

# GROWTH AND STARCH DIGESTION OF GOATS FED HIGH-AMYLOSE CORN AND WAXY CORN

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## Introduction

The ruminal fermentation of starch is accompanied by inevitable losses in heat and methane, whereas starch digested in the small intestine has 42 % more value than starch digested in the rumen (Owen et al., 1986). Therefore, it is desirable to encourage starch to escape ruminal fermentation, if there is sufficient capacity to digest starch post-ruminally.

Digestibility of cereal starchs *in vitro* and *in vivo* has generally an inverse correlation to amylose content. Thus, high-amylose corn (amylomaize) has poor digestibility, while waxy cereal starchs are among the most digestible of all starchs.

The objectives of this experiment were to determine feed efficiency, site and extent of starch digestion of goats fed high-amylose or waxy corn and to evaluate the activity of amylase and maltase in the pancreas and small intestine.

## Materials and Methods

Ten growing goats (average weight,  $9.1 \pm 0.8$  kg) were randomly assigned at 18-wk of age to one of two dietary treatments (five goats/treatment): diet containing high-amylose corn (HAC, amylose contents, 68 %) or waxy corn (WC, no amylose content), which were grounded through a 3-mm screen. Ingredient composition of the experimental diets is presented in table 1. The diets contained 0.1 % chromic oxide as an indigestible marker for estimating digestibility and were pelleted through a 7-mm die. Each goat received a daily ration of 75 g dry matter / kg<sup>0.75</sup> body weight once daily.

A 3-wk initial adaptation period preceded a 10-wk growth trial. Feed intake and body weight were recorded weekly for the duration of the trial. Fecal samples were taken two times for a 7-day period during 2 and 9-wk. At the end of the growth trials, goats were slaughtered at 6-h post-

TABLE 1. INGREDIENT AND CHEMICAL COMPOSITION OF THE EXPERIMENTAL DIETS

Ingredient	Treatment	
	HAC	WC
	(% of dry matter)	
High amylose corn	31.7	0.0
Waxy corn	0.0	31.7
Grounded alfalfa cube	54.0	54.0
Steam-pressured wood	14.1	14.1
Vitamin mix	0.1	0.1
Chromic oxide	0.1	0.1
Chemical composition		
Organic matter	93.4	93.7
Crude protein	14.1	13.7
Crude fat	3.1	3.0
Neutral detergent fiber	39.9	36.5
Acid detergent fiber	30.3	27.9
Starch	22.6	24.8

feeding. Digesta samples were taken from the rumen, abomasum and caecum, and tissue samples taken from the pancreas and jejunum to assay amylase and maltase activity by the methods of Russell et al. (1981). The extent of digestion of nutrients was calculated using marker (Cr): nutrient ratios on the rumen, abomasum, caecum digesta and faeces.

## Results and Discussion

In the 70-day growth trial, average daily gain increased 9.5 % ( $P < 0.05$ ) and feed conversion improved 9.2 % ( $P < 0.05$ ) in goats fed a diet containing high-amylose corn (amylomaize) compared with the gain and feed conversion of goats fed waxy corn diet (table 2). These results show that nutritive value of the high-amylose corn was superior to that of waxy corn. The improvement of feed conversion on HAC diet is most likely attributable to the increased digestion of starch

TABLE 2. BODY WEIGHT GAIN, FEED CONVERSION AND DIGESTIBILITY (MEAN  $\pm$  SD)

Item	Treatment	
	HAC	WC
Body weight gain (g/d)	83.4 $\pm$ 7.7	75.4 $\pm$ 3.4
Dry matter intake (g/d)	476 $\pm$ 25.7	473 $\pm$ 34.3
Feed/gain	5.73 $\pm$ 0.49	6.23 $\pm$ 0.40
Digestibility (%)		
Gross energy	67.6 $\pm$ 1.5	66.6 $\pm$ 2.1
Organic matter	64.9 $\pm$ 1.4	64.3 $\pm$ 1.9
Acid detergent fiber	45.1 $\pm$ 3.7	39.0 $\pm$ 5.2
Neutral detergent fiber	44.1 $\pm$ 3.2	38.2 $\pm$ 4.7
Crude protein	64.3 $\pm$ 1.4	62.5 $\pm$ 1.4
Ether extract	70.8 $\pm$ 1.1	69.2 $\pm$ 1.6

in the small intestine.

Apparent digestibilities in the total tract of ADF and CP tend to be higher for goats fed HAC diet, whereas OM and GE were not affected by diets (table 2). Site and the extent of starch digestion are presented in table 3. Apparent digestibilities of starch in the rumen and total tract were both greater ( $p < 0.05$ ) with the WC diet, whereas apparent digestibility of starch in the small intestine was greater ( $p < 0.01$ ) with the HAC diet. These results show that with high-amylose corn diet, starch digestion tends to be shifted postuminally, and escaped starch is digested efficiently in the small intestine.

TABLE 3. INTAKE, SITE AND EXTENT OF STARCH DIGESTION IN GOATS FED HAC OR WC DIET (MEAN  $\pm$  SD)

Item	Treatment	
	HAC	WC
	(g/d)	
Starch intake	130 $\pm$ 18	142 $\pm$ 19
	(% of intake)	
Rumen <sup>a</sup>	72.6 $\pm$ 9.8	90.7 $\pm$ 10.3
Small intestine <sup>b</sup>	22.3 $\pm$ 4.2	5.7 $\pm$ 3.5
Large intestine	1.4 $\pm$ 1.3	1.1 $\pm$ 1.9
Total tract <sup>a</sup>	96.4 $\pm$ 0.5	97.5 $\pm$ 0.4

<sup>a</sup>Treatment difference:  $p < 0.05$

<sup>b</sup>Treatment difference:  $p < 0.01$

There was no difference in pancreatic amylase and maltase in the two dietary treatments, whereas intestinal enzyme activity was higher in goats fed the diet containing high-amylose corn than in goats fed the diet containing waxy corn (table 4). Higher activity of amylase and maltase in the small intestine of goats fed the HAC diet was probably due to adaptation as input starch increases. However, Russell et al. (1981) reported that amylase activity was elevated in the pancreas of steers fed higher levels of corn, but increased dietary starch intake did not change maltase activity in the small intestine.

TABLE 4.  $\alpha$ -AMYLASE AND MALTASE ACTIVITY IN THE PANCREAS AND JEJUNUM TISSUES (MEAN  $\pm$  SD)

Treatment	$\alpha$ -Amylase <sup>a</sup>		Maltase <sup>b</sup>	
	Pancreas	Jejunum	Pancreas	Jejunum
	(mU/mg protein)			
HAC	3721 $\pm$ 290	42.8 $\pm$ 11.2	3.1 $\pm$ 0.7	19.4 $\pm$ 6.8
WC	3631 $\pm$ 995	34.0 $\pm$ 6.1	3.0 $\pm$ 1.0	8.9 $\pm$ 4.8

<sup>a</sup>One unit of amylase activity equals 10 mg of soluble starch hydrolyzed/min at 37°C at pH 6.9

<sup>b</sup>One unit of maltase activity equals 1  $\mu$  mole of maltose hydrolyzed/min at 37°C at pH 5.8

<sup>c</sup>Treatment difference:  $p < 0.05$

In conclusion, the results of the present study indicate that goats fed a high-amylose corn gain faster and are more efficient than those receiving waxy corn, resulting in efficient utilization of starch in the small intestine and also of fibrous nutrients in the rumen.

(Key Words: Starch Digestion, Corn, Amylose)

#### Literature Cited

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