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K.K. Kreikemeier

D.L. Harmon

K. Gross

See next page for additional authors

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Abstract

Pancreatic α-amylase activity was 54% higher in cattle fed at twice maintenance energy than in cattle fed at maintenance and was 52% greater in hay-fed than grain-fed cattle. Increased pancreatic α-amylase activity probably represents increased secretion as well. α-amylase activity in small intestinal digesta was greater with increased energy intake and with hay feeding. Small intestine mucosal disaccharidase activities in cattle were unaffected by diet. Lactase activity was highest in the proximal segment of the small intestine and low in both mid and distal segments. Maltase and isomaltase activities were low in the duodenum, but increased toward the jejunum and remained elevated through the terminal ileum.

Keywords

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Authors

K.K. Kreikemeier, D.L. Harmon, K. Gross, and C. Armendariz

DIETARY INFLUENCES ON PANCREATIC AMYLASE AND SMALL INTESTINAL DISACCHARIDASE ACTIVITIES IN CATTLE

K.K. Kreikemeier, D.L. Harmon,
K. Gross, and C. Armendariz.

Summary

Pancreatic alpha-amylase activity was 54% higher in cattle fed at twice maintenance energy than in cattle fed at maintenance and was 52% greater in hay-fed than grain-fed cattle. Increased pancreatic alpha-amylase activity probably represents increased secretion as well. Alpha-amylase activity in small intestinal digesta was greater with increased energy intake and with hay feeding. Small intestine mucosal disaccharidase activities in cattle were unaffected by diet. Lactase activity was highest in the proximal segment of the small intestine and low in both mid and distal segments. Maltase and isomaltase activities were low in the duodenum, but increased toward the jejunum and remained elevated through the terminal ileum.

Introduction

Previous research at Kansas State University demonstrated that starch hydrolysis in the small intestine of steers is limited. Low enzyme activity in the small intestine may be the rate-limiting process, so an increase in one or more carbohydrate-hydrolyzing enzymes might improve starch digestion. We conducted this experiment to see if enzyme activity in the pancreas and small intestine is influenced by either diet (alfalfa hay vs. grain) or energy intake (1 vs. 2 times maintenance).

Experimental Procedures

Twelve Holstein steers, four Longhorn cross steers, and four Longhorn cross heifers were fed high grain diets from weaning (6 weeks) till they were 7 months old. They were then blocked by weight, breed, and sex into five groups of four animals. For the next 140 days, they were individually fed either 90% alfalfa hay or 90% concentrate (50% dry rolled sorghum, 50% dry rolled wheat) at either maintenance or twice maintenance energy. Monensin and tylosin were fed at equal intakes on a body weight basis. Cattle fed at twice maintenance were weighed, and their intakes were adjusted biweekly.

We slaughtered one animal per day, one block (four animals) per week, for 5 consecutive weeks. After an overnight fast, the animal was stunned, bled, and eviscerated. The pancreas was removed and assayed for alpha-amylase and glucoamylase activity. Beginning 6 inches distal from the pylorus and ending 6 inches proximal to the ileo-cecal junction, five, equally spaced, 12-inch segments were removed from the small intestine. Mucosa was assayed for lactase, isomaltase, and maltase activity. Small intestinal digesta was also collected and assayed for alpha-amylase activity.

Results and Discussion

As expected, cattle fed at twice maintenance were heavier at slaughter than those fed at maintenance (Table 28.1), and there was no weight difference between hay and grain fed cattle.

The pancreas was heavier in cattle fed at twice maintenance, but was proportional to animal slaughter weight. Pancreatic alpha-amylase activity; expressed as units per g of pancreas, was 54% greater in cattle fed at twice maintenance than in cattle fed at maintenance, and 52% greater in hay-fed cattle than grain-fed cattle. Pancreatic glucoamylase activity increased 10% in cattle fed increased energy intake and was also 10% greater in hay-fed than grain-fed cattle.

The small intestine was 18 feet longer in cattle fed at twice maintenance, probably because of differences in weight at slaughter. There were 3 more pounds of digesta in the small intestine of cattle fed twice maintenance, and 2 more pounds in the small intestine of hay-fed than grain-fed cattle. The alpha-amylase activity in small intestinal digesta paralleled that of the pancreas; greater with increased energy intake and greater in hay-fed cattle. Therefore, we may speculate that increased pancreatic alpha-amylase activities are associated with greater pancreatic alpha-amylase secretions. The differences in alpha amylase are even more pronounced when activities per gm of pancreas or digesta are multiplied by organ or digesta weight, to yield to total amount of enzyme per animal.

Small intestinal disaccharidase activity was unaffected by diet consumed, so this is listed according to small intestinal sampling site (Table 28.2). Lactase activity is mostly concentrated in the first part of the small intestine. On the other hand, maltase and isomaltase activities are low in the duodenum, increase toward the jejunum, and remain elevated through the terminal ileum. This suggests that the potential for starch hydrolysis continues through the entire length of the small intestine.

According to our data, pancreatic alpha-amylase activity increases with increased energy intake. However, any increase is offset by the negative effects of grain feeding. If these opposing effects could be alleviated or offset, the capacity of the small intestine to hydrolyze starch should improve.

Table 28.1. Energy Intake and Diet Effects on Pancreatic Weight, Alpha-amylase, Glucoamylase, and Small Intestinal Length and its Digesta

Item	Energy Intake		Diet Consumed		
	Maintenance	Twice Maintenance	Hay	Grain	SE
Animal slaughter wt, lbs[a]	482	779	645	615	33
Pancreas weight, g[a]	232	323	292	264	18
Pancreatic alpha amylase activity[1] units/g pancreas[ab]	328	508	504	332	51
Pancreatic glucoamylase activity[2] units/g pancreas[ab]	1.0	1.1	1.1	1.0	.04
Small intestinal length, ft[a]	70	88	81	77	3.4
Small intestinal contents					
Digesta weight, lbs[ac]	7.0	10.1	9.5	7.5	0.9
Digesta pH[ab]	7.4	7.1	7.3	7.1	.04
Alpha amylase activity[1] units/g digesta[b]	4.8	5.5	6.1	4.2	0.6

[1]One unit of activity equals liberated reducing sugars corresponding to 1 micromole of glucose per minute.
[2]One unit of activity equals one micromole of glucose liberated per minute.
[a]Energy levels differ, $P<.05$.
[b]Hay and grain differ, $P<.05$.
[c]Hay and grain differ, $P<.10$.

Table 28.2. Small Intestinal Disaccharidase Activities per Inch of Intestine

Item	Small Intestinal Sampling Site					
	Duodenum	Jejunum I	Jejunum II	Jejunum III	Ileum	SE
Lactase	2.5[a]	4.8[b]	0.3[c]	0.1[c]	0.2[c]	0.3
Isomaltase	0.1[a]	0.6[b]	1.0[c]	0.7[b]	1.0[c]	0.1
Maltase	1.0[a]	2.5[b]	3.0[b]	2.0[b]	3.4[b]	0.3

[1]One unit of activity equals one micromole of substrate hydrolyzed per minute.
[abc]Means in the same row with different superscripts differ ($P<.01$).