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Effects of a Combination of Essential Oils (Victus LIV), Increased Zinc Oxide and Copper Sulfate, or Their Combination in Nursery Diets on Pig Performance

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Cover Page Footnote

Appreciation is expressed to, DSM Nutritional Products, Parsippany, NJ, for financial support.

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Effects of a Combination of Essential Oils (Victus LIV), Increased Zinc Oxide and Copper Sulfate, or Their Combination in Nursery Diets on Pig Performance[1]

A.J. Langemeier, J.M. Morton, S. Scotten, M.T. Thayer, and J.L. Nelssen

Summary

A total of 280 weaned pigs (Line 600 × 241; DNA, Columbus, NE; initially 11.4 lb) were used in a 35-d study to compare the effects of feeding growth promoting alternatives (added trace minerals, copper and zinc, or essential oils (Victus LIV; DSM Nutritional Products, Parsippany, NJ), alone or in combination, on nursery pig performance in comparison to Carbadox, (Mecadox, Phibro Animal Health, Teaneck, NJ). Pigs were allotted to 1 of 7 dietary treatments in pens of 5 at weaning in a randomized complete block design with 8 replications per treatment. Dietary treatments were arranged with a negative control diet with no growth promoting feed additive, a positive control with added carbadox or 5 treatments including added copper (Cu) sulfate ($CuSO_4$; 0 vs. 125 ppm Cu) and added zinc (Zn) oxide (ZnO; 0 vs. 3,000 ppm Zn from d 0 to 7 and 2,000 ppm Zn from d 7 to 35), essential oils from Victus LIV at either 0.29 lb/ton (145 ppm) or 0.86 lb/ton (435 ppm). These supplements were fed alone or in combination. From d 0 to 35 experimental diets were fed in a meal form. Feeding carbadox, essential oil at 145 ppm or added trace minerals (Cu and Zn) improved ADG ($P < 0.05$) of nursery pigs compared to the negative control diet. The use of added Cu and Zn or 145 ppm of Victus LIV alone or in combination sustained ADG and F/G that was competitive with pigs fed carbadox. In summary, under the conditions of this experiment, pigs fed the combination of zinc and copper or 145 ppm Victus LIV had growth performance similar to those fed carbadox ($P > 0.05$).

Introduction

Within the swine industry today, the removal of antimicrobial agents for growth promotion has been a pertinent objective. With increasing public concern for risks associated with antimicrobial resistance, producers removing feed-grade antibiotics have seen reductions in their nursery pig performance. Since the mid-1950s, feed-grade antibiotics have been available for use by swine producers. As research has shown, the dietary inclusion of antimicrobial agents has improved the growth rates and feed efficiency of nursery pigs. With the shift in the industry to remove antimicrobial agents for growth promotion purposes, many producers have shared their concern about the possible pro-

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duction losses with the elimination of antimicrobial agents in nursery pig diets. Thus, we conducted this experiment to focus on three critical points. First, as consumers have become increasingly more concerned, there has been a large push for antibiotic-free pork in the marketplace. Secondly, other classes of feed additives have been suggested to improve nursery pig performance. Many of these have been shown to increase feed consumption during the post-weaning period, which can positively influence the growth of young pigs during such a critical time. Some of these feed additives include, but are not exclusive to the following classes of compounds; phytogenic additives (essential oils), increased levels of certain trace minerals, or combinations of additives. Lastly, this trial was conducted as a follow-up study to a recent trial reported in the 2016 Swine Day report,[2] and we hypothesized that feeding a combination of these feed additives could improve feed intake and sustain growth performance comparable to feeding nursery pigs carbadox. Therefore, the objective of this experiment was to compare the growth performance of nursery pigs fed diets containing carbadox and different supplemental feed additives known to improve feed intake (added levels of Zn and Cu, or essential oils), either alone or in combination with each other.

Procedures

This trial was conducted in follow-up to a previous trial at Kansas State University[2] with the primary objective of evaluating the potential impact of different types of feed additives for improving the feed intake and growth of nursery pigs. This report describes the effects of some alternative feed additives on growth performance.

The protocol for this experiment #3839 was approved by the Kansas State University Institutional Animal Care and Use Committee. The study was conducted at the K-State Swine Teaching and Research farm nursery in Manhattan, KS.

A total of 280 nursery pigs (Line 600 × 241; DNA, Columbus, NE; initially 11.4 lb BW) were used in a 35-d study, with 5 pigs per pen and 8 replications per treatment. Each pen had one 4-hole self-feeder, metal tri-bar flooring, and a nipple waterer to provide ad libitum access to feed and water. Pigs were weaned at approximately 21 d of age, weighed, and blocked by initial BW to achieve equal average pen weights, within each block. The pens of pigs were randomly allotted to 1 of 7 dietary treatments, within each block. The 7 dietary treatments consisted of a corn-soybean meal-based diet and were arranged with treatments of added trace minerals with added Cu from copper sulfate ($CuSO_4$; 0 vs. 125 ppm Cu) and added Zn from zinc oxide (ZnO; 0 vs. 3,000 ppm Zn from d 0 to 7 and 2,000 ppm Zn from d 7 to 35), an essential oils blend from Victus LIV (DSM Nutritional Products, Parsippany, NJ) from d 0 to 35 at either 0.29 lb/ton (145 ppm) or 0.86 lb/ton (435 ppm), and carbadox (Mecadox, Phibro Animal Health, Teaneck, NJ) from d 0 to 35 at 50 g/ton. Equivalent amounts of corn were replaced with the chosen levels of additives to form the experimental dietary treatments. The experimental diets were fed from d 0 to 35. Phase 1 experimental diets were meal rations fed from d 0 to 7 (Table 1). All diets had an acidifier (Kem-Gest, Kemin, Des Moines, IA) added at 0.4 lb/ton during the phase 1 period. Phase 2 experimental diets

[2] Langemeier, A.; Morton, J.; Scotten, S.; and Nelssen, J. L. (2016) "Evaluating the Effects of Replacing Feed Grade Antibiotics with Yeast, Cinnamon, or Zinc Oxide and Copper Sulfate on Nursery Pig Performance," *Kansas Agricultural Experiment Station Research Reports*: Vol. 2: Iss. 8. https://doi.org/10.4148/2378-5977.1299

were fed in meal form from d 7 to 21 (Table 2). Phase 3 experimental diets were fed in meal form from d 21 until the completion of the trial on d 35 (Table 3).

All diets were prepared at the Kansas State University O.H. Kruse Feed Technology Innovation Center, Manhattan, KS. Diet samples were collected periodically throughout the study and pooled samples of each treatment diet were stored for later potential analysis. ADG, ADFI, and F/G were determined by weighing pigs and measuring feed disappearance on d 7, 14, 21, 28 and 35.

Growth data were analyzed as a randomized complete block design using PROC GLIMMIX in SAS version 9.4 (SAS Institute Inc., Cary, NC) with pen as the experimental unit. The model included the main effects of added Cu from $CuSO_4$ and Zn from ZnO, levels of essential oils from Victus LIV, and carbadox, with block as a random effect. The Kenward-Roger adjustment was used for denominator degrees of freedom. Differences between treatments were determined by using the p-diff option, and least squares means were considered significantly different at $P \leq 0.05$, or a tendency for being different at $P \leq 0.10$.

Results and Discussion

During phases 1 and 2 of the experiment (d 0 to 21), pigs fed carbadox had increased ADG ($P < 0.05$) compared to pigs fed the control. During phase 3, feeding pigs carbadox resulted in increased ADG ($P < 0.05$) compared to pigs fed the control, and overall (d 0 to 35) ADG was increased ($P < 0.05$) by feeding carbadox. Carbadox also improved ($P < 0.05$) the overall feed efficiency during the experiment.

During the experiment, feeding 435 ppm Victus LIV alone did not improve ($P > 0.05$) growth performance compared to feeding the control. However, pigs fed added trace minerals (Cu and Zn) alone, or 145 ppm Victus LIV alone, had growth performance similar ($P > 0.05$) to that of pigs fed carbadox from d 0 to 35 ($P > 0.05$). Additionally, pigs fed added levels of trace minerals in combination with Victus LIV at either 145 ppm or 435 ppm showed comparable ($P > 0.05$) growth performance to pigs fed carbadox during the entire experiment (d 0 to 35). Overall, from d 0 to 35, ADG, ADFI and G/F of pigs fed either added trace minerals or 145 ppm Victus LIV had equal ($P > 0.05$) growth performance to those fed carbadox. Additionally, pigs fed added levels of either Zn and Cu or 145 ppm Victus LIV outperformed control pigs during this period. Feeding the added trace minerals alone increased ($P < 0.05$) d-35 pig weights (36.1 lb.), as did feeding Victus LIV alone at 145 ppm, which increased ($P < 0.05$, 35.6 lb.) weights when compared to the control fed pigs (32.8 lb). The positive effects of combining added Zn and Cu and 145 ppm Victus LIV resulted in an average of a 4+ lb per pig increase in weight at d-35 post-weaning when compared to feeding the control.

Traditionally, nursery pigs are fed a diet containing an antimicrobial agent. We fed carbadox to nursery pigs and found a consistent improvement in growth performance compared to pigs fed a non-medicated diet. However, feeding antibiotics to pigs is under increased scrutiny. Thus, our industry must research dietary ingredients that could be used as growth promoting alternatives.

Added levels of Cu and Zn are typically added during different dietary phases of the nursery period. Typically, Zn is added to diets fed to nursery pigs during early nursery period (d 0 to 14) and Cu during the later period (d 14 to 42). Zinc oxide (ZnO) is the most common form of added dietary Zn, while Cu most commonly comes from copper sulfate. In our current experiment, we added zinc oxide and copper sulfate in combination to diets for nursery pigs. Pigs fed the Zn and Cu combination had equal performance to pigs fed carbadox.

Finally, we investigated the effects of an essential oils product that has been postulated to enhance nursery pig growth performance. When feeding Victus LIV at 435 ppm either alone or in combination, we found no consistent effects on nursery pig growth performance. However, pigs fed 145 ppm Victus LIV, either alone or in combination with added Cu and Zn, had growth performance comparable to pigs fed carbadox or the added trace minerals alone. This suggests that feeding 145 ppm Victus LIV could provide comparable gain and efficiency to carbadox in nursery pig diets.

In summary, we are optimistic that under the conditions of this experiment that the mineral combination of zinc oxide and copper sulfate or 145 ppm Victus LIV could be an effective alternative for carbadox in diets fed to nursery pigs.

Table 1. Composition of phase 1 diets[1]

Ingredient, %	A[2]	B[3]	C[4]	D[5]	E[6]	F[7]	G[8]
Corn	38.75	37.75	38.28	38.74	38.71	38.27	38.24
Soybean meal	16.95	16.95	16.95	16.95	16.95	16.95	16.95
Blood meal	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Blood plasma	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Corn DDGS,[9] >6 and <9% oil	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Fish meal	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Milk, whey powder	12.50	12.50	12.50	12.50	12.50	12.50	12.50
Milk, whey permeate, 80% lactose	11.25	11.25	11.25	11.25	11.25	11.25	11.25
Choice white grease	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Calcium phosphate (monocalcium)	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Limestone, ground	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Sodium chloride	0.30	0.30	0.30	0.30	0.30	0.30	0.30
L-Lys-HCL	0.23	0.23	0.23	0.23	0.23	0.23	0.23
DL-Met	0.14	0.14	0.14	0.14	0.14	0.14	0.14
L-Thr	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Choline chloride 60%	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Acidifier	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Vitamin E, 20,000 IU	0.05	0.05	0.05	0.05	0.05	0.05	0.05
HP 300 (Hamlet Protein)	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Mecadox	---	1.00	---	---	---	---	---
Zinc oxide	---	---	0.42	---	---	0.42	0.42
Copper sulfate	---	---	0.05	---	---	0.05	0.05
Victus LIV	---	---	---	0.015	0.044	0.015	0.044
Calculated analysis, %							
Lysine	1.32	1.32	1.32	1.32	1.32	1.32	1.32
Ca	0.70	0.70	0.70	0.70	0.70	0.70	0.70
P	0.65	0.65	0.65	0.65	0.65	0.65	0.65

[1] All phase 1 diets were meal form.
[2] Negative control (N.C.) -common corn-soybean meal diet.
[3] Positive control-Mecadox 50 g/ton.
[4] N.C. + zinc oxide (phase 1; 3,000 ppm d 0 to 7; phase 2; 2,000 ppm d 7 to 35) and copper sulfate (125 ppm).
[5] N.C. + Victus LIV (145 ppm).
[6] N.C. + Victus LIV (435 ppm).
[7] N.C. + $CuSO_4$ and ZnO (3,000 ppm) + Victus LIV (145 ppm).
[8] N.C. + $CuSO_4$ and ZnO (3,000 ppm) + Victus LIV (435 ppm).
[9] DDGS = dried distillers grains with solubles.

Table 2. Composition of phase 2 diets[1]

Ingredient, %	A[2]	B[3]	C[4]	D[5]	E[6]	F[7]	G[8]
Corn	49.45	48.45	49.12	49.44	49.41	49.11	49.08
Soybean meal, dehull, sol extr	24.80	24.80	24.80	24.80	24.80	24.80	24.80
Blood meal	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Corn DDGS,[9] >6 and <9% oil	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Fish meal combined	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Milk, whey powder	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Calcium phosphate (monocalcium)	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Limestone, ground	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Sodium chloride	0.30	0.30	0.30	0.30	0.30	0.30	0.30
L-Lys-HCL	0.30	0.30	0.30	0.30	0.30	0.30	0.30
DL-Met	0.18	0.18	0.18	0.18	0.18	0.18	0.18
L-Thr	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25
HiPhos 2700	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Mecadox	---	1.00	---	---	---	---	---
Zinc oxide	---	---	0.28	---	---	0.28	0.28
Copper sulfate	---	---	0.05	---	---	0.05	0.05
Victus LIV	---	---	---	0.015	0.044	0.015	0.044
Calculated analysis, %							
Lysine	1.27	1.27	1.27	1.27	1.27	1.27	1.27
Ca	0.78	0.78	0.78	0.78	0.78	0.78	0.78
P	0.65	0.65	0.65	0.65	0.65	0.65	0.65

[1] All phase 2 diets were meal form.
[2] Negative control (N.C.) -common corn-soybean meal diet.
[3] Positive control-Mecadox 50 g/ton.
[4] N.C. + zinc oxide (phase 1; 3,000 ppm d 0 to 7; phase 2; 2,000 ppm d 7 to 35) and copper sulfate (125 ppm).
[5] N.C. + Victus LIV (145 ppm).
[6] N.C. + Victus LIV (435 ppm).
[7] N.C. + $CuSO_4$ and ZnO (2,000 ppm) + Victus LIV (145 ppm).
[8] N.C. + $CuSO_4$ and ZnO (2,000 ppm) + Victus LIV (435 ppm).
[9] DDGS = dried distillers grains with solubles.

Table 3. Composition of phase 3 diets

	Phase 3,[1] day 21-35						
Ingredient, %	A[2]	B[3]	C[4]	D[5]	E[6]	F[7]	G[8]
Corn	50.96	49.96	50.63	50.95	50.92	50.62	50.59
Soybean meal	30.70	30.70	30.70	30.70	30.70	30.70	30.70
Corn DDGS,[9] >6 and <9% oil	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Calcium phosphate (monocalcium)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Limestone, ground	1.03	1.03	1.03	1.03	1.03	1.03	1.03
Sodium chloride	0.35	0.35	0.35	0.35	0.35	0.35	0.35
L-Lys-HCL	0.30	0.30	0.30	0.30	0.30	0.30	0.30
DL-Met	0.12	0.12	0.12	0.12	0.12	0.12	0.12
L-Thr	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25
HiPhos 2700	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Mecadox	---	1.00	---	---	---	---	---
Zinc oxide	---	---	0.28	---	---	0.28	0.28
Copper sulfate	---	---	0.05	---	---	0.05	0.05
Victus LIV	---	---	---	0.015	0.044	0.015	0.044
Calculated Analysis, %							
Lysine	1.22	1.22	1.22	1.22	1.22	1.22	1.22
Ca	0.69	0.69	0.69	0.69	0.69	0.69	0.69
P	0.66	0.66	0.66	0.66	0.66	0.66	0.66

[1] All phase 3 diets were meal form.
[2] Negative control (N.C.) -common corn-soybean meal diet.
[3] Positive control-Mecadox 50 g/ton.
[4] N.C. + zinc oxide (phase 1; 3,000 ppm d 0 to 7; phase 2; 2,000 ppm d 7 to 35) and copper sulfate (125 ppm).
[5] N.C. + Victus LIV (145 ppm).
[6] N.C. + Victus LIV (435 ppm).
[7] N.C. + $CuSO_4$ and ZnO (2,000 ppm) + Victus LIV (145 ppm).
[8] N.C. + $CuSO_4$ and ZnO (2,000 ppm) + Victus LIV (435 ppm).
[9] DDGS = dried distillers grains with solubles.

Table 4. Effects of added trace minerals, Victus LIV, and carbadox on nursery pig growth performance[1,2]

Added Cu/Zn[3]:	-	-	+	-	-	+	+		
Victus LIV (145 ppm)[4]:	-	-	-	+	-	+	-		
Victus LIV (435 ppm)[5]:	-	-	-	-	+	-	+		
Carbadox[6]:	-	+	-	-	-	-	-	SEM	*P*-value
Weight, lb									
d 0	11.40	11.40	11.40	11.40	11.40	11.40	11.40	0.75	1.00
d 35	32.80[c]	37.51[a]	36.10[a]	35.60[ab]	33.51[bc]	37.09[a]	36.41[a]	1.61	0.01
d 0 to 7									
ADG, lb	-0.04[b]	0.04[a]	0.07[a]	0.07[a]	0.00[ab]	0.07[a]	0.07[a]	0.02	0.06
ADFI, lb	0.11[c]	0.18[abc]	0.20[ab]	0.18[abc]	0.11[bc]	0.22[a]	0.18[ab]	0.02	0.07
F/G	-2.75	4.50	2.86	2.57	0.00	3.14	2.57	2.82	0.37
d 7 to 21									
ADG, lb	0.48[c]	0.59[ab]	0.68[a]	0.59[ab]	0.53[bc]	0.68[a]	0.68[a]	0.05	0.01
ADFI, lb	0.86[b]	0.95[ab]	1.08[a]	0.95[ab]	0.79[b]	1.06[a]	1.10[a]	0.07	0.01
F/G	1.79[b]	1.61[ab]	1.59[ab]	1.61[ab]	1.49[a]	1.56[a]	1.62[ab]	0.07	0.13

[1] A total of 280 nursery pigs (DNA, initially 11.4 lb BW) were used in a 35-day study with 5 pigs per pen and 8 replications per treatment.

[2] Experimental treatment diets were fed from d 0 to 35.

[3] Added trace minerals Cu ($CuSO_4$) added at 125 ppm from d 0 to 35 and Zn (ZnO) at 3,000 ppm from d 0 to 7 and 2,000 ppm from d 7 to 35.

[4,5] Essential oils were added as Victus Liv at either 145 ppm[4] or 435 ppm[5] from d 0 to 35.

[6] Mecadox was added at either 0 or 50 g/ton from d 0 to 35.

[abc] Least squares means in the same row were considered significantly different at $P < 0.05$, with superscripts designating significant differences.

Table 5. Effects of added trace minerals, Victus LIV, and carbadox on nursery pig growth performance[1,2]

Added Cu/Zn[3]:	-	-	+	-	-	+	+		
Victus LIV (145 ppm)[4]:	-	-	-	+	-	+	-		
Victus LIV (435 ppm)[5]:	-	-	-	-	+	-	+		
Carbadox[6]:	-	+	-	-	-	-	-	SEM	*P*-value
d 0 to 21									
ADG, lb	0.31[c]	0.42[ab]	0.48[a]	0.42[ab]	0.35[bc]	0.48[a]	0.48[a]	0.02	0.01
ADFI, lb	0.62[c]	0.68[ab]	0.77[a]	0.68[ab]	0.57[bc]	0.77[a]	0.79[a]	0.04	0.01
F/G	2.00[b]	1.62[a]	1.60[a]	1.62[a]	1.63[a]	1.60[a]	1.65[a]	0.07	0.01
d 21 to 35									
ADG, lb	1.03[b]	1.21[a]	1.03[b]	1.10[ab]	0.99[b]	1.10[ab]	1.06[ab]	0.04	0.10
ADFI, lb	1.43	1.56	1.45	1.47	1.41	1.50	1.52	0.06	0.47
F/G	1.47[ab]	1.29[a]	1.41[b]	1.34[ab]	1.42[b]	1.36[ab]	1.43[b]	0.04	0.15
d 0 to 35									
ADG, lb	0.51[c]	0.62[a]	0.59[a]	0.57[ab]	0.51[bc]	0.62[a]	0.62[a]	0.02	0.02
ADFI, lb	0.79[bc]	0.88[ab]	0.90[ab]	0.86[abc]	0.77[c]	0.92[a]	0.92[a]	0.04	0.04
F/G	1.55[b]	1.42[a]	1.53[ab]	1.51[ab]	1.51[ab]	1.48[ab]	1.48[ab]	0.04	0.16

[1] A total of 280 nursery pigs (DNA, initially 11.4 lb BW) were used in a 35-day study with 5 pigs per pen and 8 replications per treatment.

[2] Experimental treatment diets were fed from d 0 to d 35.

[3] Added trace minerals Cu ($CuSO_4$) added at 125 ppm from d 0 to 35 and Zn (ZnO) at 3,000 ppm from d 0 to 7 and 2,000 ppm from d 7 to 35.

[4,5] Essential oils were added as Victus Liv at either [4]145 ppm or [5]435 ppm from d 0 to 35.

[6] Mecadox was added at either 0 or 50 g/ton from d 0 to 35.

[abc] Least squares means in the same row were considered significantly different at $P < 0.05$, with superscripts designating significant differences.

Table 6. Economic analysis of ingredients inclusion: Cu/Zn, Victus LIV, and carbadox

	Cost per ton			
Inclusion:	Dietary cost inclusion	Phase 1 (d 0-7)	Phase 2 (d 7-21)	Phase 3 (d 21-35)
Mecadox				
50 g/ton	$1.230/lb	$24.60/ton	$24.60/ton	$24.60/ton
Zinc oxide (72%)				
3000 ppm	$0.950/lb	$7.98/ton		
2000 ppm	$0.950/lb		$5.32/ton	$5.32/ton
Copper sulfate (25%)				
125 ppm	$0.970/lb	$0.97/ton	$0.97/ton	$0.97/ton
Victus LIV				
145 ppm	$4/ton	$4/ton	$4/ton	$4/ton
435 ppm	$12/ton	$12/ton	$12/ton	$12/ton

	Final diet cost with inclusion		
	Phase 1 (d 0-7)	Phase 2 (d 7-21)	Phase 3 (d 21-35)
Common diet:	$731.10/ton	$466.37/ton	$361.55/ton
Mecadox			
50 g/ton	x	x	x
Cost:	$755.70	$490.97	$386.15
Zinc oxide			
3000 ppm	x	---	---
2000 ppm	---	x	x
Copper sulfate			
125 ppm	x	x	x
Cost:	$740.05	$472.66	$367.84
Victus LIV			
145 ppm	x	x	x
Cost:	$735.10	$470.37	$365.55
435 ppm	x	x	x
Cost:	$743.10	$478.37	$373.55