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Evaluation of Dietary Phytogenics on Growth Performance, Carcass Characteristics, and Economics of Grow-finish Pigs Housed Under Commercial Conditions

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Evaluation of Dietary Phytogenics on Growth Performance, Carcass Characteristics, and Economics of Grow-finish Pigs Housed Under Commercial Conditions

Abstract

A total of 1,260 pigs (PIC 327 × 1050, initially 48.7 lb) were used in a 125-d trial to determine the effect of two dietary essential oil mixtures on the growth performance, carcass characteristics, and economics of finishing pigs. Pigs were allotted by BW and randomly assigned to 1 of 5 dietary treatments. Pigs were fed six dietary phases. Treatment 1 was the control with no feed additives and 12% of CP in the Phase 6 diet. Treatment 2 was the same formulation as treatment 1 but contained an essential oil mixture 1 (EOM 1) containing caraway, garlic, thyme, and cinnamon fed all phases. Treatment 3 was the same formulation as treatment 1 with EOM 1 fed from Phases 3 to 6 and essential oil mixture 2 (EOM 2) containing oregano, citrus, and anise fed all phases (EOM 1+2). Treatment 4 contained EOM 1 fed in all 6 phases with 16% CP in Phase 6. Treatment 5 contained ractopamine HCl (9 g/ton) with 16% CP in the Phase 6 diet. Overall (d 0 to 125), pigs fed diets with EOM 1+2 had increased ($P = 0.003$) ADFI compared with pigs fed the control treatment. Pigs fed the diet with EOM 1 and 16% CP had increased ($P = 0.032$) ADFI in comparison with the pigs fed ractopamine HCl treatment. Pigs fed the ractopamine HCl treatment had improved ($P = 0.028$) F/G compared with pigs fed the treatment with the EOM 1 and 16% CP and the control treatment. For carcass traits, pigs fed the treatment with EOM 1+2 and had increased ($P = 0.007$) HCW compared with pigs fed EOM 1 and 12% CP and the control treatment ($P = 0.002$). Pigs fed the treatment with ractopamine HCl also had heavier ($P = 0.001$) HCW compared with the control treatment. Pigs fed diets with EOM 1+2 had increased ($P = 0.001$) carcass ADG, compared with pigs fed the control treatment and the treatment with EOM 1 and 12% CP ($P = 0.019$). Pigs fed the treatment with ractopamine HCl also had improved ($P = 0.001$) carcass ADG compared with pigs fed the control treatment. Pigs fed diets with EOM 1+2 had increased ($P = 0.021$) carcass yield compared with pigs fed the treatment with EOM 1 and 12% CP. Carcass yield was improved ($P = 0.036$) for the treatment with ractopamine HCl in comparison with the control treatment. Economically, feed cost per pound of gain was lower ($P < 0.001$) for pigs fed the control treatment compared to the treatment with EOM 1+2 and pigs fed with the ractopamine HCl treatment. Pigs fed diets with EOM 1+2 or ractopamine HCl treatment had increased ($P = 0.001$) gain value compared with pigs fed the control treatment. Pigs fed the ractopamine HCl treatment had increased income over feed cost in comparison with the treatments containing EOM 1 with 16% CP. In conclusion, the addition of EOM 1+2 improved ADFI, HCW, carcass ADG, and gain value in comparison with the control treatment. However, the increase in gain was not sufficient to overcome the increase in feed cost. The gain value improvement for the regimen with ractopamine HCl compensated for the extra feed cost resulting in a higher income over feed cost compared with the treatment with EOM 1 and 16% CP.

Keywords

essential oils, feed additives, phytogenics

Cover Page Footnote

Appreciation is expressed to Biomin America Inc. (San Antonio, TX) for providing the phytogenic products and financial support, New Horizons Farms (Pipestone, MN) for providing animals and research facilities and to Marty Heintz for technical assistance.

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Evaluation of Dietary Phytogenics on Growth Performance, Carcass Characteristics, and Economics of Grow-finish Pigs Housed Under Commercial Conditions[1]

J.A. Soto, M.D. Tokach, S.S. Dritz,[2] J.C. Woodworth, J.M. DeRouchey, and R.D. Goodband

Summary

A total of 1,260 pigs (PIC 327 × 1050, initially 48.7 lb) were used in a 125-d trial to determine the effect of two dietary essential oil mixtures on the growth performance, carcass characteristics, and economics of finishing pigs. Pigs were allotted by BW and randomly assigned to 1 of 5 dietary treatments. Pigs were fed six dietary phases. Treatment 1 was the control with no feed additives and 12% of CP in the Phase 6 diet. Treatment 2 was the same formulation as treatment 1 but contained an essential oil mixture 1 (EOM 1) containing caraway, garlic, thyme, and cinnamon fed all phases. Treatment 3 was the same formulation as treatment 1 with EOM 1 fed from Phases 3 to 6 and essential oil mixture 2 (EOM 2) containing oregano, citrus, and anise fed all phases (EOM 1+2). Treatment 4 contained EOM 1 fed in all 6 phases with 16% CP in Phase 6. Treatment 5 contained ractopamine HCl (9 g/ton) with 16% CP in the Phase 6 diet. Overall (d 0 to 125), pigs fed diets with EOM 1+2 had increased ($P = 0.003$) ADFI compared with pigs fed the control treatment. Pigs fed the diet with EOM 1 and 16% CP had increased ($P = 0.032$) ADFI in comparison with the pigs fed ractopamine HCl treatment. Pigs fed the ractopamine HCl treatment had improved ($P = 0.028$) F/G compared with pigs fed the treatment with the EOM 1 and 16% CP and the control treatment. For carcass traits, pigs fed the treatment with EOM 1+2 and had increased ($P = 0.007$) HCW compared with pigs fed EOM 1 and 12% CP and the control treatment ($P = 0.002$). Pigs fed the treatment with ractopamine HCl also had heavier ($P = 0.001$) HCW compared with the control treatment. Pigs fed diets with EOM 1+2 had increased ($P = 0.001$) carcass ADG, compared with pigs fed the control treatment and the treatment with EOM 1 and 12% CP ($P = 0.019$). Pigs fed the treatment with ractopamine HCl also had improved ($P = 0.001$) carcass ADG compared with pigs fed

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the control treatment. Pigs fed diets with EOM 1+2 had increased ($P = 0.021$) carcass yield compared with pigs fed the treatment with EOM 1 and 12% CP. Carcass yield was improved ($P = 0.036$) for the treatment with ractopamine HCl in comparison with the control treatment. Economically, feed cost per pound of gain was lower ($P < 0.001$) for pigs fed the control treatment compared to the treatment with EOM 1+2 and pigs fed with the ractopamine HCl treatment. Pigs fed diets with EOM 1+2 or ractopamine HCl treatment had increased ($P = 0.001$) gain value compared with pigs fed the control treatment. Pigs fed the ractopamine HCl treatment had increased income over feed cost in comparison with the treatments containing EOM 1 with 16% CP. In conclusion, the addition of EOM 1+2 improved ADFI, HCW, carcass ADG, and gain value in comparison with the control treatment. However, the increase in gain was not sufficient to overcome the increase in feed cost. The gain value improvement for the regimen with ractopamine HCl compensated for the extra feed cost resulting in a higher income over feed cost compared with the treatment with EOM 1 and 16% CP.

Key words: essential oils, feed additives, phytogenics

Introduction

Phytogenic feed additives are compounds derived from plant extracts incorporated into animal feed with the goal of improving animal health and performance. While the exact mode of action and physiological effects are not fully understood, most are associated with antimicrobial benefits, increased antioxidant activity, and improved gut function (Jacela et al., 2010[3]). Additionally, phytogenics potentially can increase diet palatability, which could lead to higher growth rates (Windisch et al., 2007[4]; Karaskova et al., 2015[5]).

Within the phytogenics classification, the active substances found in the products may vary widely depending upon the plant species, plant part used, harvesting season, crop density, and geographical origin (Windisch et al., 2007). Currently, phytogenic additives have been predominantly provided through essential oils. Essential oils are complex mixtures of volatile and lipophilic compounds. Due to their lipophilicity, they are associated with good intestinal absorption. The intake of phytogenics can stimulate the secretion of digestive enzymes and increase gastric and intestinal motility (Yang et al., 2012[6]). Research with phytogenics in swine diets has yielded inconsistent results with more research needed to determine the correct blend or timing of use as well as to identify the greatest opportunities to yield economic benefits (Yang et al., 2012; Thacker, 2014[7]). Therefore, the objective of this study was to determine the effect of

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[4] W. Windisch, K. Schedle, C. Plitzner and A. Kroismayr. 2007. Use of phytogenic products as feed additives for swine and poultry. J. Anim. Sci. 86:140-148.

[5] K. Karaskova, P. Suchy and E. Strakova. 2015. Current use of phytogenic feed additives in animal nutrition: a review. Czech J. Anim. Sci. 60:521-530.

[6] L. Yan, q. Meng, and I. Kim. 2012. Effect of an herb extract mixture on growth performance, nutrient, digestibility, blood characteristics, and fecal microbial shedding in weanling pigs. Livest. Sci. 145:189-195.

[7] Thacker, P. 2013. Alternatives to antibiotics as growth promoters for use in swine productions: a review. J. Anim. Sci. Biotechnol. 4(1):1-12.

dietary phytogenics on the growth performance, carcass characteristics, and economics of grow-finish pigs housed under commercial conditions.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at a commercial research-finishing site in southwest Minnesota from August to December. The barn was naturally ventilated and double-curtain-sided. Each pen was equipped with a 5-hole stainless steel feeder and bowl waterer for ad libitum access to feed and water. Feed additions to each individual pen were made and recorded by a robotic feeding system (FeedPro; Feedlogic Corp., Wilmar, MN).

A total of 1,260 mixed gender pigs (PIC 1050 × 327, initially 47.8 lb) were used in a 125-d trial. There were 28 pigs per pen (6.78 square ft^2 per pig), and 9 replications per treatment with a similar number of barrows and gilts in each pen. Pigs were allotted based on initial body weight to pens assigned to 1 of 5 treatments in a completely randomized block design.

Pigs were fed a conventional nutritional program with a total of six dietary phases (Tables 1 and 2). Treatment 1 was the control with no feed additives and 12% CP in Phase 6 diet. Treatment 2 was the same formulation as treatment 1 but contained an essential oil mixture 1 (EOM 1) of caraway, garlic, thyme, and cinnamon fed in all phases with an inclusion rate of 0.015%. Treatment 3 was the same diet formulation as treatment 1, but with EOM 1 fed from Phase 3 to 6 and essential oil mixture 2 (EOM 2) of oregano, citrus, and anise fed in all phases with an inclusion rate of 0.015% and 0.0125%, respectively (EOM 1+2). Treatment 4 contained EOM 1 fed in all 6 phases with 16% CP in the Phase 6 diet, with an inclusion rate of 0.015%. Treatment 5 contained 9 g/ton of ractopamine HCL (Paylean; Elanco Animal Health, Greenfield, IN) with 16% CP in the Phase 6 diet.

Pigs were weighed on d 0, 13, 28, 47, 70, 90, 106, and 125 of the trial to determine ADG, ADFI, and F/G. On d 106, the 3 heaviest pigs in each pen were weighed and sold according to standard farm procedures. Prior to marketing, the remaining pigs were individually tattooed with a pen ID number to allow for carcass measurements to be recorded on a pen basis. On d 125, final pen weights were taken, and pigs were transported to a USDA-inspected packing plant (JBS Swift and Company, Worthington, MN) for processing and carcass data collection. Carcass measurements taken at the plant included HCW, loin depth, backfat, and percentage lean. Percentage lean was calculated from plant proprietary equation. Carcass yield was then calculated by dividing the individual HCW at the plant by the pig's pen average final live weight at the farm.

An economic analysis was completed to determine the financial impact of the dietary treatments. Income over feed cost was calculated assuming that other costs, such as utility and labor, are equal across treatments and the only variables are carcass ADG and feed usage for the experimental period. Corn was valued at $137/ton, soybean meal at $288/ton, dried distillers grains with solubles at $130/ton, L-Lys HCl at $0.70/lb, EOM 1 at $10.91/lb, EOM 2 at $21.81/lb, and ractopamine HCl at $32.00/lb. The total feed cost per pig was calculated by multiplying the ADFI by the feed cost per pound and the number of days in each respective period, then taking the sum of those values for each period. Cost per pound of gain was calculated by dividing the total feed cost per pig by the total pounds gained overall. Gain value per pig was calculated by multiplying carcass gain by an assumed carcass value of $70.00 per cwt. To calculate income over feed cost (IOFC), total feed cost was subtracted from gain value per pig.

Diet samples from each dietary phase were taken from 6 feeders per dietary treatment 3 d after the beginning and 3 d before the end of each dietary phase and stored at -4°F until they were homogenized, subsampled and submitted to Ward Laboratories, Inc. (Kearney, NE) for analysis of DM, CP, Ca, P, crude fat, and ash (Tables 3, 4, and 5).

Data were analyzed using the PROC GLIMMIX procedure in SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit and initial BW as a blocking factor. Dietary treatments were the fixed effect and block served as the random effect in the analysis. HCW was used as a covariate for analyses of backfat thickness, loin depth, and percentage lean. When a significant difference was found between treatments, differences were determined using the PDIFF statement in SAS. Statistical significance was determined at $P < 0.05$.

Results and Discussion

The analyzed DM, CP, Ca, P, fat, and ash content of experimental diets (Tables 3, 4, and 5) were consistent with formulated estimates with the exception of the EOM1 diets in Phases 1 and 2, which analyzed lower in CP than expected.

For overall growth performance (d 0 to 125), pigs fed diets with EOM 1+2 had increased ($P = 0.003$) ADFI compared with pigs fed the control treatment. The higher ADFI promoted a numerical ($P > 0.050$) improvement in ADG. Pigs fed the treatment with EOM 1 and 16% CP had increased ($P = 0.032$) ADFI in comparison with the ractopamine HCl treatment. Pigs fed the ractopamine HCl treatment had improved ($P = 0.028$) F/G compared with pigs fed the treatment with the EOM 1 and 16% CP.

For carcass traits, pigs fed the treatment with EOM 1+2 had increased ($P = 0.007$) HCW compared with the treatment with EOM 1 and 12% CP and the control treatment ($P = 0.002$). Pigs fed the treatment with ractopamine HCl had improved ($P = 0.001$) HCW compared with the control treatment. Pigs fed diets with EOM 1+2 had increased ($P = 0.001$) carcass ADG compared with pigs fed the control treatment and the treatment with EOM 1 and 12% CP (P=0.019). Pigs fed the treatment with ractopamine HCl had improved ($P = 0.001$) carcass ADG compared with the control treatment. Pigs fed the treatment with ractopamine HCl had improved (P=0.001) carcass F/G in comparison with the treatment with EOM 1 and 16% CP and the control treatment ($P < 0.001$) with no differences among the other treatments. Pigs fed diets with EOM 1+2 had increased ($P = 0.021$) carcass yield compared with pigs fed the treatment with EOM 1 and 12% CP. Carcass yield also was improved ($P = 0.036$) for the treatment with ractopamine HCl in comparison with the control treatment. Pigs fed the ractopamine HCl had reduced ($P = 0.001$) backfat in comparison with pigs fed the treatment with EOM 1 and 16% CP, or the control treatment ($P < 0.001$). Pigs fed the control treatment or treatments with EOM 1 or EOM 1+2 with 12% CP had similar backfat. Pigs fed the treatment with ractopamine HCl had increased ($P = 0.002$)

lean percentage in comparison with pigs fed the treatment with EOM 1 and 16% CP, or the control treatment ($P = 0.002$).

For economics, total feed cost per pig was lower ($P = 0.006$) for pigs fed the control treatment compared to the treatment with EOM 1 and the treatment with EOM 1+2, both with 12% CP ($P < 0.001$). Pigs fed the treatment with EOM 1+2 had higher ($P = 0.001$) feed cost per pig in comparison with the treatment with EOM 1 and 12% CP. Pigs fed the treatment with ractopamine HCl treatment had higher ($P < 0.001$) feed cost compared with the control treatment. Feed cost per pound of gain was lower ($P < 0.001$) for pigs fed the control treatment compared to the treatment with EOM 1+2. Pigs fed with the ractopamine HCl treatment had higher ($P = 0.023$) feed cost per pound of gain compared with the control treatment. Pigs fed diets with EOM 1+2 had increased ($P = 0.001$) gain value compared with pigs fed the control treatment. Pigs fed the treatment with ractopamine HCl had increased ($P = 0.001$) gain value in comparison with the control treatment.

In summary, the addition of the combination of EOM 1+2 to the diets improved ADFI, HCW, and carcass ADG in comparison with the control treatment. The inclusion of this treatment improved gain value, however, the increase in gain was not sufficient to overcome the increase in feed cost. Thus, income over feed cost was similar to the control treatment. Regardless of the lower ADFI with the ractopamine HCl treatment in comparison with pigs fed EOM 1 and 16% CP, the treatment with ractopamine HCl had improved F/G, carcass F/G, lean percentage, and reduced backfat. The gain value improvement for the regimen with ractopamine HCl compensated for the extra feed cost, resulting in a higher income over feed cost compared with the treatment with EOM 1 and 16% CP. Similar positive effects in growth and carcass characteristics were observed with the ractopamine HCl treatment compared with the control treatment; however, income over feed cost was similar for both treatments. The addition of combined essential oils provided with positive effects for growth and carcass characteristics for grow-finish pigs. However, the magnitude of the benefits value did not economically justify their inclusion into the diets. As expected, the ractopamine HCl had positive effects on growth and carcass characteristics, nonetheless it provided only numerical differences in income over feed cost in comparison with the control treatment.

Table 1. Diet composition from Phase 1 to 5 (as-fed basis)[1,2]

Item	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Ingredient, %					
Corn	59.36	65.13	70.50	74.05	76.42
Soybean meal, (46.5% CP)	23.13	17.48	12.24	8.85	6.44
DDGS[3]	15.00	15.00	15.00	15.00	15.00
Limestone	1.10	1.10	1.05	1.00	1.00
Monocalcium P, (21% P)	0.25	0.15	0.10	0.05	0.05
Salt	0.35	0.35	0.35	0.35	0.35
L-Lys-HCl	0.41	0.41	0.41	0.42	0.42
DL-Met	0.09	0.06	0.04	0.02	0.02
L-Thr	0.10	0.10	0.09	0.09	0.09
L-Trp	0.03	0.04	0.04	0.04	0.04
Phytase[4]	0.02	0.02	0.02	0.02	0.02
Trace mineral premix	0.10	0.10	0.10	0.06	0.10
Vitamin premix	0.08	0.08	0.08	0.06	0.06
Total	100.0	100.0	100.0	100.0	100.0
Calculated analysis					
Standardized ileal digestible amino acids, %					
Lys	1.12	0.98	0.85	0.77	0.71
Ile:Lys	61	60	58	57	56
Leu:Lys	139	145	152	157	162
Met:Lys	32	32	31	30	30
Met and Cys:Lys	56	56	56	56	57
Thr:Lys	62	62	62	62	63
Trp:Lys	19	19	18	19	18
Val:Lys	67	67	67	67	67
SID lysine: ME, g/Mcal	3.38	2.95	2.55	2.31	2.13
ME, kcal/lb	1,503	1,507	1,511	1,515	1,515
CP, %	19.7	17.4	15.3	14.0	13.0
Ca, %	0.57	0.53	0.49	0.45	0.44
P, %	0.46	0.42	0.38	0.36	0.35
Available P, %	0.30	0.28	0.26	0.24	0.24
Standardized digestible P, %	0.34	0.31	0.29	0.27	0.26

[1]Phases 1, 2, 3, 4, and 5 diets were fed from d 0 to 13, d 13 to 47, d 47 to 70, 70 to 90, and d 90 to 106, respectively.
[2] EOM 1 was included at 0.015% in all 6 phases only for treatments 2 and 4. EOM 1 was included at 0.015% from Phase 3 to 6 and EOM 2 was included at 0.0125% from Phase 1 to 6 only for treatment 3.
[3] Dried distillers grains with solubles.
[4] Optiphos 2000 (Enzyvia LLC, Sheridan, IN) provided 136.5 FTU per pound of diet.

Table 2. Phase 6 diet composition (as-fed basis)[1,2]

Item	Control	EOM 1	EOM 1+2	EOM 1	Ractopamine HCl
Ingredient, %					
Corn	85.50	85.48	85.47	76.13	76.10
Soybean meal, (46.5% CP)	12.38	12.38	12.38	21.66	21.66
Limestone	1.00	1.00	1.00	1.00	1.00
Monocalcium (21% P)	0.25	0.25	0.25	0.20	0.20
Salt	0.35	0.35	0.35	0.35	0.35
L-Lys-HCl	0.23	0.23	0.23	0.25	0.25
DL-Met	0.03	0.03	0.03	0.09	0.09
L-Thr	0.08	0.08	0.08	0.12	0.12
L-Trp	0.02	0.02	0.02	0.02	0.02
Ractopamine HCl[3]	0.00	0.00	0.00	0.00	0.05
Phytase[4]	0.02	0.02	0.02	0.02	0.02
Trace mineral premix	0.10	0.10	0.10	0.10	0.10
Vitamin premix	0.06	0.06	0.06	0.06	0.06
EOM 1	- - -	0.015	0.015	0.015	- - -
EOM 2	- - -	- - -	0.0125	- - -	- - -
Total	100.0	100.0	100.0	100.0	100.0
Calculated analysis					
Standardized ileal digestible amino acids, %					
Lysine	0.65	0.65	0.65	0.90	0.90
Ile:Lys	63	63	63	63	63
Leu:Lys	155	155	155	137	137
Met:Lys	32	32	32	35	35
Met and Cys:Lys	60	60	60	60	60
Thr:Lys	67	67	67	67	67
Trp:Lys	19	19	19	19	19
Val:Lys	72	72	72	69	69
SID lys:ME, g/Mcal	1.95	1.95	1.96	2.71	2.71
ME, kcal/lb	1,509	1,508	1,508	1,506	1,505
CP, %	12.2	12.2	12.2	16.0	16.0
Ca, %	0.49	0.49	0.49	0.51	0.51
P, %	0.36	0.36	0.36	0.39	0.39
Available P, %	0.23	0.23	0.23	0.23	0.23
Standard digestible P, %	0.27	0.27	0.27	0.29	0.29

[1]Phase 6 diets were fed from d 106 to 125.
[2] EOM 1 was included at 0.015% in all 6 phases only for treatments 2 and 4. EOM 1 was included at 0.015% from Phase 3 to 6 and EOM 2 was included at 0.0125% from Phases 1 to 6 for treatment 3 only.
[3]Paylean (Elanco Animal Health, Greenfield, IN).
[4]Optiphos 2000 (Enzyvia LLC, Sheridan, IN) provided 136.5 FTU per pound of diet.

Table 3. Chemical analysis of experimental diets (as-fed basis)[1,2]

	Phase 1			Phase 2		
Feed additive:	Control[3]	EOM 1[4]	EOM 1+2[5]	Control	EOM 1	EOM 1+2
Item, %						
DM	89.6	89.2	89.6	89.4	88.9	88.6
CP	21.2	17.8	20.1	18.6	16.8	19.1
Ca	0.66	0.61	0.70	0.66	0.61	0.60
P	0.47	0.46	0.47	0.46	0.43	0.44
Ether extract	2.9	3.0	3.0	3.4	3.0	2.9
Ash	4.0	3.9	4.4	3.7	3.8	3.9

[1] Multiple diet samples were collected from each diet throughout the study, homogenized, and then subsampled for analysis (Ward Laboratories, Inc. Kearney, NE).
[2] Phases 1 and 2 were fed from d 0 to 13 and d 13 to 47, respectively.
[3] Control treatment (T1) had the same formulation to the ractopamine HCL treatment (T5) until Phase 5.
[4] EOM 1 was included at 0.02% in all 6 phases for treatments 2 and 4.
[5] EOM 1 was included at 0.02% for Phase 3 to 6 and EOM 2 was included at 0.01% for Phase 1 to 6 for treatment 3.

Table 4. Chemical analysis of experimental diets (as-fed basis)[1,2]

	Phase 3			Phase 4		
Feed additive:	Control[3]	EOM 1[4]	EOM 1+2[5]	Control	EOM 1	EOM 1+2
Item, %						
DM	88.8	88.8	89.1	88.4	89.1	88.6
CP	14.7	15.7	15.7	14.1	14.6	15.0
Ca	0.52	0.51	0.54	0.60	0.45	0.49
P	0.38	0.41	0.38	0.40	0.38	0.42
Ether extract	3.1	3.5	3.4	3.3	4.0	4.0
Ash	3.3	3.4	3.3	3.2	3.2	3.2

[1] Multiple diet samples were collected from each diet throughout the study, homogenized, and then subsampled for analysis (Ward Laboratories, Inc. Kearney, NE).
[2] Phase 3 and 4 were fed from d 47 to 70 and d 70 to 90, respectively.
[3] Control treatment (T1) had the same formulation to the ractopamine HCL treatment (T5) until Phase 5.
[4] EOM 1 was included at 0.02% in all 6 phases for treatments 2 and 4.
[5] EOM 1 was included at 0.02% for Phases 3 to 6 and EOM 2 was included at 0.01% for Phases 1 to 6 for treatment 3.

Table 5. Chemical analysis of experimental diets (as-fed basis)[1,2]

	Phase 6				
Feed additive:	Control[3]	EOM 1[4]	EOM 1+2[5]	EOM 1	Ractopamine HCL
Item, %					
DM	87.4	87.4	87.0	88.0	89.5
CP	12.7	11.7	11.9	15.3	14.1
Ca	0.46	0.55	0.48	0.62	0.64
P	0.36	0.34	0.32	0.41	0.38
Ether extract	2.5	2.5	2.8	2.8	3.0
Ash	2.8	2.7	2.9	3.4	3.5

[1] Multiple diet samples were collected from each diet throughout the study, homogenized, and then subsampled for analysis (Ward Laboratories, Inc. Kearney, NE).
[2] Phase 6 was fed from d 106 to 125.
[3] Control treatment (T1) had the same formulation to the ractopamine HCL treatment (T5) until phase 5.
[4] EOM 1 was included at 0.02% in all 6 phases for treatments 2 and 4.
[5] EOM 1 was included at 0.02% for Phase 3 to 6 and EOM 2 was included at 0.01% for Phase 1 to 6 for treatment 3.

Table 6. The effects of dietary phytogenics on the growth, carcass characteristics, and economics of grow-finish pigs[1,2,3]

CP in Phase 6, %:	12			16			Probability, P<
Feed additive:	Control	EOM 1	EOM 1+2	EOM 1	Ractopamine HCl[4]	SEM	Treatment
BW, lb							
d 0	48.8	48.8	48.7	48.7	48.7	1.01	0.998
d 125	270.6	274.7	274.7	273.0	273.1	2.37	0.611
d 0 to 125							
ADG, lb	1.79	1.83	1.83	1.82	1.82	0.014	0.215
ADFI, lb	4.82[bc]	4.92[ab]	5.01[a]	4.91[ab]	4.78[c]	0.046	0.003
F/G	2.68[ab]	2.67[ab]	2.72[a]	2.69[a]	2.61[b]	0.026	0.047
Carcass characteristics							
HCW, lb	208.3[b]	209.1[b]	214.0[a]	211.8[ab]	214.6[a]	1.34	0.001
Carcass ADG, lb[5]	1.38[c]	1.39[bc]	1.43[a]	1.41[ab]	1.43[a]	0.009	0.002
Carcass F/G[6]	3.50[a]	3.53[a]	3.50[a]	3.49[a]	3.34[b]	0.029	<0.001
Carcass yield, %	77.0[bc]	76.1[c]	77.9[ab]	77.6[ab]	78.6[a]	0.53	0.021
Backfat,[7] in.	0.67[a]	0.68[a]	0.66[a]	0.66[a]	0.61[b]	0.011	<0.001
Loin depth,[7] in.	2.75	2.73	2.68	2.73	2.71	0.036	0.819
Lean,[7] %	56.8[b]	56.7[b]	56.8[b]	56.9[b]	57.8[a]	0.19	0.002
Economics, $/pig							
Feed cost	54.24[c]	56.21[b]	58.61[a]	57.28[ab]	56.88[b]	0.547	<0.001
Feed cost/lb gain[8]	0.242[c]	0.246[bc]	0.256[a]	0.252[a]	0.250[ab]	0.002	0.001
Gain value[9]	120.22[c]	120.76[bc]	124.25[a]	122.72[ab]	124.64[a]	0.851	<0.001
IOFC[10]	65.99[ab]	64.55[b]	65.64[b]	65.45[b]	67.77[a]	0.723	0.030

[1] A total of 1,260 pigs (PIC 1050 × 327) were used with 28 pigs per pen and 9 replications per treatment.
[2] Treatment 1 was the control with 12% of CP in Phase 6 diet. Treatment 2 contained EOM 1 fed all phases with 12% of CP in Phase 6 diet. Treatment 3 was EOM 1 fed from Phase 3 to 6 and EOM 2 fed all phases with 12% CP in Phase 6. Treatment 4 contained EOM 1 fed all 6 phases with 16% CP in Phase 6. Treatment 5 contained ractopamine HCL (9 g/ton) with 16% CP in Phase 6 diet.
[3] Means with the same letter are not significantly different from each other.
[4] Paylean (Elanco Animal Health, Greenfield, IN).
[5] Carcass average daily gain = overall ADG * carcass yield.
[6] Carcass F/G = overall average feed intake/carcass average daily gain.
[7] Adjusted using HCW as a covariate.
[8] Feed cost/lb gain = total feed cost divided by total gain per pig.
[9] Gain value = (HCW × $0.70) - (d 0 BW × 0.75 × $0.70).
[10] Income over feed cost = gain value – feed cost.