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HYDROCORTISONE ACETATE-INJECTED PIGLETS HAVE A LARGER PANCREAS AND GREATER MUCOSAL WEIGHT AND LACTASE, MALTASE, AND SUCRASE ACTIVITIES IN THE DUODENUM

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Summary

One litter of 12 piglets was used in a completely random design to evaluate the effects of hydrocortisone acetate injections on organ weight and carbohydrase activities. Dams' milk was the only food source available to the piglets. When they were 7 d old, six pigs were injected with hydrocortisone acetate (50 mg/kg BW; 50 mg/ml) and six others were injected with an equal volume of saline (1 ml/kg BW). When the pigs were 14 d old, tissues were collected, weighed, and analyzed for carbohydrase activities. Hydrocortisone acetate injection had no effect on pig daily gain (d 7 to 14), liver weight, spleen weight, or small intestinal (SI) length. However, it did increase pancreatic weight by 29%. Consequently, total pancreatic alpha-amylase was 38% greater in hydrocortisone-injected pigs. Hydrocortisone also increased duodenal mucosal weight (per cm of SI) by 23%, duodenal lactase activity (per cm of SI) by 44%, duodenal maltase activity (per cm of SI) by 163% and duodenal sucrase activity (per cm of SI) by 214%. There was little effect on disaccharidase activities in the jejunum or ileum. We conclude that hydrocortisone acetate may be useful to stimulate pancreatic growth and duodenal mucosal weight as well as lactase, maltase, and sucrase activity in 7-d-old pigs.

(Key Words: Piglet, Glucocorticoid, Pancreas, Small Intestine, Intestinal Mucosa, Carbohydrases.)

Introduction

Hydrocortisone acetate, a glucocorticoid, is prepared by synthetic modification of naturally occurring steroids. Absorption into the bloodstream is slow following subcutaneous or intramuscular injection, probably because of its low solubility in body fluids. Compared to other synthetic glucocorticoids (prednisone, prednisolone), it is three to five times less effective in its glucocorticoid, antiinflammatory, eosinophil, and lymphocyte suppressive actions.

Recently, it has been reported that hydrocortisone acetate injections into 10-d-old rats (50 mg/kg BW) increased small intestinal (SI) maltase, glucoamylase, trehalase, sucrase, and palatinase activities between 9 and 35 times by d 14. Similar effects occur in the mouse and rabbit as well. We felt that this approach might be useful for increasing SI carbohydrase activities in the early-weaned piglet. Therefore, the objectives of this experiment were to determine if hydrocortisone acetate injections into suckling piglets would increase carbohydrase activities and to measure its effects on body weight gain and organ and tissue weights.

Experimental Procedures

One litter of 12 piglets (9 male and 3 female) was used in the experiment. During gestation, the dam was individually fed 4.4 lb (DM basis) of a sorghum/soybean meal diet (14% CP) once daily. Three days before farrowing, she was moved into a farrowing house. Following parturition, she was fed a sorghum/soybean meal diet ad lib (16% CP, 1.0% Ca, .85% P).

Shortly after birth, pigs were routinely processed and vaccinated (1 ml intranasal) for Porcine Bordetella Bronchiseptica. Male pigs were castrated when they were 5 d old. All pigs were weighed when they were 1, 7, and 14 d old. They were provided with supplemental heat lamps at all times, and their dam's milk was the only food source available.

When the pigs were 7 d old, 6 pigs were given an intramuscular injection (base of ham) of hydrocortisone acetate (50 mg/ml; 50 mg/kg BW) and 6 others were injected with saline (.154 M NaCl; 1 ml/kg BW). At 14 d of age, the pigs were electrocuted and bled; tissues were collected. The liver, spleen, and pancreas were placed on ice. The entire small intestine was removed from the viscera and laid out on a lab cart; three equally spaced 24-in. segments (proximal, mid, and distal) were cut out and placed on ice. These sections/sites will be referred to as duodenum, jejunum, and ileum. The entire process, electrocution through tissue collection, took 5 to 7 min per pig. All tissue samples then were transported to a laboratory.

The liver and spleen were weighed and discarded. The pancreas was weighed, homogenized with saline, and assayed for alpha-amylase activity.

Each section of the SI was cut open longitudinally and gently rinsed with saline; mucosa was stripped from the basal membrane using a glass microscope slide. The mucosa was weighed, diluted with saline, and homogenized as described above and assayed for lactase, sucrase, maltase, and trehalase activities.

Results

Pig weights on d 1, 7 and 14 as well as daily gains from d 7 to 14 were similar among treatment groups (Table 1). Likewise, liver and spleen weights were unaffected by injection, but the pancreas was 29% larger ($P < .09$) in hydrocortisone-injected piglets. Treatment had no effect on pancreatic alpha-amylase activity when expressed per g of pancreas, because of the increased size of the pancreas in piglets injected with hydrocortisone, total alpha-amylase activity tended to be greater (38%). Small intestinal length was similar among treatments.

Lactase activity, when expressed per gram mucosa, and trehalase activity (per gram mucosa and per centimeter intestine) were unaffected by hydrocortisone injection (Table 2). These activities were greater in the duodenum and jejunum than the ileum ($P < .05$).

Hydrocortisone acetate injection increased ($P < .05$) duodenal mucosal weight per centimeter of SI (Figure 1), duodenal lactase activity (per centimeter of SI; Figure 2), duodenal maltase activity (per centimeter of SI; Figure 3), and duodenal sucrase activity (per centimeter of SI; Figure 4).

Table 1. Effect of Saline and Hydrocortisone-acetate Injection on Pig Weight Gain, Organ Weight, and Pancreatic Alpha-amylase Activity

Item	Injection group		SE	Probability that treatments are similar
	Saline	Hydrocortisone		
Bodyweight, lb				
day 1	2.68	3.08	.19	.16
day 7	4.69	4.90	.31	.66
day 14	7.86	7.76	.54	.89
Daily gain				
day 7-14, lb	205	185	16	.41
Organ weight, g				
liver	101.18	99.63	7.36	.88
spleen	8.11	7.88	.72	.82
pancreas	5.58	7.25	.61	.08
Pancreatic alpha-amylase ($\times 10^{-3}$)				
units/g ^a	2.3	2.4	.3	.81
total units ^{ab}	13.1	18.0	2.5	.20
Small intestinal length, ft	22.5	22.3	.8	.82

^aOne unit of activity equals that amount of reducing sugars liberated per min from gelled potato starch corresponding to one micromole of glucose (used as a standard).

^bTotal activity calculated by multiplying units per gram of pancreas by pancreas weight.

Discussion

The increased pancreas weight (31%) with no effect on the spleen or liver indicate a high specificity for the pancreas. Increased pancreatic alpha-amylase activity caused by glucocorticoids has been reported to occur in rats. In our study, an increase in total pancreatic alpha-amylase occurred, but it was due to the increased pancreatic mass, not a change in specific activity. Whether or not the increased pancreatic mass would correspond to increased pancreatic secretions is unclear, but it would be beneficial if alpha amylase is rate limiting to starch digestion in early-weaned piglets. In our experiments, the increased disaccharidase activity was confined to the duodenum with no apparent effect in the jejunum or ileum.

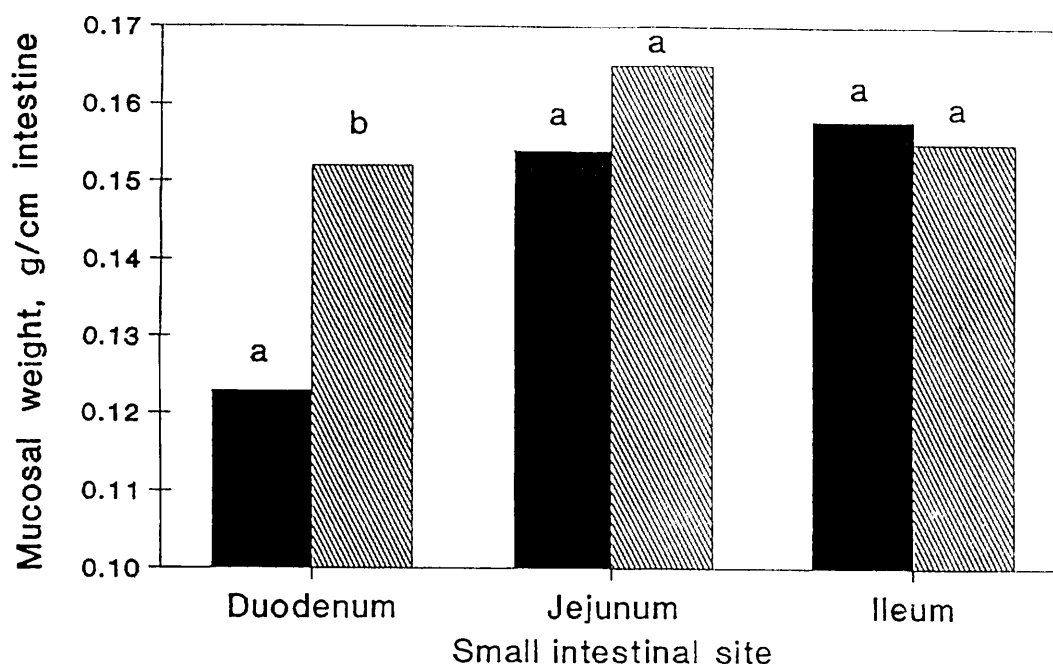


Figure 1. Small intestinal mucosal weight per cm of intestine as affected by saline injection (solid bar) and hydrocortisone injection (hatched bar). Each value represents the mean of six observations. Bars within small intestinal site without a common lower case letter differ, $P < .05$. Pooled SE is .008.

Table 2. Effect of Saline and Hydrocortisone-acetate Injection and Small Intestinal Site on Small Intestinal Lactase and Trehalase Activity^{ab}

Item	Injection group		SE	Small intestinal site			SE
	Saline	Hydrocortisone		Duodenum	Jejunum	Ileum	
Lactase activity, units per g mucosa	3.41	3.13	.42	4.62 ^c	4.48 ^c	0.71 ^d	.35
Trehalase activity, units per g mucosa	.047	.049	.005	.064 ^c	.059 ^c	.022 ^d	.003
units per cm intestine	.007	.007	.001	.009 ^c	.009 ^c	.003 ^d	.001

^aOne unit of lactase activity equals one micromole of lactose hydrolyzed per min.

^bOne unit of trehalase activity equals one micromole of trehalose hydrolyzed per min.

^{cd}Means in the same row with different superscripts differ ($P < .05$).

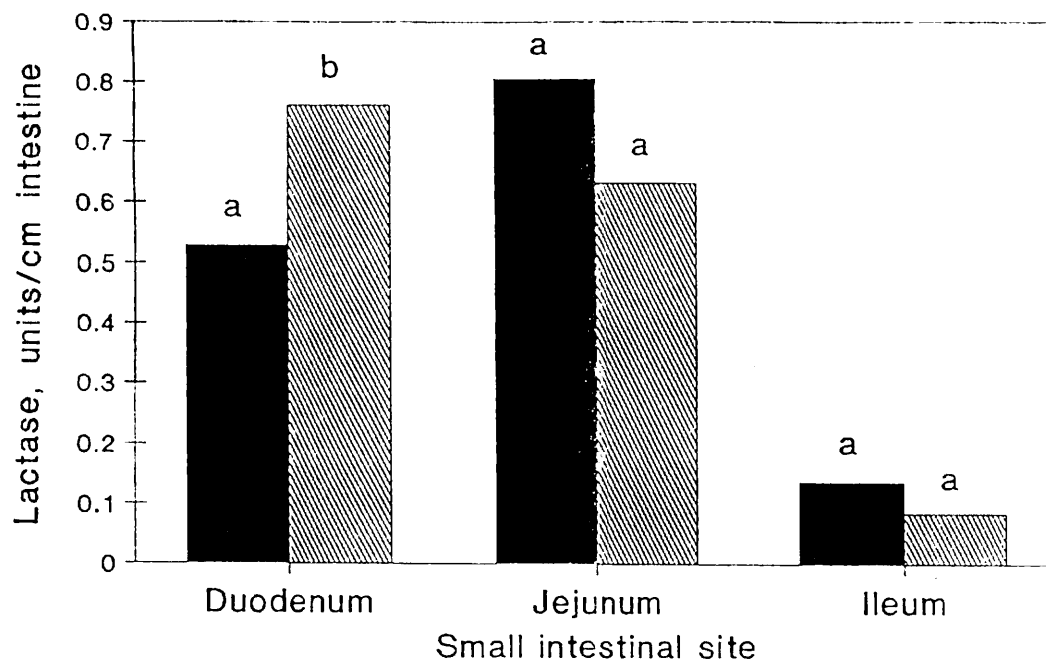


Figure 2. Small intestinal lactase activity per cm of intestine as affected by saline injection (solid bar) and hydrocortisone injection (hatched bar). Each value represents the mean of six observations. Bars within small intestinal site without a common lower case letter differ, $P < .05$. Pooled SE is .078.

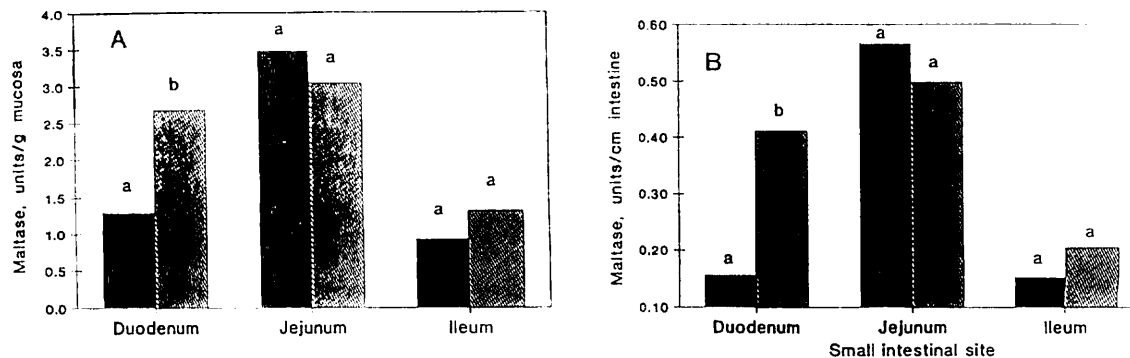


Figure 3. Small intestinal maltase activity per cm of intestine as affected by saline injection (solid bar) and hydrocortisone injection (hatched bar). Each value represents the mean of six observations. Bars within small intestinal site without a common lower case letter differ, $P < .05$. Pooled SE is .292 and .053 for figure A and B respectively.

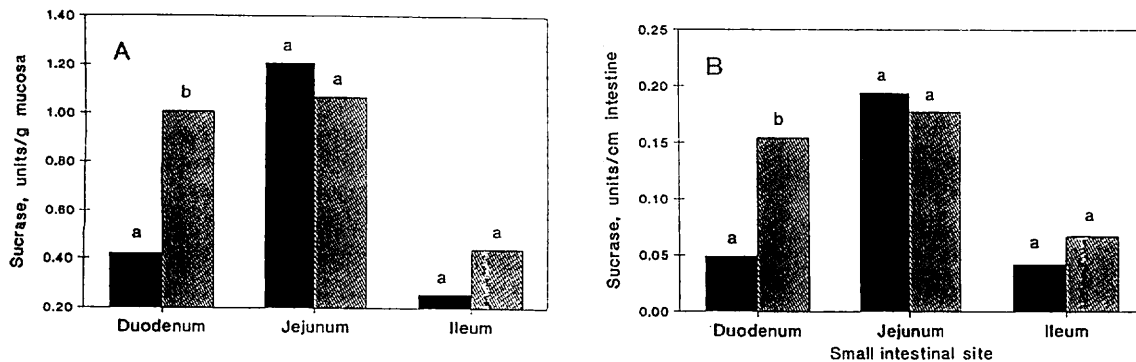


Figure 4. Small intestinal sucrase activity per cm of intestine as affected by saline injection (solid bar) and hydrocortisone injection (hatched bar). Each value represents the mean of six observations. Bars within small intestinal site without a common lower case letter differ, $P < .05$. Pooled SE is .11 and .019 for figure A and B respectively.

Although duodenal maltase and sucrase activity were elevated 163 and 214%, respectively, this is rather small compared to the increase of 18 to 35 times reported in rats. It is important to note that after this large increase in rat pups, enzyme activities were comparable to those in a normal adult rat. Therefore, the dramatic effect was a function of extremely low to nondetectable disaccharidase activity in 10- to 14-d-old rat pups. A 7-wk-old pig has about 120% greater maltase and 200% greater sucrase activities than a 2-wk-old pig, differences comparable to those obtained with our hydrocortisone-injected pigs. If 7-wk intestinal disaccharidase activities represent those of the adult pig, then the increased duodenal maltase and sucrase activities observed in this study may represent a means to hasten this maturation process.

Trehalase activity was not affected by hydrocortisone injection in the piglets, which differs from reports on rats. Why this did not occur in the 14-d-old piglet is not clear. However, because the physiological function of trehalase in intestinal mucosa has not been conclusively established, the importance of the lack of effect of hydrocortisone on trehalase in the piglet, becomes secondary.

If amylase, maltase, and sucrase are rate limiting to small intestinal carbohydrate digestion in the early-weaned piglet, this technology may allow for the more efficient use of starch and sucrose as carbohydrate sources by young pigs.