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Potential of Amylolytic Cultures of *Lactobacillus Acidophilus* to Improve Dietary Starch Utilization in Weanling Pigs

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Story in Brief

Pancreatic α-amylase activity is low in the young pig until approximately 4 wk of age, which results in poor starch digestibility. One method to improve starch digestibility is by providing exogenous sources of amylase through *Lactobacillus* species. In *in vitro* experiments *Lactobacillus acidophilus* L23 has been shown to have relatively high amylase activity by hydrolyzing large amounts of corn starch, the primary energy source in swine rations. Because of the amylase activity, *Lactobacillus acidophilus* L23 was evaluated as a source of amylase for weanling pigs. Seventy-five pigs (6.5 kg, 20 d) were allotted to one of three dietary treatments based on weight, sex, and litter. Treatments consisted of 10 mL of nonfat milk (Control), 10 mL of nonfat milk mixed with approximately 3 x 10^8 cells of L23 (Low), and 10 mL of nonfat milk mixed with approximately 3 x 10^9 cells of L23 (High). Pigs were dosed every 24 h with a 12-mL syringe. Pigs were fed a simple corn-soybean meal diet in two dietary phases (Phase 1, d 0 to 21; Phase 2, d 21 to 35) and allowed *ad libitum* access to feed and water. Pigs and feeders were weighed weekly to determine rate and efficiency of gain. Over the 5-wk period, addition of both levels of the culture improved growth performance when compared to the control. However, there were no differences between low and high levels of the culture on growth performance. These data suggest the dosage of *L. acidophilus* L23 to weanling pigs improves growth rates and feed efficiency.

Key Words: Pigs, *Lactobacillus acidophilus*, Amylase, Starch Utilization

Introduction

The digestibility of starch in baby pigs is limited due to their lack of ability to produce enough pancreatic α-amylase (Mahan & Newton, 1993). Amylase is a pancreatic enzyme that aids in digestion. Its purpose is to hydrolyze the α-(1,4)-glucan links in polysaccharides. Therefore, the enzyme acts on starch, glycogen, and related polysaccharides and oligosaccharides (McDonald et al., 1995). The activity of α-amylase is present at birth but remains low until about 4 wk of age. Alternatively, the activity of lactase is high at birth and reaches a maximum in the first week of life and then slowly declines over the third and fourth week. Lactase is an enzyme that breaks down lactose, an important source of carbohydrate in the diets of young pigs. Large portions of starch are believed to escape digestion in the small intestine (Sambrook, 1979) and then travel to the large

intestine where they are fermented by microorganisms (Mason, 1979). Improving the digestibility of starch in the small intestine can be advantageous to the pig because starch serves as the main carbohydrate source and the main energy source in most swine diets.

One way to improve the digestibility of starch in the small intestine is to supply amylase to the baby pig through the use of amylolytic strains of *Lactobacillus* species. Various sources such as animal digestive tracts and plant wastes have been used to isolate amylolytic strains of *lactobacilli* (Champ et al., 1983; Nakamura, 1981; Sen and Chakrabarty, 1986). However, no studies evaluating the effects of the amylase synthesized by species of *Lactobacillus,* especially *L. acidophilus,* isolated from pigs on growth performance have been reported. The objective of this study was to determine the influence of a selected amylolytic species of *Lactobacillus* isolated from the intestine of the pig on growth performance of newly weaned pigs on a high starch diet.

Materials and Methods

Twenty cultures of *Lactobacillus* species were originally isolated from the intestinal contents of pigs. These cultures were then tested for amylase activity. Three strains had greater activity than the remaining strains and thus were selected for further study. The three strains were identified as *Lactobacillus fermentum* L9, *Lactobacillus acidophilus* A-4, and *Lactobacillus acidophilus* L23. The cellular location of amylase activity was then determined among these three strains. *Lactobacillus acidophilus* L23 showed the greatest amylase activity among the intact cell and cell debris fraction of the lysed cells. Because of this increased activity, L23 was selected for use in a weanling pig experiment (Lee et al., 2000).

Seventy-five Yorkshire pigs were randomly allotted to three treatments based on weight, sex and litter. The experiment included four replications of each treatment with 6 to 7 pigs per pen. All pigs were fed common fortified corn-soybean meal–whey protein concentrate diets (pelleted) in two dietary phases (Phase 1, d 0 to 21; Phase 2, d 21 to 35; Table 1). Low lactose (<1%) whey protein concentrate was utilized in Phase 1 to provide an easily digestible amino acid source. Thus, the diets for both phases contained less than .1% simple sugars. The pelleted feed and water were offered *ad libitum*. Each pig in the four pens designated as Control were given 10 ml of sterile nonfat milk via a 12cc syringe at 24-h intervals throughout the trial. Pigs in the four pens designated as Low were given, in a like manner, nonfat milk containing 3×10^8 cells of *L. acidophilus* L23 at 24-h intervals. Those in the remaining pens, designated as High, were given 10 ml of nonfat milk containing 3×10^9 cells of *L. acidophilus* L23 at 24-h intervals. The pigs in each pen and the feeders were weighed at weekly intervals to determine weight gains and feed efficiency.

The performance data from the feeding trial were analyzed as a randomized complete block design using variance procedures described by Steel and Torrie (1980). The model included the effects of block, treatment, and block x treatment (error). Pre-planned non-orthogonal contrasts were utilized to compare treatment means. Pen served as the experimental unit.

Results and Discussion

The effect of oral dosing on pig performance is shown in Table 2. During Phase 1 of the study, pigs receiving both the Low and High dosage rates of *L. acidophilus* L23 exhibited greater (P<.05) average daily gain (ADG) and were more (P<.05) efficient in their F:G ratio than were pigs in the Control group. There were no differences (P<.05) in pig performance between the Low and High doses of L23 for this period. During Phase 2, administration of L23 did not result in any significant increases in pig weight gain or feed efficiency when compared to the Control. When data from both phases were combined, there were improvements (P<.05) in ADG for both groups receiving *lactobacilli* compared to the Control group. However, feed efficiency was improved (P<.05) over the Control group only for pigs receiving the Low level of *lactobacilli*. There were no differences in ADG and feed efficiency between the Low and High dosage rates over the entire study.

Pig performance in this study was poor. This poor performance could be related to the fact that the whey protein concentrate utilized contained less than 1% lactose, a simple sugar that is efficiently utilized as a carbohydrate source by young pigs. Lactose is often included in the diet of young pigs at a rate of 15 to 25% to overcome the limited ability of the young pig to utilize starch. However, the increased amylase activity associated with the cells of *L. acidophilus* L23 most likely increased starch digestion, which resulted in the improved growth and feed efficiency observed in the pigs administered *lactobacilli*.

Implications

Weanling pig diets usually include a high proportion of dried milk products containing lactose as a primary carbohydrate source. These lactose products are relatively expensive. However, because pancreatic α-amylase activity is low in weanling pigs, they are often included in the diet. In this experiment, simple sugars, (i.e., lactose), were maintained at less than .1% to evaluate amylase activity in weanling pigs. Results from this experiment suggest that the administration of L23 improved growth performance in weanling pigs. These improvements in growth performance are probably due to the increased amylase activity of L23. The increased amylase activity can increase starch digestibility, which can possibly decrease the amount of dried milk products added to weanling pig diets resulting in lower feed costs. Further studies are planned to look at the effects of *lactobacilli* as an

in-feed additive on growth performance in weanling pigs.

Literature Cited

Champ, M. et al. 1983. J. Appl. Bacteriol. 55 (6):487.

Lee, H.S. et al. 2000. J. Food Sci. (Submitted).

Mahan, D.C. and E.A. Newton. 1993. J. Anim. Sci. 71 (12):3376.

Mason, V.C. 1979. National Institute for Research in Dairying. p 112. Reading.

McDonald, P. et al. 1995. In: Animal Nutrition (5th Ed.). John Wiley & Sons, Inc., New York.

Nakamura, L.K. 1981. J. Syst. Bacteriol. 31 (1):56.

Sambrook, I.E. 1979. National Institute for Research in Dairying. p 78. Reading.

Sen, S. and S.L. Chakrabarty. 1986. J. Appl. Bacteriol. 60 (5):419.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and Procedures of Statistics: A Biometrical Approach (2nd Ed.). McGraw-Hill Publishing Co., New York.

Table 1. Composition of diets, as-fed basis.

Ingredient, %	Phase 1	Phase 2
Corn, grain	62.20	61.83
Soybean meal, dehulled	19.58	30.20
Whey protein conc.[a]	10.00	-
L-lysine HCl	.19	.19
DL-Methionine	.06	.10
L-Threonine	.05	.11
Dicalcium phosphate	2.73	2.67
Limestone	.39	.60
Salt	.50	.50
Soy protein concentrate	3.00	3.00
Vit/trace mineral mix	.30	.80
Neo-terramyacin	1.00	1.00
Calculated analysis		
ME, kcal/kg	3200	3240
CP, %	24.3	21.7

Lysine, %	1.50	1.35
Ca, %	1.00	1.00
P, %	.90	.90

[a]Whey protein concentrate contained less than 1% lactose, and 77% CP (New Zealand Milk Products).

Table 2. Influence of *Lactobacillus acidophilus* L23 on growth performance of weanling pigs[ab].

	Treatment[c]			
Period	Control	Low	High	CV
Phase 1	.251[d]	.290[e]	.299[e]	7.38
	.4511.798[d]	.4551.568[e]	.4731.581[e]	5.847.36
ADG, lb				
ADF, lb				
F/G				
Phase 2	.873	.931	.953	9.98
	1.2651.448	1.2581.352	1.3351.402	7.907.08
ADG, lb				
ADF, lb				
F/G				
Overall	.513[d]	.561[e]	.568[e]	5.41
	.792	.796	.829	4.81
ADG, lb	1.545[d]	1.420 [e]	1.461[de]	4.11
ADF, lb				
F/G				

[a]Least squares means for 4 pens/treatment of 6 to 7 pigs/pen.

[b]Phase 1 = d 0 to 21; Phase 2 = d 2 to 35; and Overall = d to 35.

[c]Control = corn-SBM-WPC diet and 10 mL of non-fat milk; Low = basal diet and 10 mL of non-fat milk containing approximately $3x10^8$ cells of L23; and High = basal diet and 10 mL of non-fat milk containing approximately $3x10^9$ cells of L23.

[d,e]Means within a row with different superscripts differ (P<.10).

2000 Research Report - Table of Contents