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Effect of Chromium, Dried Brewers Yeast, and Mannan Oligosaccharides on Sow Productivity and Growth Performance of Weanling Pigs.

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EFFECT OF CHROMIUM, DRIED BREWERS YEAST, AND MANNAN OLIGOSACCHARIDES ON SOW PRODUCTIVITY AND GROWTH PERFORMANCE OF WEANLING PIGS

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Adieu LeMieux

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ABSTRACT

Five experiments were conducted to evaluate the effects of mannan oligosaccharides (Bio-Mos) on growth performance, carcass characteristics, and pork quality of pigs. The first two experiments evaluated 0.20 and 0.30% Bio-Mos. The data indicated that the 0.20% level of Bio-Mos was more effective, and this level was used in the remainder of the experiments. Interactive effects of Bio-Mos and excess dietary Zn were evaluated in Exp. 2 and 3 and Trial 2 of Exp. 4. In Trial 1 of Exp. 4, Bio-Mos was fed with and without an antibiotic. In addition to the weanling pig experiments, 0.30% Bio-Mos was fed to finishing pigs to determine the effect on growth, carcass traits, and meat quality.

Bio-Mos addition did not affect growth performance ($P > 0.1$) in any phase of production in Exp. 1. However in Exp. 2 and 3, Bio-Mos increased ADG during Phase 2. Bio-Mos is not effective if Zn is included in the diet. Bio-Mos did not affect growth or carcass response variables in finishing pigs.

Three experiments were conducted to evaluate the effects of dried brewers yeast (Brewtech®) on growth performance of nursing and weanling pigs. Experiment 1 was conducted to determine the effect of dried brewers yeast (Brewtech®) fed to nursing pigs and subsequent growth performance during the nursery period. Experiment 2 evaluated the effect of Brewtech® on growth performance of weanling pigs during a 7 d Phase 1 period. In Exp. 3, 5% Brewtech® was compared with 5% spray-dried animal plasma and weanling pig growth was evaluated.

In the nursery period, pigs fed diets containing Brewtech® had increased ADG and gain:feed in Phase 1 and increased ADG overall compared with pigs not fed Brewtech®. Brewtech® did not affect growth performance of pigs during Phase 1, unless Brewtech® was fed pre-weaning, but Brewtech® increased ADG and gain:feed in Phase 2, and increased gain:feed in the overall data.

One experiment was conducted to determine the effects of Cr (0, 200, or 1,000 ppb) as Cr picolinate on sow productivity. Chromium supplementation at 200 ppb increased total number of pigs born and weaned. The 1,000 ppb level had no effect.

CHAPTER 1

LITERATURE REVIEW

INTRODUCTION

As world population continues to grow, the area available to produce swine has decreased. This coupled with environmental issues that geographically limit the swine industry are major concerns facing the United States and world swine producers. In addition, the occurrence of animal diseases and the limitation of antibiotic usage in the livestock industry has made it even more difficult for swine producers to be profitable. Alternative feed ingredients have provided some potential avenues to increase sow production and weanling pig growth. These nutrient sources include, but are not limited tochromium, dried brewers yeast (Brewtech®), and mannan oligosaccharides (Bio-Mos).

The swine industry has become more performance intense and structured, resulting in sow performance becoming the most economically important unit of production. Many factors have changed the swine industry in the past 10 years, including increased loin muscle area, decreased backfat, expanding sow herds, diminishing slaughter capacity, increased slaughter weights, national disease threats (e.g., Foot and Mouth Disease, Bovine Spongiform Encephalopathy, Porcine Respiratory and Reproductive Syndrome), environmental issues, food safety, animal welfare activists, and more concentrated swine farms. All of these factors have contributed to a more restricted economic margin that puts more pressure on sow performance. With all of these changes, the sow has been pushed to the extreme to produce more pigs with less

recovery time after each farrowing. In order for this to happen, sow nutrition must be optimum to maximize pig production.

DiPietre (1998) reported that increasing the number of pigs marketed per sow per year could have a dramatic effect on net farm income. In the simulated farrow to finish study, each additional pig marketed per sow resulted in a $35.00 to $38.00 net return per sow. In general, the sow has become the key to profitability in the swine industry.

CHROMIUM

Recent studies indicate that the addition of Cr picolinate to gestation and lactation diets increases the number of pigs born alive, number of pigs weaned, and fewer days to return to estrus.

Supplemental organic Cr for swine gained interest in the early 1990's when researchers reported that supplemental Cr picolinate improved growth and carcass performance of growing-finishing pigs (Page et al., 1993; Lindemann et al., 1995). However, the effect of Cr on growth and carcass performance was variable.

Organic Cr was subsequently evaluated in experiments with breeding females. Initial research indicated that the addition of Cr picolinate increased number of pigs born alive and weaned, and reduced days to return to estrus (Lindemann et al., 1995). More recently, Trottier et al. (1998) reported an increase in total pigs born and number born alive during the second production cycle when sow diets were supplemented with 200 ppb Cr as Cr picolinate. In the same experiment, sows were fed 1,000 ppb Cr as Cr picolinate for a 60 d loading phase and then 200 ppb Cr for the remainder of the

experiment; litter and sow performance were not improved by this Cr feeding regime. Hagen et al. (1998) conducted a study with 48,000 females. Sows were fed either 200 ppb Cr as Cr picolinate during a 6 month loading phase and remained on the same diet throughout gestation, or a basal diet without supplemental Cr. The sows fed diets with supplemental Cr had increased number of pigs born alive and weaned and decreased sow mortality.

The mode of action in which supplemental Cr affects reproductive performance is not known. However, it is well known that Cr is associated with the glucose tolerance factor, which facilitates insulin function (Mertz, 1969). Cox et al. (1987) reported that insulin administration before estrus increased ovulation rate, and in addition, administration of insulin before breeding increased litter size (Cox et al.,1994).

MANNAN OLIGOSACCHARIDES

There is an increased emphasis on reducing antibiotic usage in animal feeds. There also are concerns of environmental damage from high mineral deposits resulting from swine waste. The swine industry must find comparable products to replace these antimicrobials and excess dietary minerals.

In the swine industry during the nursery phase of production, a high concentrate diet containing Zn, Cu, Se, and antibiotics is fed to maximize growth performance. It has been suggested (Bio-Mos Technical Dossier, 1997) that feeding a mannan oligosaccharide (Bio-Mos) improves gut health, and that it may take the place of some of these traditional ingredients, resulting in equal performance.

There are two modes of action of Bio-Mos that may contribute to improved pig growth. Bio-Mos is cultivated from yeast cell walls where mannan is one of the three main components. The mannan oligosaccharides bind to lectins on cell walls of bacteria such as *Salmonella*, *Escherichia coli*, and *Vibrio cholera* preventing them from attaching to intestinal epithelial cells. The mannan oligosaccharides along with the detrimental cells attached are passed undigested through the digestive system. In addition, the mannan oligosaccharides may enhance the specific and non-specific action of the immune system by acting as antigenic substances and evoking a direct antibody response (O'Carra, 1997). O'Carra (1997) reported that when Bio-Mos was included in rat diets at 0.2, 0.4, 0.8, or 1.0 % of diet, intestinal IgA levels were increased ($P < 0.05$) compared with controls. In another immune response experiment, dogs fed Bio-Mos at 0.20% of diet had increased circulating levels of neutrophils (O'Carra, 1997).

Several experiments with weanling pigs have been conducted. Dvorak (1998) reported that pigs fed 0.20% Bio-Mos had improved growth performance. Davis et al. (1999) also reported that growth performance was improved during Phases 2 and 3 when pigs were fed diets containing 0.20% Bio-Mos. Similarly, Brendemuhl et al. (1999) reported that pigs fed 0.20% Bio-Mos during Phase 1 had improved ($P < 0.06$) gain:feed. In the same experiment, pigs fed 0.20% Bio-Mos throughout the growing-finishing phase had improved ($P < 0.09$) gain:feed compared with control pigs.

DRIED BREWERS YEAST

The swine industry is constantly searching for feed sources that have excellent nutritional value and that will provide equal or better growth performance than

traditional ingredients. In addition, these feeds need to be practical and economical. One product that may have potential as a protein source for weanling pigs is Brewtech®, or dried brewers yeast, which is a by-product of the brewing industry and is 100% dried *Saccharomyces cerevisiae*. It is a quality protein supplement high in B-vitamins, amino acids, and micro minerals that may take the place of other starter pig protein sources, such as fish meal, soybean meal, or whey products.

In an experiment conducted by Veum and Bowman (1973), pigs were fed a control diet or the control diet + 2.0% *saccharomyces cervisiae* (SCYC) from 2 to 23 d of age and from 23 to 65 or 72 d of age. Average daily gain and gain:feed were not affected ($P > 0.05$) by SCYC for 2 to 23 days of age. Likewise, there was no effect ($P > 0.05$) when SCYC was fed from 23 to 65 or 72 d. However, when 2.5% SCYC was fed, growth performance was decreased ($P < 0.05$).

Several studies have been conducted with dried brewers grains (DBG) and dried brewers yeast (DBY) fed in combination, usually 95% DBG and 5% DBY. Preston et al. (1973) reported that addition of 20% DBG and 5% DBY improved growth and carcass traits of feedlot cattle. In addition, there was a reduced incidence of rumen keratosis and liver abscesses in cattle fed DBG + DBY, which may have contributed to the increase in growth performance. Visek et al. (1976) fed beagles a diet containing 20% of a combination of dried brewers grain and dried brewers yeast. Growth and health were both maintained, and these researchers suggested that this may have been due to a better intestinal environment.

Improved growth performance from the addition of yeast also has been observed in swine. Knabe (1988) and Veum et al. (1988) both reported positive growth responses when pig diets were supplemented with yeast. Jurgens et al. (1997) also reported that active dry yeast *(Saccharomyces cerevisiae)* increased ADG and feed efficiency in neonatal pigs.

SUMMARY

All of the these dietary additions have the potential to improve animal performance. If the swine industry continues to narrow the margin for profit, the producer must find the most cost effective performance enhancing methods to produce pork. In addition, the consumer is going to continue to demand a safe nutritious product that has been produced in a humane environment. With these factors in mind, the following experiments were conducted to evaluate the effects of supplemental Cr as Cr picolinate on reproductive performance of sows, of dried brewers yeast (Brewtech®) and mannan oligosaccharides (Bio-Mos) on growth performance of weanling pigs, and Bio-Mos on growth performance, carcass characteristics, and pork quality of finishing pigs.

CHAPTER 2

EFFECT OF MANNAN OLIGOSACCHARIDES (BIO-MOS) ON GROWTH PERFORMANCE OF WEANLING PIGS

INTRODUCTION

There is an increased emphasis on reducing the use of antibiotics and excess levels of minerals in animal feeds. Because of these potential changes, other methods to improve swine production efficiency are being considered, especially during the nursery phase.

During the nursery phase of production, a diet containing Zn, Cu, Se, and antibiotics is fed to maximize growth performance. It has been suggested (Bio-Mos Technical Dossier, 1997) that feeding a mannan oligosaccharide (Bio-Mos) will improve gut health and take the place of some of these traditional ingredients, resulting in equal or better growth performance of nursery pigs. There are two modes of action that may contribute to improved pig growth. Bio-Mos is cultivated from yeast cell walls where mannan is one of the three main components. The mannan oligosaccharides bind to lectins on cell walls of bacteria such as *Salmonella*, *Escherichia coli*, and *Vibrio cholera* preventing them from attaching to intestinal epithelial cells. The mannan oligosaccharides, along with the detrimental cells attached, are passed undigested through the digestive system. In addition, mannan oligosaccharides may enhance the specific and non-specific action of the immune system by acting as antigenic substances and evoking a direct antibody response (O'Carra, 1997). Dvorak (1998) reported that pigs fed 0.20% Bio-Mos had improved growth performance. Similarly, Davis et al.

(1999) reported that growth performance was improved during Phases 2 and 3 of the nursery period by the addition of 0.20% Bio-Mos. Thus, the following experiments were conducted to further evaluate the effect of Bio-Mos, excess dietary Zn, and an antibiotic on growth performance of weanling pigs.

MATERIALS AND METHODS

Five experiments with 471 weanling pigs were conducted at the Louisiana State University Agricultural Center Swine Facility. All experiments were approved by the University Animal Care and Use committee.

In all experiments, Yorkshire x Landrace or Yorkshire x Landrace x Duroc barrows, boars, and gilts were allotted to treatments on the basis of ancestry, gender, and weight in randomized complete block designs. Pigs were housed in an environmentally controlled nursery in 0.97 m x 1.47 m pens on hard plastic completely slotted flooring. Average daily gain, ADFI, and gain:feed data were determined weekly. In each experiment, pigs were fed a corn soybean meal basal diet (Table 2.1) formulated to contain 1.60%, 1.50%, or 1.10% lysine in Phases 1, 2, and 3 respectively, and to meet or exceed the nutritional requirements (NRC, 1998) of pigs during the nursery period. Pigs and their environment were monitored at least twice daily. Treatment diets and water were available ad libitum throughout the experiment.

In Exp. 1, one hundred and five weanling boars and gilts were allotted to three treatments: 1) Basal diet (B), 2) B + 0.20% Bio-Mos, and 3) B + 0.30% Bio-Mos. The average initial age of the pigs was 20 d, and average initial and final BW were 4.8 and 14.7 kg, respectively. Each treatment was replicated with seven pens of five pigs each.

TABLE 2.1 Composition of basal diet, %

Ingredient	Phase 1	Phase 2	Phase 3
Corn	38.154	45.872	67.26
Soybean meal (48.5% CP)	20.778	28.516	20.97
Whey	15.000	10.000	-
Lactose	5.000	-	-
Spray-dried animal plasma[a]	5.002	-	-
Fishmeal, menhaden	8.000	8.000	5.00
Dry fat[b]	4.000	3.000	2.00
Monocalcium phosphate	0.644	0.898	1.37
Limestone	0.470	0.458	0.71
Trace minerals[c]	0.100	0.100	0.100
ZMC-Fe[d]	0.100	0.100	0.100
Se premix[e]	0.050	0.050	0.050
Salt	0.250	0.500	0.500
Zinc oxide[f]	-/+	-/+	-
Vitamins[g]	0.500	0.500	0.500
L-Lysine · HCl	0.050	0.100	0.100
DL-Methionine	0.110	0.116	0.018
Choline chloride	0.050	0.050	-
Sodium bentonite	0.500	0.500	0.500
Antibiotic[h]	-/+	-/+	-/+
Flavor[i]	0.075	0.075	0.075
Calculated composition			
Crude protein	23.83	23.71	18.85
Lysine	1.60	1.50	1.10
Tryptophan	0.31	0.29	0.21
Threonine	1.07	0.95	0.71
Methionine+Cystine	0.96	0.90	0.66
Calcium	0.90	0.90	0.90
Phosphorus	0.80	0.80	0.80

[a]AP 920, American Protein Corporation, Ames, IA.
[b]Fat Pak 100, Milk Specialties Co., Dundee, IL.
[c]Provided the following per kilogram of diet: Zn (zinc sulfate), 127; Fe (ferrous sulfate monohydrate), 127; Mn (manganous sulfate), 20; Cu (copper sulfate), 12.7; I (calcium iodate), .80.
[d]Provided the following in milligrams per kilogram of diet as mineral proteinates: Zn, 40; Mn, 7.5; Cu, 6 ; Fe, 25 (Ducoa L.P., Highland, IL).
[e]Provided 0.3 mg Se per kilogram of diet.
[f]Zn (3,000 ppm) added as ZnO depending on the diet.
[g]Provided the following per kilogram of diet: vitamin A, 11,023 IU; vitamin D, 3,307 IU; vitamin E, 88 IU; menadionine (menadionine pyrimidinol bisulfite) 8.3 mg; riboflavin, 13 mg; pantothenic acid, 50 mg; niacin, 88 mg; vitamin B_{12}, 61 μg; biotin, 441 μg; choline (as choline chloride), 882 mg; folic acid, 3.3 mg, pyridoxine, 4.41; thiamin, 4.41; and vitamin C, 110 μg.
[h]Neo-Terra 10/10, Oxytetracycline (from oxytetracycline quaternary salt) equivalent to oxytetracycline hydrochloride 22 g/kg (Nutra Blend Corporation, Neosho, MO).
[i]Dried strawberry, Feed Flavors, Inc., Wheeling, IL.

The experimental period was 28 d. The Phase 1 diet was fed for 8 d, the Phase 2 diet for 13 d, and the Phase 3 diet for 7 d (Table 2.1).

Experiment 2 was conducted to determine the effect of Bio-Mos with and without 3,000 ppm Zn on growth performance of weanling pigs. One hundred fifty weanling pigs were allotted to six diets: 1) Basal diet without excess Zn (B), 2) B + 0.20% Bio-Mos without excess Zn, 3) B + 0.30% Bio-Mos without excess Zn, 4) B + 3,000 ppm Zn as ZnO, 5) B + 0.20% Bio-Mos + 3,000 ppm Zn as ZnO, or 6) B + 0.30% Bio-Mos + 3,000 ppm Zn as ZnO. Antibiotic was included in each of the diets and cornstarch and sand replaced Bio-Mos and Zn, respectively. Average initial age of pigs was 17 d, and average initial and final BW were 5.4 and 13.8 kg, respectively. Each treatment was replicated with five pens of five pigs each. The experimental period was 28 d. Pigs were fed the Phase 1 diet for 7 d, the Phase 2 diet for 14 d, and the Phase 3 diet for 7 d.

Experiment 3 again evaluated Bio-Mos (0 or 0.20%) and Zn (0 or 3,000 ppm as ZnO) in a 2 x 2 factorial arrangement. All diets contained an antibiotic and cornstarch and sand replaced Bio-Mos and ZnO, respectively. Ninety-six weanling pigs were allotted to treatment with five replications of five pigs each. Average initial age of the pigs was 16 d, and average initial and final BW were 4.9 and 9.9 kg, respectively. The experimental period was 21 d. Pigs were fed the Phase 1 diet for 7 d and the Phase 2 diet for 14 d.

Experiment 4 will be presented and analyzed as two trials, but they were conducted simultaneously and a common basal and basal plus Bio-Mos diet were used in

the two trials. One-hundred twenty weanling pigs were allotted to six dietary treatments. In Trial 1, the treatments were: 1) basal diet without antibiotic or excess dietary Zn (B), 2) B + 0.75% antibiotic (Neo-Terra 10/10, Nutra Blend Corporation, Neosho, MO), 3) B+ 0.20% Bio-Mos, or 4) B + antibiotic + Bio-Mos. In Trial 2, the treatments were: 1) basal diet without antibiotic or excess dietary Zn (B), 2) B+ 0.20% Bio-Mos, 3) B+ 3,000 ppm Zn as ZnO, or 4) B + Bio-Mos + Zn. Cornstarch was added in place of antibiotic, Bio-Mos, or Zn when appropriate. The average initial age of the pigs was 18 d and average initial and final BW were 4.7 and 14.1 kg, respectively. Each treatment was replicated with five pens of four pigs each. The experimental period was 27 d. Pigs were fed the Phase 1, 2, and 3 diets for 7, 12, and 8 d, respectively.

Statistical Analyses. Data were analyzed by analysis of variance procedures (Steel and Torrie, 1980) appropriate for randomized complete block designs using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). Orthogonal single degree of freedom contrasts were used to determine treatment differences. The pen of pigs served as the experimental unit for all data.

RESULTS

In Exp. 1, Bio-Mos addition had no effect ($P > 0.10$) on growth performance of pigs during Phase 1, 2, 3, and overall (Table 2.2).

In Exp. 2, there was no effect ($P > 0.10$) of Zn or Bio-Mos on growth performance during Phase 1 (Table 2.3). However, in Phases 2 and 3 and overall, the addition of excess Zn at 3,000 ppm increased ($P < 0.08$) ADG. Excess Zn also increased ($P < 0.08$) ADFI in Phases 2 and 3 and overall. There were Zn x Bio-Mos quadratic

TABLE 2.2 Effect of 0.20 or 0.30% Bio-Mos on growth performance of weanling pigs, Experiment 1[a]

	Bio-Mos			
Item	0%[b]	0.20%	0.30%	SEM
Day 0-8 (Phase 1)				
ADG, g	194	222	194	31
ADFI, g	204	217	175	16
Gain:feed	939	996	886	51
Day 8-21 (Phase 2)				
ADG, g	424	420	430	16
ADFI, g	565	568	550	25
Gain:feed	749	741	758	12
Day 21-28 (Phase 3)				
ADG, g	410	418	402	24
ADFI, g	736	727	715	29
Gain:feed	555	576	563	20
Day 0-28 (overall)				
ADG, g	355	363	355	12
ADFI, g	501	508	482	20
Gain:feed	705	716	703	12

[a]Data are means of seven replicates with five pigs each. Average initial and final BW were 4.8 and 14.7 kg, respectively. The experimental period was 28 d.
[b]Basal diet includes antibiotic (Neo-Terra 10/10, Oxytetracycline from oxytetracycline quaternary salt equivalent to oxytetracycline hydrochloride 22 g/kg, Nutra Blend Corporation, Neosho, MO), and 3,000 ppm Zn as ZnO.

TABLE 2.3 Effect of Bio-Mos with and without excess Zn on growth performance of weanling pigs, Experiment 2[a,b]

	- Zn			+ Zn[c]			
Bio-Mos	0%	0.20%	0.30%	0%	0.20%	0.30%	SEM
Day 0-7 (Phase 1)							
ADG, g	73	145	106	122	86	124	32
ADFI, g	251	298	280	246	241	280	20
Gain:feed	231	464	381	478	330	429	103
Day 7-21 (Phase 2)							
ADG, g[d]	347	386	352	384	415	422	21
ADFI, g[de]	390	476	415	485	487	515	24
Gain:feed[e]	891	808	845	790	850	821	28
Day 21-28 (Phase 3)							
ADG, g[de]	282	321	275	339	308	353	26
ADFI, g[d]	518	516	506	564	578	603	25
Gain:feed[e]	532	621	541	601	530	589	29
Day 0-28 (overall)							
ADG, g[de]	262	310	271	307	307	330	17
ADFI, g[de]	386	441	403	445	448	477	19
Gain:feed	675	699	673	688	679	695	20

[a]Data are means of five replicates with five pigs each except for Trt. = Zn + 0% Bio-Mos, which is four replicates with five pigs each. Average initial and final BW were 5.4 and 13.8 kg, respectively. The experimental period was 28 d.
[b]Basal diet contains antibiotic (Neo-Terra 10/10, Oxytetracycline from oxytetracycline quaternary salt equivalent to oxytetracycline hydrochloride 22 g/kg, Nutra Blend Corporation, Neosho, MO).
[c]Zn (3,000 ppm) added as ZnO.
[d]Zn effect, $P < 0.08$.
[e]Zn x BM quadratic effect, $P < 0.08$.

effects ($P < 0.08$) in ADFI for Phase 2 and overall, in ADG for Phase 3 and overall, and in gain:feed for Phases 2 and 3. In Phases 2 and 3 and in the overall data, the 0.20% Bio-Mos addition increased the respective response variables in the absence of excess Zn, but it was not effective or decreased these response variables in the presence of excess Zn. The exception was gain:feed during Phase 2. The 0.20% Bio-Mos addition decreased gain:feed without Zn, but increased gain:feed with Zn.

In Exp. 3, excess Zn decreased ($P < 0.09$) ADG in Phase 1 but increased ADG and ADFI in Phase 2 (Table 2.4). In the overall data, the addition of Bio-Mos decreased ($P < 0.03$) ADFI. Zinc x Bio-Mos interactions ($P < 0.02$) occurred in Phase 2 for ADG, ADFI, and gain:feed. Average daily gain and gain:feed were increased by Bio-Mos without excess Zn but decreased in pigs fed excess Zn. Average daily feed intake was decreased by Bio-Mos, but the decrease was greater in pigs fed excess Zn and Bio-Mos. Zinc x Bio-Mos interactions also were observed in the overall data ($P < 0.07$). Bio-Mos increased ADG and gain:feed without excess Zn but decreased these responses in the presence of excess Zn.

In Trial 1 of Exp. 4, the antibiotic addition increased ($P < 0.01$) ADG and ADFI in Phases 2 and 3 and in the overall data (Table 2.5). The Bio-Mos addition decreased ADG and gain:feed in Phase 2 when antibiotic was not in the diet but increased ADG when antibiotic was in the diet (antibiotic x Bio-Mos, $P < 0.05$). In Trial 2 of Exp. 4, excess Zn increased ($P < 0.07$) ADG and ADFI during Phases 2 and 3 and in the overall data (Table 2.6). There was no main effect of Bio-Mos, but in Phase 2, Bio-Mos

TABLE 2.4 Effect of Bio-Mos with and without excess Zn on growth performance of weanling pigs, Experiment 3[a]

	-Zn		+Zn[b]		
Bio-Mos	0%[c]	0.20%	0%	0.20%	SEM
Day 0-7 (Phase 1)					
ADG, g[d]	122	103	84	64	20
ADFI, g	212	182	183	137	25
Gain:feed	565	543	523	429	64
Day 7-21 (Phase 2)					
ADG, g[de]	280	328	363	311	17
ADFI, g[de]	480	455	520	467	14
Gain:feed[e]	584	722	696	659	30
Day 0-21 (overall)					
ADG, g[e]	228	242	270	228	14
ADFI, g[f]	390	353	404	359	16
Gain:feed[e]	583	686	668	632	23

[a]Data are means of five replicates with five pigs each. Average initial and final BW were 4.9 and 9.9 kg, respectively. The experimental period was 21 d.
[b]Excess Zn (3,000 ppm) added as ZnO.
[c]Basal diet includes antibiotic (Neo-Terra 10/10, Oxytetracycline from oxytetracycline quaternary salt equivalent to oxytetracycline hydrochloride 22 g/kg, Nutra Blend Corporation, Neosho, MO).
[d]Zn effect, $P < 0.09$.
[e]Zn x Bio-Mos effect, $P < 0.07$.
[f]Bio-Mos effect, $P < 0.03$.

TABLE 2.5 Effect of Bio-Mos with and without antibiotic on growth performance of weanling pigs, Experiment 4, Trial 1[a]

	-Antibiotic[b]		+Antibiotic		
Bio-Mos	0%	0.20%	0%	0.20%	SEM
Day 0-7 (Phase 1)					
ADG, g	130	130	136	126	15
ADFI, g	194	194	214	194	11
Gain:feed	666	675	646	645	55
Day 7-19 (Phase 2)					
ADG, g[cde]	401	342	414	423	12
ADFI, g[cd]	552	497	622	595	21
Gain:feed[e]	730	689	666	714	20
Day 19-27 (Phase 3)					
ADG, g[c]	394	414	496	479	27
ADFI, g[c]	731	754	873	862	37
Gain:feed	539	551	566	554	18
Day 0-27 (overall)					
ADG, g[c]	329	308	366	363	12
ADFI, g[c]	512	495	591	570	20
Gain:feed	643	626	620	637	12

[a]Data are means of five replicates with five pigs each. Average initial and final BW were 4.7 and 14.1 kg, respectively. The experimental period was 27 d.

[b]Antibiotic was (Neo-Terra 10/10, oxytetracycline from oxytetracycline quaternary salt equivalent to oxytetracycline hydrochloride 22 g/kg, Nutra Blend Corporation, Neosho, MO).

[c]Antibiotic effect, $P < 0.01$.

[d]Bio-Mos effect, $P < 0.08$.

[e]Antibiotic x Bio-Mos effect, $P < 0.05$.

TABLE 2.6 Effect of Bio-Mos with and without excess Zn on growth performance of weanling pigs, Experiment 4, Trial 2[a]

	-Zn		+Zn[b]		
Bio-Mos	0%[c]	0.20%	0%	0.20%	SEM
Day 0-7 (Phase 1)					
ADG, g	130	130	138	107	13
ADFI, g	194	194	207	191	13
Gain:feed	666	675	682	539	60
Day 7-19 (Phase 2)					
ADG, g[d]	401	342	419	444	16
ADFI, g[d]	552	497	602	597	20
Gain:feed[e]	730	689	696	742	18
Day 19-27 (Phase 3)					
ADG, g[d]	394	414	483	442	26
ADFI, g[d]	731	754	854	785	38
Gain:feed	539	551	560	564	18
Day 0-27 (overall)					
ADG, g[d]	329	308	365	356	13
ADFI, g[d]	512	495	575	548	20
Gain:feed	643	626	636	650	14

[a]Data are means of five replicates with five pigs each. Average initial and final BW were 4.7 and 14.1 kg, respectively. The experimental period was 27 d.
[b]Zn (3,000 ppm) added as ZnO.
[c]Basal diet contains no antibiotic or excess Zn.
[d]Zn effect, $P < 0.07$.
[e]Zn x Bio-Mos effect, $P < 0.03$.

decreased gain:feed when excess Zn was not added to the diet but increased gain:feed when Zn was included (Zn x Bio-Mos, $P < 0.03$).

DISCUSSION

These experiments were conducted to determine the efficacy of the mannan oligosaccharide, BioMos, in nursery diets. Previous studies have reported that supplemental Bio-Mos during the nursery phase improved growth performance (Dvorak et al., 1998; Davis et al., 1999). The rational for Bio-Mos inclusion was that it might be a replacement for antibiotics or excess Zn, which would decrease the use of antibiotics in animal diets and decrease Zn excretion to the environment.

Bio-Mos addition at 0.20% or 0.30% in Exp. 1 did not affect growth performance in any phase of production. The diets used in this experiment contained both an antibiotic and excess dietary Zn. Subsequent research was conducted to evaluate Bio-Mos in the presence or absence of excess Zn or an antibiotic. Exp. 2 and 3 and Trial 2 of Exp. 4 evaluated the interactive effects of Bio-Mos and excess dietary Zn. The results are somewhat inconsistent, but the 0.20% Bio-Mos addition increased ADG in Phase 2 and in the overall data in Exp. 2. The effect was more pronounced in diets with no excess Zn than in diets with excess Zn. In this experiment, the 0.30% Bio-Mos addition was not as effective as the 0.20% Bio-Mos addition. The 0.20% addition was used in subsequent experiments. In Exp. 3, the results are similar to those of Exp. 2. The 0.20% Bio-Mos addition increased ADG and gain:feed in Phase 2 and in the overall data, and again, the response was more pronounced in diets without excess Zn. In fact in this experiment the Bio-Mos addition in the presence of excess Zn reduced pig

performance relative to those just fed Zn. The results of Exp. 4 Trial 2 are not in agreement with the two previous experiments. The 0.20% Bio-Mos addition was effective only in the presence of excess Zn and the effect was significant only in gain:feed. Recall that in this experiment, the basal diet did not contain an antibiotic.

The antibiotic increased ADG, ADFI, and gain:feed in Phases 2 and 3 and overall data, which is in agreement with numerous reports as indicated in the review by Cromwell (2001). Bio-Mos decreased ADG in Phase 2 when no antibiotic was in the diet but increased ADG in the presence of the antibiotic. This response may suggest that an antibiotic is synergistic with Bio-Mos. The antibiotic addition may make the gut microflora more favorable for a positive Bio-Mos response.

These data suggest that Bio-Mos improves growth performance of weanling pigs during Phase 2 of production, and the response is greater if excess Zn is not included in the diet. Also, this response was not observed in one Exp. where no antibiotic was included in the diet. The indication that Bio-Mos is more effective in diets with no excess Zn suggests that Bio-Mos and excess Zn have similar modes of action.

Bio-Mos did not affect growth performance of pigs during Phase 1. This was not expected, and because excess Zn generally improves growth performance during Phase 1, their modes of action may not be similar. The reason that Bio-Mos did not affect growth performance during Phase 1 is not known. It may be that Bio-Mos is effective by altering the microflora in the intestine and that it may take at least 1 week for this change to take place. It would be interesting to evaluate Bio-Mos in pre-wean diets and then determine the effect of Bio-Mos during the nursery phase. This initial exposure

to Bio-Mos in the pre-wean feed may allow adequate time for changes in the intestinal microflora to take place, and then result in a response in the Phase 1 nursery period.

These data suggest that Bio-Mos fed at the 0.20% level may have some benefit during Phase 2 of the nursery period when fed in combination with antibiotic and without excess Zn.

CHAPTER 3

EFFECT OF DRIED BREWERS YEAST (BREWTECH®) ON GROWTH PERFORMANCE OF NURSING AND WEANLING PIGS

INTRODUCTION

The swine industry is constantly searching for feed sources that have excellent nutritional value and that will provide equal or better performance than traditional ingredients. In addition, these feeds need to be practical and economical. One product that may have potential as a protein source for weanling pigs is Brewtech®, which is dried brewers yeast. Brewtech® is a by-product of the brewing industry and is 100% dried *Saccharomyces cerevisiae*. It is a quality protein supplement (Table 3.1) high in B-vitamins, amino acids, and micro minerals, and it may be able to replace all or part of other starter pig protein sources, such as fish meal, soybean meal, or whey products.

Several studies have been conducted with dried brewers grains (DBG) and dried brewers yeast (DBY) fed in combination, usually 95% DBG and 5% DBY. Preston et al. (1973) reported that dietary addition of 20% DBG and 5% DBY improved growth and carcass traits of feedlot cattle. In addition, there was a reduced incidence of rumen keratosis and liver abscesses in cattle fed DBG + DBY, which may have contributed to the increase in growth performance.

Improved growth performance from the addition of yeast also has been observed in swine. Knabe (1988) and Veum et al. (1988) both reported positive growth responses when pig diets were supplemented with yeast. Jurgens et al. (1997) also reported that active dry yeast *(Saccharomyces cerevisiae)* increased ADG and feed efficiency in

TABLE 3.1 Composition of Brewtech® Dried Brewers Yeast

	%
Crude protein	43.00
Crude fat	1.5
Crude fiber	1.0
Ash	5.5
Moisture	6.0
M.E. (Calculated)	3,137 Kcal/kg
Amino Acids:	
Arginine	2.25
Histidine	1.09
Isoleucine	1.98
Leucine	2.85
Lysine	2.97
Methionine + Cystine	1.16
Phenylalanine	1.62
Tyrosine	1.50
Threonine	2.05
Tryptophan	0.52
Valine	2.36
Minerals:	
Calcium	0.12
Phosphorus	1.13
Potassium	1.41
Chlorine	0.06
Magnesium	0.20
Sodium	0.06
Sulfur	0.36
Selenium	0.82 ppm

neonatal pigs. These researchers suggested that the improved growth may have been due to a better intestinal environment. Therefore, the following studies were conducted to determine the effect of dried brewers yeast (Brewtech®, International Ingredient Corporation, St. Louis, MO) on growth performance of weanling pigs.

MATERIALS AND METHODS

Three experiments with 402 weanling pigs were conducted at the Louisiana State University Agricultural Center Swine Facility. All experiments were approved by the University Animal Care and Use Committee.

In all experiments, Yorkshire x Landrace or Yorkshire x Landrace x Duroc barrows and gilts were allotted to treatments on the basis of ancestry, gender, and weight in randomized complete block designs. Pigs were housed in an environmentally controlled nursery in 0.97 m x 1.47 m pens on hard plastic completely slotted flooring. Pigs and their environment were monitored twice daily. Feed and water were provided ad libitum throughout the experiments. Average daily gain, ADFI, and gain:feed were determined weekly during the experiments. In each experiment, pigs were fed diets (Table 3.2, 3.3) formulated to contain 1.60 or 1.50% (1.60 or 1.40% in Exp. 3) lysine in Phases 1 and 2, respectively, and to meet or exceed the nutrient requirements (NRC, 1998) of nursery pigs.

Experiment 1 was conducted to determine the effect of dried brewers yeast (Brewtech®) fed pre-weaning as a pre-wean diet on growth of pigs pre-weaning and subsequent growth performance during the nursery period. Sows and gilts were housed in an environmentally controlled facility in 1.5 x 2.7 m farrowing pens. Sows were

TABLE 3.2 Basal diet composition, Experiment 1 and 2

Ingredient	Phase 1 Basal	Phase 1 Brewtech®	Phase 2 Basal	Phase 2 Brewtech®
	%	%	%	%
Corn	38.68	38.63	45.50	45.46
Soybean meal (48.5% CP)	20.34	16.41	29.26	25.32
Whey	15.00	15.00	10.00	10.00
Lactose	5.00	5.00	-	-
Spray-dried animal plasma[a]	5.00	5.00	-	-
Brewtech®	-	4.00	-	4.00
Fishmeal, menhaden	8.00	8.00	8.00	8.00
Dry fat [b]	4.00	4.00	3.00	3.00
Monocalcium phosphate	0.55	0.46	0.74	0.66
Limestone	0.53	0.58	0.48	0.54
Trace minerals [c]	0.10	0.10	0.10	0.10
ZMC-Fe[d]	0.10	0.10	0.10	0.10
Se premix[e]	0.05	0.05	0.05	0.05
Salt	0.25	0.25	0.25	0.25
Zinc oxide[f]	0.42	0.42	0.42	0.42
Vitamins[g]	0.50	0.50	0.50	0.50
L-Lysine · HCl	0.05	0.05	0.05	0.05
DL-Methionine	0.06	0.71	0.10	0.11
L-Theorine	-	-	0.08	0.07
Choline chloride	0.05	0.05	0.05	0.05
Sodium bentonite	0.50	0.50	0.50	0.50
Antibiotic[h]	0.75	0.75	0.75	0.75
Flavor [i]	0.08	0.08	0.08	0.08
Calculated composition:				
Crude protein	23.65	23.51	23.71	23.87
Lysine	1.60	1.60	1.50	1.50
Tryptophan	0.31	0.30	0.29	0.29
Threonine	1.03	1.04	0.95	1.02
Methionine + Cystine	0.90	0.90	0.90	0.90
Calcium	0.90	0.90	0.90	0.90
Phosphorus	0.80	0.80	0.80	0.80

[a]AP 920, American Protein Corporation, Ames, IA.
[b]Fat Pak 100, Milk Specialties Co., Dundee, IL.
[c]Provided the following in milligrams per kilogram of diet: Zn (zinc sulfate), 127; Fe (ferrous sulfate monohydrate), 127; Mn (manganous sulfate), 20; Cu (copper sulfate), 12.7; I (calcium iodate), .80.
[d]Provided the following per kilogram of diet: Zn, 40 mg; Mn, 7.5 mg; Cu, 6 mg; Fe, 25 mg.
[e]Provided .3 mg Se per kilogram of diet.
[f]Zn provided (3,000 ppm) added as ZnO.
[g]Provided the following per kilogram of diet: vitamin A, 11,023 IU; vitamin D, 3,307 IU; vitamin E, 88 IU; menadionine (menadionine pyrimidinol bisulfite) 8.3 mg; riboflavin, 13 mg; pantothenic acid, 50 mg; niacin, 88 mg; vitamin B_{12}, 61 μg; biotin, 441 μg; choline (as choline chloride), 882 mg; folic acid, 3.3 mg, pyridoxine, 4.41; thiamin, 4.41; and vitamin C, 110 μg.
[h]Neo-Terra 10/10, Oxytetracycline (from oxytetracycline quaternary salt) equivalent to oxytetracycline hydrchloride 22 g/kg (Nutra Blend Corporation, Neosho, MO).
[i]Dried strawberry, Feed Flavors, Inc., Wheeling, IL.

TABLE 3.3 Basal diet composition, Experiment 3

Ingredient	Phase 1 Basal	Phase 1 Brewtech®	Phase 2 Basal	Phase 2 Brewtech®
	%	%	%	%
Corn	36.94	29.26	46.96	45.43
Soybean meal (48.5% CP)	24.52	31.54	31.44	25.35
Whey	15.00	15.00	10.00	10.00
Lactose	5.00	5.00	-	-
Spay-dried animal plasma[a]	5.00	-	-	-
Brewtech®	-	5.00	-	4.00
Fishmeal, menhaden	6.00	6.00	5.00	8.00
Dry fat[b]	4.00	4.00	3.00	3.00
Monocalcium phosphate	0.68	0.82	0.57	0.66
Limestone	0.72	0.60	0.68	0.54
Trace minerals[c]	0.10	0.10	0.10	0.10
ZMC-Fe[d]	0.10	0.10	0.10	0.10
Se premix[e]	0.05	0.05	0.05	0.05
Salt	0.25	0.25	0.50	0.25
Zinc oxide[f]	0.28	0.28	0.28	0.42
Vitamins[g]	0.50	0.50	0.50	0.50
L-Lysine · HCl	-	-	-	0.05
DL-Methionine	0.07	0.11	0.02	0.11
L-Threonine	-	0.01	-	0.07
Choline chloride	0.05	0.05	0.05	0.05
Sodium bentonite	0.50	0.50	0.50	0.50
Antibiotic[h]	0.75	0.75	0.75	0.75
Flavor[i]	0.08	0.08	0.08	0.08
Sand	-	0.14	-	-
Calculated composition:				
Crude protein	24.14	23.83	23.10	23.87
Lysine	1.60	1.60	1.40	1.50
Tryptophan	0.32	0.31	0.28	0.29
Threonine	1.06	1.07	0.92	1.02
Methionine + Cystine	0.92	0.96	0.79	0.89
Calcium	0.90	0.90	0.80	0.90
Phosphorus	0.79	0.80	0.69	0.80

[a]AP 920, American Protein Corporation, Ames, IA.
[b]Fat Pak 100, Milk Specialities Co., Dundee, IL.
[c]Provided the following in milligrams per kilogram of diet: Zn (zinc sulfate), 127; Fe (ferrous sulfate monohydrate), 127; Mn (manganous sulfate), 20; Cu (copper sulfate), 12.7; I (calcium iodate), .80.
[d]Provided the following per kilogram of diet: Zn, 40 mg; Mn, 7.5 mg; Cu, 6 mg; Fe, 25 mg.
[e]Provided .3 mg Se per kilogram of diet.
[f]Zn provided as ZnO.
[g]Provided the following per kilogram of diet: vitamin A, 11,023 IU; vitamin D, 3,307 IU; vitamin E, 88 IU; menadionine (menadionine pyrimidinol bisulfite) 8.3 mg; riboflavin, 13 mg; pantothenic acid, 50 mg; niacin, 88 mg; vitamin B_{12}, 61 μg; biotin, 441 μg; choline (as choline chloride), 882 mg; folic acid, 3.3 mg, pyridoxine, 4.41; thiamin, 4.41; and vitamin C, 110 μg.
[h]Neo-Terra 10/10, Oxytetracycline (from oxytetracycline quaternary salt) equivalent to oxytetracycline hydrochloride 22 g/kg (Nutra Blend Corporation, Neosho, MO).
[i]Dried strawberry, Feed Flavors, Inc., Wheeling, IL.

housed in conventional 0.50 x 2.1 m crates. Pigs were provided 2.1 x 0.5 m creep areas on both sides of the sow and 0.6 x 1.5 m creep area in the front of the sow. Pig flooring was a slotted hard plastic and sows were on slotted cast iron floors. Supplemental heat was provided in the front creep area opposite the two hole creep feeders. Sows were provided a lactation diet (Table 3.4) containing 0.80 % lysine and formulated to meet or exceed the nutritional requirements (NRC, 1998) for lactating sows. Sow feed was provided ad libitum for the entire lactation period. At 5 d of age, litters were assigned to: 1) no pre-wean feed, 2) basal diet (B), 3) B + 4% Brewtech® (Table 3.2), and they were fed these diets until weaning at 21 d of age. At weaning, pigs within litters were assigned to: 1) basal (B) or 2) B + 4% Brewtech® (Table 3.2), resulting in six treatments (3 x 2 factorial arrangement) for the nursery period: 1) no pre-wean and B in nursery, 2) no pre-wean and Brewtech® in nursery, 3) B as pre-wean and B in nursery, 4) B as pre-wean and Brewtech® in nursery, 5) Brewtech® as pre-wean and B in nursery, and 6) Brewtech® as pre-wean and Brewtech® in nursery. Assignment of dietary pre-wean treatments to litters was random, with the exception that littermate sows were not assigned to the same treatment and sow parity and sire of litter were equalized across treatments. Pre-weaning treatments were replicated with 7 or 8 litters with 4 to 13 pigs each. Average initial and final litter BW were 18.4 and 49.3 kg. At weaning, pigs within litters were assigned to nursery treatments on the basis of weight, gender, and ancestry. The average initial age of the pigs was 21 d, and average initial and final BW were 5.7 and 10.5 kg, respectively. Each of the two nursery treatments (1) B or 2) B+ 4% Brewtech®) was replicated with seventeen pens of five or six pigs per replicate. The

TABLE 3.4 Composition of lactation diet

Ingredient	%
Corn	73.43
Soybean meal (48.5% CP)	23.00
Monocalcium phosphate	1.67
Limestone	1.20
Trace minerals [a]	0.08
Salt	0.50
Vitamins [b]	0.10
Choline chloride	0.15

[a]Provided the following per kilogram of diet: Zn (zinc sulfate), 127 mg; Fe (ferrous sulfate monohydrate), 127mg; Mn (manganous sulfate), 20 mg; Cu (copper sulfate), 12.7 mg; and I (calcium iodate), .80 mg.

[b]Provided the following per kilogram of diet: vitamin A, 10,000,066 IU; vitamin D_3, 1,000,888 IU; vitamin E, 75,000 IU; menadionine (menadionine pyrimidinol bisulfite) 6,058 mg; riboflavin, 7,500 mg; d-pantothenic acid, 23,999 mg; niacin, 30,000 mg; vitamin B_{12}, 30 mg; d-biotin, 351 mg; folic acid, 5,000 mg, pyridoxine hydrochloride, 7,317 mg; thiamin, 2,000 mg; thiamin mononitrate, 2,172 mg; calcium d-pantothenate, 26,085 mg; vitamin k, 2,000 mg; and vitamin B_6, 6001 mg.

experimental period in the nursery was 18 d. Pigs were fed the Phase 1 diet for 7 d and the Phase 2 diet for 11 d (Table 3.2).

Experiment 2 was conducted to determine the effect of Brewtech®on growth performance of weanling pigs during a 7 d Phase 1 period. Pigs were allotted to a basal diet or a diet containing 4% Brewtech® (Table 3.2). The average initial age of the pigs was 18 d; and the average initial and final BW were 5.1 and 6.2 kg, respectively. Each treatment was replicated with fourteen pens of five pigs per replicate.

In Exp. 3, pigs were allotted to a basal diet with either 5% spray-dried animal plasma (AP 920, American Protein Corporation, Ames, IA 30041) or a diet containing 5% Brewtech® without spray-dried animal plasma in Phase 1. During Phase 2, pigs that had been fed spray-dried animal plasma in Phase 1 were fed the basal diet and those that had been fed 5% Brewtech® in Phase 1 were fed 4% Brewtech® in Phase 2. The average initial age of pigs was 18 d, and average initial and final BW were 5.2 and 10.7 kg, respectively. Each treatment was replicated with six pens of six pigs each. The experimental period was 20 d. Pigs were fed the Phase 1 diet for 7 d and the Phase 2 diet for 13 d (Table 3.3).

Statistical Analyses. Data were analyzed by analysis of variance procedures (Steel and Torrie, 1980) appropriate for randomized complete block designs using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). In Exp. 1, the LSD procedure was used to determine differences among treatment means for the pre-wean and nursery data independent of each other. Orthogonal contrasts were used to determine differences between treatments when the six treatments combining the pre-wean diets and nursery

diets were considered. The litter or the pen of pigs was the experimental unit when the pre-wean and nursery data were considered independently, respectively, but the individual pig served as the experimental unit when the six treatments combining the pre-wean and nursery data were considered together. In Exp. 2 and 3, the LSD procedure of SAS was used to determine differences among treatment means. The pen of pigs served as the experimental unit for data in Exp. 2 and 3.

RESULTS

In Exp. 1, litters fed pre-wean diets containing Brewtech® had increased ($P < 0.05$) ADG compared with pigs fed a conventional pre-wean diet, but ADG of pigs that did not receive a pre-wean diet was similar ($P > 0.10$) to that of pigs fed the pre-wean diet with Brewtech® (Table 3.5). In the nursery period, pigs fed diets containing 4% Brewtech® had increased ($P < 0.05$) ADG and gain:feed during Phase 1 (Table 3.6) and increased ADG overall ($P < 0.10$) compared with pigs not fed Brewtech®.

The results of the pre-wean and nursery treatments are shown in Figure 3.1. Pigs fed pre-wean diets containing Brewtech® had decreased ADG in Phase 1 compared with pigs fed the conventional pre-wean diet ($P < 0.02$). However, pigs fed nursery diets containing Brewtech® had increased ($P < 0.03$) ADG. During Phase 2 and in the overall data, pigs fed Brewtech® during the pre-wean period had an increased ($P < 0.10$) ADG compared to pigs fed no pre-wean diet or the conventional diet. In addition during Phase 2 and overall, pigs fed Brewtech® pre-weaning had increased ADG if fed Brewtech® in the nursery compared to pigs not fed Brewtech® in the nursery (nursery feed x Brewtech® pre-wean feed interaction, $P < 0.09$). When pigs were fed pre-wean

TABLE 3.5 Effect of 4% Brewtech® on growth performance of nursing pigs

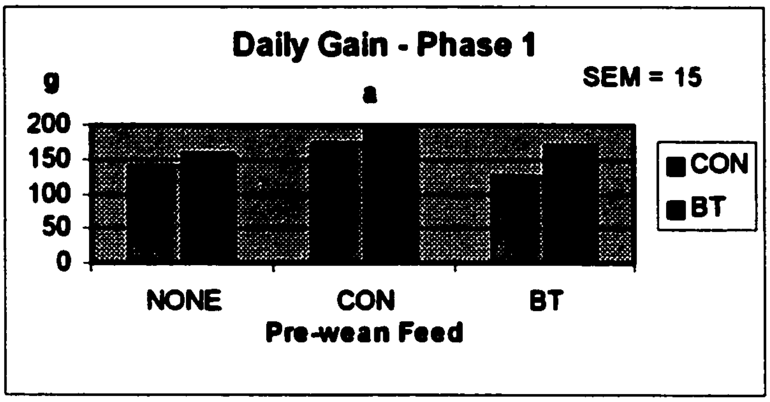
Item	No Creep	Basal	Brewtech®	SEM
n[a]	7	8	8	
ADG, g	240[b]	186[c]	243[b]	17

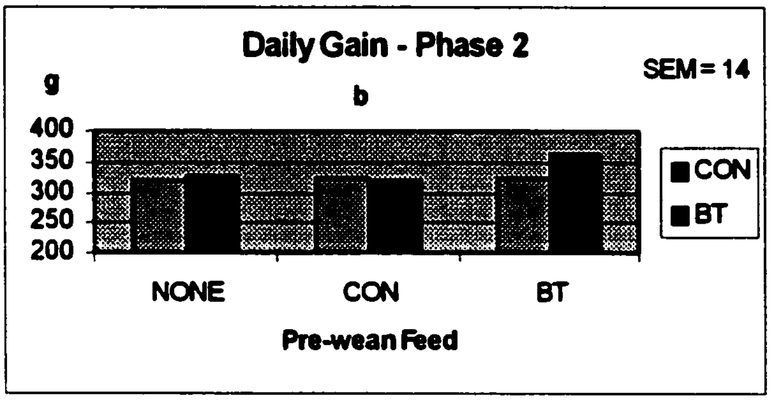
[a]Litters had four to thirteen pigs each. Average initial and final litter BW were 18.4 and 49.3 kg, and the experimental period was 16 d, from 5 d of age until weaning at 21 d of age.
[bc]Means with unlike superscripts differ ($P < 0.05$).

TABLE 3.6 Effect of 4% Brewtech® on growth performance of weanling pigs[a]

Item	Basal	Brewtech®	P > F	SEM
Day 0-7 (Phase 1)				
ADG, g	148	173	0.05	8
ADFI, g	190	205	0.20	8
Gain:feed	778	850	0.05	23
Day 7-18 (Phase 2)				
ADG, g	325	337	0.40	10
ADFI, g	433	452	0.20	11
Gain:feed	756	748	0.70	18
Day 0-18 (Overall)				
ADG, g	256	273	0.10	7
ADFI, g	339	356	0.20	8
Gain:feed	763	772	0.70	17

[a]Data are means of seventeen replicates with five or six pigs each. Average initial and final BW were 5.7 and 10.5 kg and the experimental period was 18 d.





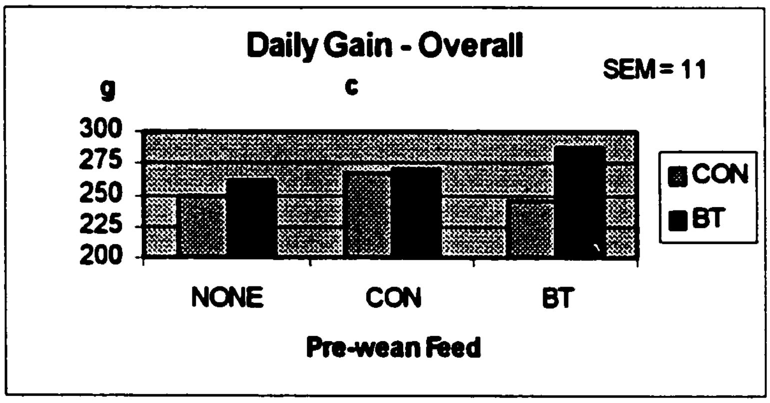


Figure 3.1 Effect of Brewtech® on ADG of weanling pigs. (CON = conventional diet and BT = Brewtech® fed in the nursery period) The ADG data are means of individual pigs. (a) Brewtech® pre-wean feed effect ($P < 0.02$), nursery feed effect ($P < 0.03$), (b) Brewtech® pre-wean feed effect ($P < 0.10$), nursery feed x Brewtech® pre-wean feed effect ($P < 0.09$), (c), nursery feed effect ($P < 0.05$), nursery feed x Brewtech® pre-wean feed ($P < 0.09$).

diets (conventional or Brewtech®), there was no effect (P > 0.10) on growth performance in the nursery period (Figure 3.2). In Exp. 2, there was no effect (P > 0.10) of Brewtech® on ADG, ADFI, or gain:feed (Table 3.7) in this Phase 1 study.

In Exp. 3, the addition of Brewtech® to the diet in place of spray-dried animal porcine plasma did not affect (P > 0.10) growth performance of pigs in Phase 1 (Table 3.8). However during Phase 2, pigs fed diets supplemented with Brewtech® had an increased (P < 0.05) ADG and gain:feed. In the overall data, pigs fed diets containing Brewtech® had an improved (P < 0.05) gain:feed.

DISCUSSION

The addition of Brewtech® improved pig growth and feed efficiency during Phase 1 in Exp. 1 but not in Exp. 2 or 3. This variable response may have been due to the availability of pre-wean feed in Exp. 1 but not in Exp. 2 or 3. These results are similar to the increased growth reported by Jurgens et al. (1997) when pigs were fed 0.20% dried yeast for 1 wk before and 1 wk after weaning and 0.125% dried yeast for 3 wk in the nursery. In Exp. 3, Brewtech® did not affect growth performance in Phase 1, but increased ADG and gain:feed in Phase 2, and gain:feed in the overall data.

These data suggest that Brewtech® is not detrimental to the growth performance of nursery pigs, and that in some instances Brewtech® may improve growth performance.

The results further suggest that some prior exposure to Brewtech® is necessary for the positive benefit to occur. In Exp. 1, pigs fed Brewtech® pre-weaning had better nursery performance than those not fed Brewtech® pre-weaning. Also, in Exp. 3,

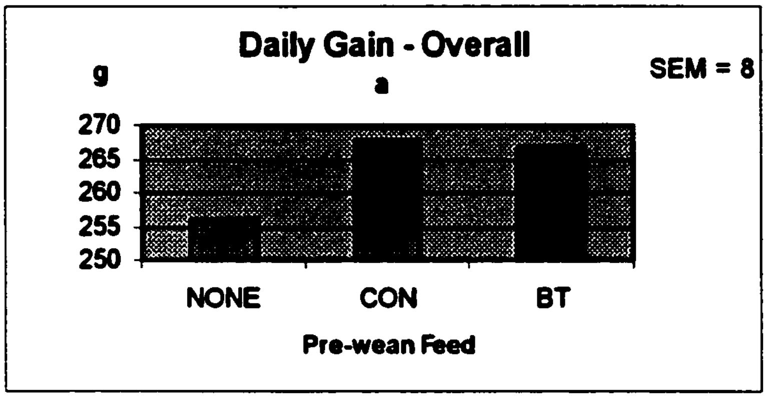


Figure 3.2 Effect of pre-wean diets on nursery growth. (CON = conventional diet and BT = Brewtech®). The ADG data are means of individual pigs. (a) Effects of pre-wean feed on subsequent nursery growth.

TABLE 3.7 Effect of 4% Brewtech® on growth performance of weanling pigs[a]

Item	Basal[b]	Brewtech®	SEM
Day 0-7 (Phase 1)			
ADG, g	159	154	16
ADFI, g	207	207	14
Gain:feed	713	746	57

[a]Data are means of fourteen replicates with five pigs each. Average initial and final BW were 5.1 and 6.2 kg, and the experimental period was 7 d.

TABLE 3.8 Effect of Brewtech® or spray-dried animal plasma on growth performance of weanling pigs[a]

Item	SDAP[b]	Brewtech®	P > F	SEM
Day 0-7 (Phase 1)[c]				
ADG, g	171	132	0.40	24
ADFI, g	221	227	1.00	44
Gain:feed	766	657	0.20	52
Day 7-20 (Phase 2)[d]				
ADG, g	310	377	0.01	10
ADFI, g	565	542	0.60	24
Gain:feed	549	705	0.02	30
Day 0-20 (Overall)				
ADG, g	261	291	0.30	15
ADFI, g	444	430	0.80	28
Gain:feed	587	695	0.05	29

[a]Data are means of six replicates of six pigs each. Average initial and final BW were 5.2 and 10.4 kg and the experimental period was 20 d.
[b]Sprayed dried animal plasma = AP 920, American Protein Corporation, Ames, IA.
[c]Brewtech® was added at 5% during Phase 1.
[d]Brewtech® was added at 4% during Phase 2.

Brewtech® did not affect growth performance of pigs during Phase 1, but it improved these response variables in Phase 2 and in the overall data. Further studies with lower dietary concentrations of Brewtech® during the pre-weaning and nursery periods needs to be investigated to determine the economic feasibility of this feed additive.

CHAPTER 4

EFFECT OF BIO-MOS ON GROWTH PERFORMANCE OF FINISHING PIGS

INTRODUCTION

Animal feeds traditionally have contained some level of antibiotics to increase health and growth performance (Cromwell, 2001). Many of today's consumers want products that are organically grown, antibiotic free, and environmentally safe. With these consumer concerns in mind, the animal industry is faced with finding alternatives to antibiotics. A natural alternative that may be beneficial is oligosaccharides. Mannan oligosaccharides are derived from yeast cell walls. The inclusion of these mannan oligosaccharides in the diets of young animals results in a more desirable gut microflora, which aids in improved performance (Bio-Mos technical dossier, 1997). The mannan oligosaccharide, Bio-Mos, has been used to increase nursery pig performance (Dvorak et al., 1998; Davis et al., 1999). Maxwell et al. (1999) also reported that the addition of supplemental Bio-Mos during the growing-finishing phase of production may have the potential to improve gain and efficiency. If Bio-Mos is able to improve gut health and performance through the finishing phase, the inclusion of traditional antimicrobial products may be eliminated or reduced in this phase of production, resulting in greater consumer approval. With this in mind, the following experiment was conducted to determine the effect of Bio-Mos during the finishing phase of growth of pigs.

MATERIALS AND METHODS

An experiment was conducted with thirty-six crossbred Yorkshire x Landrace x Duroc finishing barrows at the Louisiana State University Agricultural Center Swine

Facility. The experiment was approved by the University Animal Care and Use committee.

Pigs were allotted to treatment on the basis of weight and ancestry in a randomized complete block design. Each treatment was replicated three times with six pigs per replicate. They were housed in an open-sided barn with a solid concrete floor in 2.4 x 6.1 m pens during the entire trial. Pigs were fed conventional corn-soybean meal diets (Table 4.1) with or without the addition of Bio-Mos at 0.30%. Diets were formulated to meet or exceed the requirements for finishing pigs (NRC, 1998). Average initial and final BW were 61.8 and 110.6 kg, and the experimental period was 62 d. Weight gain and feed consumption were measured every 2 wk to determine ADG, ADFI, and gain:feed. Water and feed were provided ad libitum throughout the experiment.

At the termination of the experiment, pigs were slaughtered at the Louisiana State University Agricultural Center Meats Laboratory and hot carcass weights were recorded for calculation of dressing percentage. Feed was withdrawn 24 h before slaughter. Conventional carcass measurements were obtained after a 24 h chill at 2° C. These included tenth rib backfat thickness (measured 3/4 of the lateral length of the longissimus muscle) and longissimus muscle area. Total-body electrical conductivity (TOBEC; Model MQI-27: Meat Quality Inc., Springfield, IL) was used to determine fat-free lean and fat content in the total carcass (Higbie et al., 2002). Percentage lean in thecarcass was calculated as ([fat-free lean ÷ hot carcass weight (kg)] x 100. Percentage fat in the carcass was calculated as ([total fat (kg) ÷ hot carcass weight (kg)] x 100).

Table 4.1 Composition of basal diet (Bio-Mos included at 0.30% for respective treatment)

Ingredient	%
Corn	78.61
Soybean meal (48.5% CP)	17.82
Monocalcium phosphate	0.81
Limestone	1.09
Trace minerals [a]	0.10
Se premix [b]	0.05
Salt	0.50
Vitamins [c]	0.37
L-Lysine · HCl	0.15
Sodium bentonite	0.50

[a]Provided the following per kilogram of diet: Zn (zinc sulfate), 127 mg; Fe (ferrous sulfate monohydrate), 127 mg; Mn (manganous sulfate), 20 mg; Cu (copper sulfate), 12.7 mg; and I (calcium iodate), .80 mg.

[b]Provided .3 mg Se per kilogram of diet.

[c]Provided the following per kilogram of diet: vitamin A, 11,023 IU; vitamin D, 3,307 IU; vitamin E, 88 IU; menadionine (menadionine pyrimidinol bisulfite) 8.3 mg; riboflavin, 13 mg; pantothenic acid, 50 mg; niacin, 88 mg; vitamin B_{12}, 61 μg; biotin, 441 μg; choline (as choline chloride), 882 mg; folic acid, 3.3 mg, pyridoxine, 4.41; thiamin, 4.41; and vitamin C, 110 μg.

Lean gain per day was calculated using ([fat-free lean (kg) - initial lean (kg)] ÷ number of days on trial). Initial lean was determined using the equation of Brannaman et al. (1984): (-1.59+ [0.44 x initial BW (kg)]). Percentage muscling was determined by the NPPC (1991) equation, which uses a 5% estimation for intramuscular fat and compensates for unequal body weights.

Pork quality scores (color, marbling, and firmness-wetness) were determined according to the guidelines of the NPPC (1991) using the interface of the longissimus muscle at the 10^{th} rib. The CIE L*, a*, and b* values were obtained from the 10^{th} rib longissimus muscle after a 15-min bloom using a Minolta chromameter CR-300 (Minolta Camera Co., Japan, illuminant D65 and 0°). Temperature and pH were taken 45 min and 24 h post slaughter between the 10^{th} and 11^{th} ribs using a hand held pH meter (Model 2000; VWR Scientific Products Co., South Plainfield, NJ 07080) fitted with a spear-tipped electrode (Catalog # P-05658-60; Cole-Parmer Instrument Co., Vernon Hills, IL 60061). The 10^{th}-rib chop was removed from the loin section, deboned, cleaned of any adhering intermuscular fat, and weighed for 24-h drip loss determination by a suspension method. The chops were weighed, and then suspended on a hook and line in a 10.8 x 21.6 cm Whirl-Pak sample bag, then stored for 24 h at 2°C and then weighed again. Drip loss was calculated as ([{initial wt. - final wt. of drip chop}÷initial wt.] x 100).

Statistical Analyses. The data were analyzed by analysis of variance procedures (Steel and Torrie, 1980) appropriate for a randomized complete block design using the

GLM procedure of SAS (SAS Inst. Inc., Cary, NC). The pen of pigs served as the experimental unit for all data.

RESULTS

Growth performance was not affected ($P > 0.10$) by the 0.30% Bio-Mos addition (Table 4.2). Similarly, longissimus muscle area, tenth rib 3/4 backfat, dressing percentage, fat-free lean, total fat, lean:fat, and lean gain per day were not affected ($P > 0.10$) by Bio-Mos (Table 4.3). The NPPC (1991) pork quality scores, CIE L^*, a^*, b^*, drip loss and pH were not affected ($P > 0.10$) by Bio-Mos (Table 4.4).

DISCUSSION

The majority of research conducted with Bio-Mos has been with weanling pigs. The nursery phase is a period of high stress with major nutritional and physiological changes for the pig. When pigs are fed diets with supplemental Bio-Mos during this growth phase, performance has been increased (Dvorak et al., 1998; Davis et al., 1999). Very few studies however, have been conducted to determine the effect of Bio-Mos in growing-finishing pigs. Brendemuhl and Harvey (1999) conducted a study with pigs from weaning to finishing. Pigs were fed 0, 0.1%, or 0.20% Bio-Mos during the 28 d nursery phase, after which time the pigs that were fed 0% Bio-Mos continued on this treatment, and pigs fed the Bio-Mos treatments either continued on their respective treatment or were fed diets without supplemental Bio-Mos. Pigs fed diets containing 0.20% supplemental Bio-Mos from weaning to finishing tended to perform better than pigs fed Bio-Mos only during the nursery phase, pigs fed 0.10% Bio-Mos, or pigs fed diets without supplemental Bio-Mos. Maxwell et al. (1999) also fed diets containing

supplemental Bio-Mos with and without growth promoting levels of Cu ($CuSO_4 \cdot 5H_2O$) from the nursery period through the finisher phase. There were no significant effects of Bio-Mos on growth performance. However, there was slight improvement in gain:feed in the growing phase and ADG in the finishing phase when Bio-Mos was included in the diet without $CuSO_4 \cdot 5H_2O$.

The data from the present study is similar to the reports of Brendemuhl and Harvey (1999) and Maxwell et al. (1999), wherein supplemental Bio-Mos did not affect growth performance of pigs in the finishing phase. In addition, Bio-Mos did not affect carcass traits or pork quality.

The addition of Bio-Mos throughout the entire feeding phase may be more beneficial than supplementation only in the finishing phase. The lack of response to Bio-Mos in the finishing phase may be because the pigs digestive and immune systems have fully developed in these latter growth stages. Also, there is usually less stress to the pig during these growth phases.

TABLE 4.2 Effect of 0.30% Bio-Mos on growth performance of finishing pigs[a]

Item	Basal[b]	Bio-Mos	SEM
ADG, kg	0.79	0.78	0.05
ADFI, kg	2.45	2.89	0.20
Gain:feed	0.33	0.27	0.02

[a]Data are means of three replicates with six pigs each. Average initial and final BW was 61.8 and 110.6 kg, and the experimental period was 62 d.

TABLE 4.3 Effect of 0.30% Bio-Mos on carcass characteristics of finishing pigs[a]

Item	Basal	Bio-Mos	SEM
LMA, cm^2 [a]	40.93	40.95	1.00
Tenth rib3/4 backfat, cm	1.99	2.02	0.02
Dressing percentage	72.06	72.35	0.38
TOBEC[ab]			
Fat-free lean, kg	38.74	38.5	1.38
Percentage lean	48.29	48.81	0.57
Total fat, kg	23.88	23.26	0.16
Percentage fat	29.47	28.98	0.49
Lean:fat	1.74	1.84	0.05
Lean gain per day, g	206.90	212.70	23.00
NPPC[ac]			
Percentage muscling	53.48	53.71	0.35
Kilograms of lean	42.97	42.35	1.00

[a]Data are means of three replicates of six pigs each. Average initial and final BW were 61.8 and 110.6 kg, and the experimental period was 62 d. LMA = longissimus muscle area, TOBEC = total body electrical conductivity analysis, and NPPC = National Pork Producers Council.

[b]Calculated using total body electrical conductivity analysis equations from Higbie et al., (2002).

[c]Calculated with the equation described by NPPC (1991), which uses a 5% estimation for intramuscular fat and compensates for unequal body weights.

TABLE 4.4 Effect of 0.30% Bio-Mos on pork quality of finishing pigs[a]

Item	Basal	Bio-Mos	SEM
45 min pH	40.93	40.95	1.00
24 h pH	1.99	2.02	0.02
Dressing percentage	72.06	72.35	0.38
NPPC pork quality			
Color	2.28	2.19	0.07
Firmness-wetness	2.47	2.44	0.05
Marbling	1.81	1.78	0.14
CIE color score			
L*	58.23	58.59	0.87
a*	2.34	2.87	0.38
b*	13.36	13.92	0.53
Drip loss,%	2.83	3.05	0.58

[a]Data are means of three replicates with six pigs each. Average initial and final BW were 61.8 and 110.6 kg, and the experimental period was 62 d.

CHAPTER 5

EFFECTS OF SUPPLEMENTAL CHROMIUM PICOLINATE ON SOW PRODUCTIVITY

INTRODUCTION

The swine industry has become more performance intense and structured, and sow performance has become the most economically important unit of production. Many factors have changed the swine industry in the past 10 years, including increased loin muscle area, decreased backfat, expanding sow herds, diminishing slaughter capacity, increased slaughter weights, national disease threats (e.g., Foot and Mouth Disease, Bovine Spongiform Encephalopathy, Porcine Reproductive and Respiratory Syndrome), environmental issues, food safety, animal welfare activists, and more concentrated swine farms. All of these factors have contributed to a more restricted economic margin that puts more pressure on sow performance. With all of these changes, the sow has been pushed to the extreme to produce more pigs with less feed and recovery time after each farrowing. In order for this to happen, sow nutrition has to be ideal to maximize numbers of pigs per sow per year.

It has been suggested that supplementing sow diets with Cr picolinate may improve sow performance. Early research suggested that supplemental Cr picolinate improved growth and carcass performance of growing-finishing pigs (Page et al., 1993; Lindemann et al., 1995). These improvements were thought to be related to the function of Cr as part of the glucose tolerance factor and its subsequent effect on insulin. Initial sow research has indicated that the addition of organic Cr may increase number of pigs

born alive, number of pigs weaned, and reduced days to return to estrus (Lindemann et al., 1995). Cox et al. (1987) reported that insulin administration before estrus increased ovulation rate. In addition, administration of insulin before breeding increased litter size Cox et al. (1994). Therefore, the following experiment was conducted to determine the effect of three levels of Cr as Cr picolinate on reproductive performance of gilts and sows.

MATERIALS AND METHODS

One experiment with 83 Purebred Yorkshire or Yorkshire x Landrace sows or gilts was conducted at the Louisiana State University Agricultural Center Swine Facility. The experiment was approved by the University Animal Care and Use Committee.

Sows or gilts were allotted to treatment on the day of breeding, and parity and ancestry were equalized across treatment. Sire of litter was random among treatments. Supplemental Cr levels were 0, 200, or 1000 ppb from Cr picolinate.

Sows were housed in groups of 5 to 6 females per 2.4 x 4.8 m pen during gestation. Pens were in an open-sided barn on concrete floors with 1.2 m of slats in the rear of the pen. Sows were fed 2.27 kg per day during gestation and after a gradual increase after farrowing, sows were fed ad libitum three to four times per day during lactation. Both gestation and lactation diets were formulated to meet or exceed the nutritional requirements (NRC, 1998) of sows during these periods (Table 5.1, 5.2). Normal sow and gilt management was performed on each group of sows. Females were vaccinated with a parvovirus vaccine (Parvo Shield® L5, Grand Laboratories, Inc., Larchwood, IA) as recommended before breeding and *Escherichia coli* vaccine

TABLE 5.1 Composition of gestation basal diet

Ingredient	0 ppb	200 ppb	1000 ppb
	%	%	%
Corn	83.68	83.68	83.68
Soybean meal (48.5% CP)	12.60	12.60	12.60
Monocalcium phosphate	1.85	1.85	1.85
Limestone	1.18	1.13	0.93
Trace minerals [a]	0.08	0.08	0.08
Salt	0.50	0.50	0.50
Vitamins [b]	0.10	0.10	0.10
Choline chloride	0.15	0.15	0.15
Chromax	-	0.05	0.25

[a]Provided the following per kilogram of diet: Zn (zinc sulfate), 127 mg; Fe (ferrous sulfate monohydrate), 127 mg; Mn (manganous sulfate), 20 mg; Cu (copper sulfate), 12.7 mg; and I (calcium iodate), .80 mg.

[b]Provided the following per kilogram of diet: vitamin A, 10,000,066 IU; vitamin D_3, 1,000,888 IU; vitamin E, 75,000 IU; menadionine (menadionine pyrimidinol bisulfite) 6,058 mg; riboflavin, 7,500 mg; d-pantothenic acid, 23,999 mg; niacin, 30,000 mg; vitamin B_{12}, 30 mg; d-biotin, 351 mg; folic acid, 5,000 mg, pyridoxine hydrochloride, 7,317 mg; thiamin, 2,000 mg; thiamin mononitrate, 2,172 mg; calcium d-pantothenate, 26,085 mg; vitamin k, 2,000 mg; and vitamin B_6, 6001 mg.

TABLE 5.2 Composition of lactation basal diet

Ingredient	0 ppb	200 ppb	1000 ppb
	%	%	%
Corn	73.43	73.43	73.43
Soybean meal (48.5% CP)	23.00	23.00	23.00
Monocalcium phosphate	1.67	1.67	1.67
Limestone	1.20	1.15	0.95
Trace minerals [a]	0.08	0.08	0.08
Salt	0.50	0.50	0.50
Vitamins [b]	0.10	0.10	0.10
Choline chloride	0.15	0.15	0.15
Chromax	-	0.05	0.25

[a]Provided the following per kilogram of diet: Zn (zinc sulfate), 127 mg; Fe (ferrous sulfate monohydrate), 127 mg; Mn (manganous sulfate), 20 mg; Cu (copper sulfate), 12.7 mg; and I (calcium iodate), .80 mg.

[b]Provided the following per kilogram of diet: vitamin A, 10,000,066 IU; vitamin D_3, 1,000,888 IU; vitamin E, 75,000 IU; menadionine (menadionine pyrimidinol bisulfite) 6,058 mg; riboflavin, 7,500 mg; d-pantothenic acid, 23,999 mg; niacin, 30,000 mg; vitamin B_{12}, 30 mg; d-biotin, 351 mg; folic acid, 5,000 mg, pyridoxine hydrochloride, 7,317 mg; thiamin, 2,000 mg; thiamin mononitrate, 2,172 mg; calcium d-pantothenate, 26,085 mg; vitamin k, 2,000 mg; and vitamin B_6, 6001 mg.

(Porcine Pili Shield™ + C, Grand Laboratories, Inc. Larchwood, IA) as recommended before farrowing. Females were dewormed [Safe-Guard® (fenbendazole), Hoechst Roussel Vet, Warren, NJ] during the first 3 d in the farrowing house after they had been washed and treated for external parasites (Prolate®/Lintox®-HD, Sandoz Agro, Inc., Des Plaines, IL). Each group of females entered the farrowing house when the first sow of the group reached 110 d of gestation. During farrowing and lactation, sows were housed in an environmentally controlled farrowing house. Sows farrowed in conventional 0.50 x 2.7 m farrowing crates that are within a 1.5 x 2.7 m farrowing area. The sow floor is a slotted cast iron and the pig area is slotted plastic. Drip lines were provided for sows during the summer months when building temperatures reached 24.9° C. A 0.6 x 1.5 m creep area with a 100 watt lamp for heat was provided for pigs in front of the sow and 0.5 x 2.1 m creep areas on both sides of the sow. The farrowing house was treated as an all-in, all-out facility.

Sows were weighed at breeding, 110 d, farrowing and at weaning. Response variables were gestation weight gain (breeding to 110 d), lactation weight change (farrowing to weaning), lactation feed intake, total number and weight of pigs born, number and weight of pigs alive at birth and weaning, and weaning to estrus interval.

Statistical Analyses. Data were analyzed by analysis of variance procedures (Steel and Torrie, 1980) appropriate for randomized block designs using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). All data were analyzed with treatment in the model and parity as a covariate. Data also were analyzed excluding the first parity

on test and excluding parity one and two on test. Thus, data will be shown with all parities on test, two or more parities on test, and three or more parities on test.

RESULTS

Addition of Cr resulted in a quadratic effect ($P < 0.08$) for total number of pigs born (Table 5.3). Sows that were fed diets containing 200 ppb Cr had larger litters than sows fed 1,000 ppb Cr or the basal diet. In addition, number of pigs born alive, number of pigs weaned, and percentage survival at weaning tended to be increased in sows fed 200 ppb Cr. There was again a quadratic effect ($P < 0.03$) for total number of pigs born and number of pigs weaned ($P < 0.09$) when the first parity on test data were excluded (Table 5.4). These same litter responses were not significant ($P > 0.10$) when the data from the first two parities were excluded (Table 5.5).

Sow response variables also were affected by the addition of Cr (Table 5.3). There was a quadratic effect for lactation weight loss ($P < 0.09$). Sows fed 200 ppb Cr loss less weight from farrowing to weaning. Average daily feed intake during lactation was increased ($P < 0.06$) in sows fed diets containing 200 ppb Cr. There was a linear effect ($P < 0.01$) for days to estrus. As the level of Cr increased, days to estrus increased. Again, this effect occurred when data from two or more parities on test were evaluated (Table 5.4). Also, sows receiving 200 ppb Cr had increased ($P < 0.07$) breeding weights. There were linear effects ($P < 0.04$) for farrowing and 110 d weights when parity on test of three or greater was evaluated. Average daily feed intake was increased ($P < 0.02$) and lactation weight loss was decreased when sows were fed 200 ppb Cr (Table 5.5).

TABLE 5.3 Effect of Cr on sow and litter performance[a]

	Cr					
Item	0	200	1,000	SEM	LIN	Quad
Sows, n	44	20	19			
Parity	2.80	2.80	2.80			
Lactation length, d	19.40	18.60	19.90	0.40	0.30	0.10
Litter response criteria						
Initial weight, kg	14.90	14.30	14.10	0.50	0.50	0.60
Weaning weight, kg	45.30	45.00	48.10	2.00	0.30	0.80
Litter weight gain, kg/d	1.60	1.60	1.70	0.07	0.30	0.70
Pig average daily gain, kg	0.20	0.20	0.20	0.01	0.40	0.50
Total pigs born	10.70	11.60	10.60	0.40	0.50	0.08
Pigs born alive	9.50	10.10	9.20	0.40	0.30	0.20
Number of pigs weaned	8.10	8.70	8.00	0.34	0.60	0.20
Percentage survival, %	89.80	92.70	90.50	1.80	1.00	0.30
Sow response criteria						
Farrowing weight, kg	219.10	215.70	212.80	3.60	0.30	0.70
Weaning weight, kg	214.60	214.20	207.30	3.30	0.20	0.80
Lactation weight loss, kg	-4.00	-1.30	-4.80	1.30	0.40	0.09
Average daily feed intake, kg	5.30	5.70	5.50	0.12	0.70	0.06
Days to estrus, d	5.40	5.80	6.40	0.20	0.01	0.30
Breeding weight, kg	189.30	194.80	187.10	2.90	0.30	0.20
110 d weight, kg	227.50	220.70	220.90	4.10	0.50	0.30

[a]Data are least square means.

TABLE 5.4 Effect of Cr on sow and litter performance[a]

	Cr					
Item	0	200	1,000	SEM	LIN	Quad
Sows, n	41	20	19			
Parity	3.40	3.40	3.40			
Lactation length, d	19.50	17.80	18.50	0.50	0.60	0.02
Litter response criteria						
Initial weight, kg	14.90	14.40	14.60	0.70	0.90	0.70
Weaning weight, kg	45.20	43.40	44.00	2.40	0.90	0.60
Litter weight gain, kg/d	1.50	1.60	1.60	0.08	1.00	0.60
Pig average daily gain, kg	0.20	0.20	0.20	0.01	0.60	0.30
Total pigs born	10.60	12.10	10.90	0.53	0.80	0.03
Pigs born alive	9.40	10.30	9.20	0.48	0.40	0.20
Number of pigs weaned	8.00	8.90	7.70	0.71	0.40	0.09
Percentage survival, %	89.00	91.30	86.50	2.60	0.40	0.40
Sow response criteria						
Farrowing weight, kg	223.30	221.90	224.50	4.75	0.80	0.80
Weaning weight, kg	219.10	220.40	217.80	4.40	0.80	0.80
Lactation weight loss, kg	-3.50	-1.40	-6.20	1.70	0.20	0.30
Average daily feed intake, kg	5.30	5.50	5.30	0.14	0.90	0.60
Days to estrus, d	5.50	6.10	6.70	0.25	0.01	0.30
Breeding weight, kg	191.80	198.00	193.60	3.70	1.00	0.30
110 d weight, kg	232.40	226.10	232.90	5.50	0.80	0.40

[a]Data are least square means of parity 2 and greater.

TABLE 5.5 Effect of Cr on sow and litter performance[a]

Item	Cr 0	Cr 200	Cr 1,000	SEM	LIN	Quad
Sows, n	26	9	9			
Parity	4.1	4.1	4.1			
Lactation length, d	19.3	18.0	19.6	0.64	0.50	0.20
Litter response criteria						
Initial weight, kg	15.6	14.2	16.4	1.00	0.40	0.30
Weaning weight, kg	45.2	42.5	49.0	3.70	0.40	0.50
Litter weight gain, kg/d	1.5	1.5	1.7	0.10	0.60	0.90
Pig average daily gain, kg	0.2	0.2	0.2	0.01	0.50	0.90
Total pigs born	11.4	12.5	11.9	0.70	0.90	0.40
Pigs born alive	10.0	10.4	9.9	0.71	0.80	0.70
Number of pigs weaned	8.0	8.6	8.3	0.70	1.00	0.60
Percentage survival, %	85.8	90.2	84.7	4.40	0.70	0.40
Sow response criteria						
Farrowing weight, kg	230.0	231.4	249.5	6.70	0.04	0.80
Weaning weight, kg	226.3	232.0	236.4	6.60	0.40	0.70
Lactation weight loss, kg	-2.2	0.6	-9.8	2.50	0.02	0.20
Average daily feed intake, kg	5.3	6.0	5.3	0.20	0.50	0.02
Days to estrus, d	5.3	6.2	6.3	0.35	0.20	0.20
Breeding weight, kg	196.0	200.0	210.0	5.70	0.10	0.90
110 d weight, kg	240.0	234.0	262.0	7.80	0.03	0.40

[a]Data are least square means of parity 3 and greater.

DISCUSSION

The addition of Cr to sow diets during gestation and lactation has been found to improve litter and sow responses (Lindemann et al. 1995, Hagen et al., 1998). In both of these studies, positive results were reported when sows were fed 200 ppb Cr picolinate. Sows in both experiments had prior Cr supplementation before the reproductive experiment was initiated. However, Trottier et al. (1998) found no positive results when sows were fed diets supplemented with 1,000 ppb Cr picolinate for the first 60 d then 200 ppb Cr picolinate for the remainder of the experiment. In their experiment, Cr picolinate supplementation was initiated when sows entered the farrowing house or, approximately 2 mo before the expected onset of estrus for gilts. In our experiment, sows and gilts were initiated on Cr at breeding.

The results from our experiment are similar to previous experiments by Lindemann et al. (1995) and Trottier et al. (1998). Sows supplemented with 200 ppb Cr had increased total number of pigs born. Sows supplemented with Cr also had increased days to estrus compared with sows fed the control diet. This response is not consistent with data of Trottier et al. (1998) and Campbell, (1996) who reported that the addition of Cr picolinate tended to decrease the wean to estrus interval. However, Lindemann et al. (1995) did not find a decrease in days to estrus post wean.

Lactation weight loss was reduced in sows fed diets containing 200 ppb Cr picolinate, which resulted from an increase in ADFI during the lactation period. Subsequent breeding weight after weaning was increased for these sows, which is also a result of the increased ADFI during lactation and reduced weight loss.

The results of this experiment suggest that the addition of Cr as Cr picolinate at 200 ppb is effective in increasing total number of pigs born. In addition, it may reduce the lactation weight loss for sows.

CHAPTER 6

SUMMARY AND CONCLUSIONS

The addition of Bio-Mos at 0.20% to weanling pig diets increased growth performance in Phase 2 of the nursery period. However, Bio-Mos was not affective in increasing growth performance, carcass measurements or pork quality in finishing pigs.

The addition of Brewtech® to nursing and weanling pig diets increased growth performance during Phase 2. When Brewtech® was fed only for the Phase 1 period growth performance was not improved. This response might suggest that a loading period may be needed for Brewtech® to be effective.

The addition of 200 ppb Cr as Cr picolinate increased total number of pigs born over the entire experiment. The addition of 1,000 ppb Cr did not positively affect litter or sow responses. This response may suggest that the 1,000 ppb level of Cr is too high. When the data were evaluated excluding the first parity, the litter response was more pronounced for the 200 ppb supplementation. This response is similar to previous data that suggests a loading period is needed to build Cr stores and to increase these litter responses. In this study, days to estrus post weaning was increased for sows supplemented with Cr. Even though days to estrus was increased, this interval was still acceptable and can be expected if more pigs are being nursed and weaned. If the addition of Cr to gestation and lactation diets is cost effective, Cr can be a viable dietary additive for producers.

The purpose of all of these experiments was to find ways to economically increase production of pigs and sows without causing detrimental effects to the environment. All of the additives evaluated have potential to improve swine performance.

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VITA

Frederick Masson LeMieux was born on February 12, 1966, to Marlene and Fred LeMieux in Baton Rouge, Louisiana. Frederick graduated from Tara High School in 1984. Frederick entered Louisiana State University and obtained a bachelor of science degree in agriculture with a major in animal science in August of 1991. While attending Louisiana State University, Frederick worked on the Animal Science Swine Farm. After graduation he obtained a managerial position with a purebred swine farm in McQuady, Kentucky. In July, 1992, Frederick accepted the position of Research Associate for the Louisiana State University Agricultural Center Central Stations Swine Unit and has worked in that capacity to the present. In December, 1996, Frederick received a master of science degree in animal science and the title of the thesis was Effects of Excess Dietary Zn on Growth Performance, Carcass Traits and Tissue Levels of Zn in Pigs. Frederick is currently a doctoral candidate in the area of non-ruminant nutrition.

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DOCTORAL EXAMINATION AND DISSERTATION REPORT

Candidate: Frederick LeMieux Jr.

Major Field: Animal and Dairy Science

Title of Dissertation: Effect of Chromium, Dried Brewers Yeast, and Mannan Oligosaccharides on Sow Productivity and Growth Performance of Weanling Pigs

Approved:

Lee Southern
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