square. During the digestion trials, samples were taken from the abomasum except for the SIA infusion period, the ileum and excreted feces. The obtained digesta were freeze-dried immediately, and used for analysis of Cr_2O_3 , neutral detergent fiber (NDF) and starch. Starch (α -glucoside) was determined by an enzymatic method using glucoamylase, glucose-oxidase and peroxidase. The quantities of NDF reaching the abomasum and the digestibility of orally ingested starch in the rumen and in the small intestine and large intestine were determined from changes of NDF: Cr_2O_3 or the starch: Cr_2O_3 ratio in each digesta. The SIA digestibilities of the small and the large intestine were estimated by the difference.

Results and Discussion

Starch intake levels from HH, HP, LH and LP rations were 57, 134, 193 and 228 g/d, respectively. The digestibilities of orally ingested starch in the rumen, small intestine and large intestine as a percentage of starch intake on each ration were: HH; 56, 14 and 15%, HP; 70, 10 and 10%, LH; 70, 19 and 4%, LP; 89, 5 and 3%. The ruminal digestibilities were much higher than the intestinal digestibilities with every ration; furthermore the higher ruminal digestion caused a lower post-ruminal digestion. The ruminal and total digestion was lowest for the HP ration and conversely highest for the LP ration. Goetsh *et al.* (1987) also reported that starch digestion of ground corn tended to be higher with ground hay than with coarsely chopped hay. Perhaps ground corn leaves the rumen more rapidly as roughage size increases.

The quantities of NDF undigested in the rumen

TABLE 1. NEUTRAL DETERGENT FIBER ENTERING ABOMASUM AND INTESTINAL DIGESTION OF STARCH INFUSED INTO THE ABOMASUM OF SHEEP FED DIFFERENT RATIONS

Ration	NDF (g/d)	Starch digestibility (%)		
		Small intestine	Large intestine	Total intestine
HH	263 ^a ± 14	75.1 ^a ± 1.6	21.1 ^a ± 5.3	96.2 ± 6.8
HP	201 ^b ± 16	79.0 ^{ab} ± 6.6	15.8 ^{ab} ± 6.3	94.8 ± 3.3
LH	146 ^c ± 10	86.0 ^b ± 5.7	10.6 ^b ± 7.3	96.6 ± 1.9
LP	93 ^d ± 11	44.7 ^c ± 16.0	48.5 ^c ± 14.1	93.2 ± 3.6

Each value is the mean ± SD of 4 observations.

^{a-d}Means in the same column with different letters are significantly different ($P < 0.05$).

which pass into the abomasum and the small intestinal and large intestinal digestibilities of SIA are presented in table 1. Although the NDF digestibility in the rumen was different with each ration, the NDF quantity entering the abomasum was influenced considerably by the NDF consumption (HH; 481, HP; 256, LH; 244, LP; 148 g/d) from the ration. The SIA digestibility in the small intestine became higher in the order, LH, HP, HH and LP; the difference between LH and HH was only 11 %, but a greater difference of 30 % was found between HH and LP was found. In the reverse order, the digestibility in the large intestine was higher, that is, large intestinal digestion of SIA was increased with decrease in small intestinal digestion. In the total intestinal tract, therefore the digestibility of SIA on all rations was over 90 % and there was no significant difference between the rations.

Except for the case of the LP ration, an increase in NDF reaching the abomasum depressed SIA digestion in the small intestine, possibly by increasing the rate of starch passage. *In vitro* studies on the effects of dietary fiber on digestive enzymes have suggested that a slowing of enzymatic hydrolysis in the intestine could contribute to the apparently lower rate of nutrient assimilation associated with certain fiber-rich foods or diets (Schneeman and Gallar, 1986). Perhaps the

presence of NDF in the ruminant small intestine also affects enzymatic hydrolysis of starch. However, other factors having a greater effect on starch digestion in the small intestine must be considered, since the LP ration gave markedly lower digestibility of starch in the small intestine despite the lowest degree of intestinal NDF flow associated with any of the rations. The ruminal fermentation product may thus indirectly affect enzymatic activity in the intestine.

(Key Words: Starch Digestion, Small Intestine, Sheep)

Literature Cited

- Goetsch, A.L., E.N. Owens, M.A. Funk and B.E. Doran, 1987. Effects of whole or ground corn with different forms of hay in 85 % concentrate diets on digestion and passage rate in beef heifers. *Anim. Feed Sci. Technol.* 18: 151-164.
- Owens, F.N., R.A. Zinn and Y.K. Kim, 1986. Limits to starch digestion in the ruminant small intestine. *J. Anim. Sci.* 63:1634-1648.
- Schneeman, B. and D. Gallaher, 1986. Effects of dietary fiber on digestive enzymes. In "Handbook of Dietary Fiber in Human Nutrition" (Ed. by G.A. Spiller) CRC Press, pp.305-312.