Oregano oil as an alternative to antimicrobials in nursery diets

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Summary

Objectives: To evaluate the growth-promoting potential of oregano oil in nursery pigs and evaluate the effect of oregano oil concentration on palatability, feed intake, and growth.

Materials and methods: In Experiment One, 180 seventeen-day-old Yorkshire-Landrace pigs were randomly assigned to three dietary treatments, including an unsupplemented, unmedicated basal diet (Control) and the basal diet supplemented with either 55 g per tonne carbadox (Phibro Animal Health, Ridgefield Park, New Jersey) or 1.5 kg per tonne oregano oil (Van Beek Scientific, Orange City, Iowa). In Experiment Two, 160 twenty-one-day-old Yorkshire-Landrace pigs were randomly assigned to four dietary treatments, including an unsupplemented, unmedicated basal diet (Control) and the basal diet supplemented with 0.5, 1.0, or 1.5 kg per tonne oregano oil. Growth parameters were assessed during a 35-day period in each experiment.

Results: In Experiment One, pigs fed the carbadox-supplemented diet and Control diet exhibited higher average daily gain (ADG) and better feed utilization than pigs fed oregano oil ($P < .05$). In Experiment Two, pigs fed oregano oil at 1.5 kg per tonne achieved the highest ADG ($P < .05$). Feed utilization was similar ($P > .05$) in groups fed oregano oil at 1.0 and 1.5 kg per tonne. Pigs fed the Control diet achieved higher ADG and better feed utilization than pigs fed oregano oil at 0.5 kg per tonne ($P < .05$).

Implications: Oregano oil supplementation does not support pig growth equivalently to antimicrobial feed additives. Feed intake is not negatively influenced by palatability of oregano oil.

Keywords: swine, nursery, oregano oil, feed additives, growth promotion

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Resumen - El aceite de orégano como una alternativa a los antimicrobianos en las dietas de destete

Objetivos: Evaluar el potencial de promoción de crecimiento del aceite de orégano en cerdos en destete y evaluar el efecto del la concentración de aceite de orégano en la palatabilidad, consumo de alimento, y crecimiento.

Materiales y métodos: En el Experimento Uno, se asignaron al azar 180 cerdos Yorkshire-Landrace de diecisiete días de edad a tres tratamientos alimenticios, incluyendo una dieta base (Control) no medicada, no suplementada, y la dieta base suplementada con 55 g por tonelada de carbadox (Phibro Animal Health, Ridgefield Park, New Jersey) ó 1.5 kg por tonelada de aceite de orégano (Van Beek Scientific, Orange City, Iowa). En el experimento Dos, se asignaron al azar 160 cerdos Yorkshire-Landrace de veintiún días de edad a cuatro tratamientos alimenticios, incluyendo una dieta base (Control) no suplementada, no medicada y la dieta base suplementada con 0.5, 1.0, o 1.5 kg de aceite de orégano por tonelada. En cada experimento se evaluaron los parámetros de crecimiento durante un periodo de 35 días.

Resultados: En el experimento Uno, los cerdos alimentados con la dieta suplementada con carbadox y la dieta Control presentaron una ganancia diaria promedio (ADG por sus siglas en inglés) más alta y una mejor utilización del alimento que los cerdos alimentados con aceite de orégano ($P < .05$). En el experimento Dos, los cerdos alimentados con aceite de orégano a 1.5 kg por tonelada obtuvieron la ADG más alta ($P < .05$). La utilización del alimento fue similar ($P > .05$) en grupos alimentados con aceite de orégano a 1.0 y 1.5 kg por tonelada. Los cerdos alimentados con la dieta Control lograron un ADG más alto y mejor utilización del alimento que los cerdos alimentados con aceite de orégano a 0.5 kg por tonelada ($P < .05$).

Implicaciones: La adición de aceite de orégano no mantiene un crecimiento del cerdo equivalente al de los aditivos antimicrobianos. El consumo de alimento no se afectó de manera negativa debido a la palatabilidad del aceite de orégano.

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Résumé - L'huile d'origan comme alternative aux antimicrobiens dans la diète en pouponnière

Objectifs: Évaluer le potentiel comme promoteur de croissance de l'huile d'origan chez des porcs en pouponnière et évaluer l'effet de la concentration d'huile d'origan sur la palatabilité, la prise de nourriture, et la croissance.

Matériels et méthodes: Lors de l'expérience 1, 180 porcs Yorkshire-Landrace âgés de 17 jours ont été répartis de manière aléatoire à trois traitements alimentaires, incluant une diète de base non-supplémentée et non-médicamentée (Témoin), et la diète de base supplémentée avec soit 55 g par tonne de carbadox

(Phibro, Animal Health, Ridgefield Park, New Jersey) ou 1.5 kg par tonne d'huile d'origan (Van Beek Scientific, Orange City, Iowa). Dans l'expérience 2, 160 porcs Yorkshire-Landrace âgés de 21 jours ont été répartis de manière aléatoire dans quatre groupes de traitement alimentaire, incluant une diète de base non-supplémentée et non-médicamentée (Témoin), et la diète de base supplémentée avec 0.5, 1.0, ou 1.5 kg par tonne d'huile d'origan. Les paramètres de croissance ont été mesurés durant une période de 35 jours lors des deux expériences.

Résultats: Lors de l'expérience 1, les porcs recevant la diète supplémentée avec du carbadox et ceux recevant la diète témoin ont eu des gains journaliers moyens (ADG) plus élevés et une meilleure utilisation alimentaire que les porcs recevant de l'huile d'origan ($P < .05$). Lors de l'expérience 2, les porcs recevant 1,5 kg d'huile d'origan par tonne ont eu l'ADG le plus élevé ($P < .05$). L'utilisation alimentaire était similaire ($P > .05$) pour les groupes recevant 1.0 et 1.5 kg par tonne d'huile d'origan. Les porcs recevant la diète de base ont montré un ADG plus élevé et une meilleure utilisation alimentaire que les porcs recevant 0.5 kg par tonne d'huile d'origan ($P < .05$).

Implications: L'addition d'huile d'origan ne favorise pas la croissance des porcs de manière équivalente à l'ajout d'antimicrobiens. La prise de nourriture n'est pas influencée négativement par la palatabilité de l'huile d'origan.

The ability of antimicrobials to enhance growth and feed efficiency of food-producing animals was first recognized in the late 1940s and has evolved to become an important component of livestock production in the United States.[1] The practice of antimicrobial growth promotion is being opposed on the basis that it has compromised the efficacy of antimicrobials used in human therapeutics.[2] Imposing limitations on subtherapeutic use of antimicrobials may mitigate concerns related to the development of antibiotic resistance. Research evaluating the impact of removal of antimicrobials from the production environment has demonstrated that antibiotic resistance is subsequently decreased in swine herds.[3] In Denmark, restrictions on subtherapeutic antimicrobial growth promotion were first approved in 1995, and antimicrobial resistance in enterococci recovered from pigs was significantly reduced.[4] However, the restrictions on subtherapeutic applications prompted marked increases in the amounts of antimicrobials used to treat and control infectious diseases.[5] For this reason, restrictions on subtherapeutic antimicrobial use appear to have a detrimental effect on swine health and would be unwarranted in the absence of an effective replacement in the nursery phase of growth. Numerous antimicrobial-free products described as having positive effects on pig growth, feed utilization, and overall health have been advocated to facilitate reductions in the use of subtherapeutic antimicrobials. Plant-based compounds referred to as nutraceuticals or phytochemicals have been viewed as possible replacements to subtherapeutic antimicrobials in swine diets. One such compound that has generated interest relative to its potential use in livestock production is oregano oil, a volatile aromatic product obtained from the leaves of *Origanum vulgare.* Two active compounds in oregano oil, carvacrol and thymol, are postulated to possess antimicrobial properties and are considered to act by disrupting cell wall integrity of microbes.[6] Numerous researchers have investigated the described antimicrobial properties of oregano oil and determined that it is a potent inhibitor of clinically significant bacterial pathogens, such as *Salmonella* serovar Typhimurium, *Escherichia coli, Yersinia enterocolitica*, *Listeria monocytogenes*, and methicillin-resistant staphylococci.[7-10] Published results of growth and feed-utilization studies with pigs are limited and have yielded mixed results. European investigators describe beneficial growth responses to feed supplementation with oregano oil in nursery-age pigs, but the duration of the response was less than that obtained with the subtherapeutic antimicrobial avilamycin.[11] Enhanced growth of grower-finisher pigs fed diets supplemented with oregano oil and vitamin E has been reported.[12] However, the possibility of a synergistic effect or correction of vitamin E deficiency must be considered in the favorable response obtained from oregano oil and vitamin E supplementation. The studies cited suggest that oregano oil supplementation may have application as a growth-promoting feed additive for swine. Hence, the objectives of the experiments described herein were to evaluate the growth-promoting potential of oregano oil in nursery-age pigs and to evaluate the effect of oregano oil concentration on palatability, feed intake, and growth.

Materials and methods

Experimental design

Two experiments were completed to evaluate oregano oil in diets for nursery-age pigs as an alternative to subtherapeutic antimicrobial growth promotion. A 35-day growth assay was used in each study to evaluate the effect of oregano oil on pig growth and feed utilization. Pigs were assigned to the dietary treatments on entering the nurseries (Day 0). In each experiment, initial bodyweight was the criterion used to assign pigs to experimental blocks, ie, bodyweights were arranged from heaviest to lightest and blocked such that the heaviest pigs assigned to each treatment were in the first block and the lightest pigs were in the last block.

Experiment One consisted of a randomized complete block experimental design with a total of 10 replicate blocks. Pen served as the experimental unit and three dietary treatments were used. Pigs were weighed weekly and a feed record was maintained to monitor feed additions. Feeder weights were obtained on Day 21 (when the change was made from phase 1 to phase 2 diets), and on Day 35 (when the study was terminated).

Experiment Two consisted of a randomized complete block experimental design with a total of eight replicate blocks. Pen served as the experimental unit and four dietary treatments were used. Pigs were weighed weekly and a feed record was maintained to monitor feed additions. Feeder weights were obtained on Day 18 (when the change was made from phase 1 to phase 2 diets), and on Day 35 (when the study was terminated).

Pigs and housing

Experiment One. One hundred eighty 17-day-old female Yorkshire-Landrace pigs with an average weight of 5.6 kg (SD, 0.03) were assigned to dietary treatments on Day 0. The pigs were obtained from a commercial swine farm that practiced early weaning. Antimicrobials were not administered during processing of piglets while on the sow or on the day of weaning. The study was conducted in the early-wean nurseries at the Purdue University Animal Sciences Research and Education Center (West Lafayette, Indiana). The nurseries were environmentally controlled, the pens were 1.49 m^2, the flooring was plastic-coated wire, and six pigs were housed in each pen.

Experiment Two. One hundred sixty 21-day-old Yorkshire-Landrace pigs with an average weight of 5.2 kg (SD, 0.03) were assigned to dietary treatments on Day 0, with equal numbers of barrows and gilts. The pigs were farrowed at the Purdue University Animal Sciences Research and Education Center and the study was completed in the conventional on-site nursery. Antimicrobials were not administered during processing of piglets while on the sow or on the day of weaning. The nursery was environmentally controlled, the pens were 1.98-m^2, the flooring was plastic-coated wire, and five pigs were housed in each pen.

Both studies were reviewed and approved by the Purdue University Animal Care and Use Committee.

Diets

The basal diet (Control) for both experiments consisted of an unsupplemented, unmedicated nursery formulation that was representative of standard nursery diet formulations used by the Purdue University Animal Sciences Research and Education Center Swine Unit. The basal diet met or exceeded National Research Council recommendations for nursery-age pigs.[13]

Experiment One. The basal diet (Table 1) was supplemented with either carbadox (Phibro Animal Health, Ridgefield Park, New Jersey) at a concentration of 55 mg per kg (Carbadox treatment) or Royal Powder 75 (Van Beek Scientific, Orange City, Iowa), a powdered oregano-oil product, at a concentration of 1.5 mg per kg (Oregano 1.5 treatment).

Experiment Two. The basal diet (Table 1) was supplemented with Royal Nutrizyme (Van Beek Scientific), a powdered oregano-oil product, at a concentration of 0.5, 1.0, or 1.5 mg per kg (Oregano 0.5, Oregano 1.0, and Oregano 1.5 treatments, respectively).

The experimental diets were fed in meal form and were isonitrogenous and isocaloric. Feed additives were added to the basal diet at the expense of corn. The amount of oregano oil in Royal Powder 75 and Royal Nutrizyme was identical at 75 g oregano oil per kg of product, and the two products were considered to differ only in their digestible carriers. The Royal Powder 75 formulation utilized corn starch and dextrose as the primary carrier, and the Royal Nutrizyme formulation utilized calcium carbonate as the primary carrier.

Statistical analysis

Pen served as the unit for analysis. For both experiments, least squares means for bodyweight, average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency were calculated and subjected to an unbalanced ANOVA using the GLM procedure in SAS (SAS Institute, Cary, North Carolina). The least significant difference test was used as the mean separation procedure.

Results

Experiment One

Bodyweight, ADG, ADFI, and feed efficiency data are shown in Table 2. Pigs fed the Carbadox diet had the heaviest bodyweight at the end of the study, achieved the greatest ADG, consumed the greatest amount of feed, and exhibited the best feed utilization ($P < .05$). With the exception of week 5 of the study, pigs fed the Control diet achieved the second highest ADG and feed utilization. Signs of infectious disease were not observed during the study. One pig from the Oregano 1.5 treatment was removed from the study and euthanized due to a musculoskeletal injury that failed to respond to anti-inflammatory therapy.

Experiment Two

Bodyweight, ADG, ADFI, and feed efficiency data are shown in Table 3. Pigs fed the Oregano 1.5 diet had the heaviest bodyweight at the end of the study, exhibited the highest ADG, and consumed the most feed ($P < .05$). Feed utilization of pigs fed the Oregano 1.0 and Oregano 1.5 diets were similar ($P > .05$). Performance of pigs fed the Oregano 0.5 diet was inferior ($P < .05$) to that of pigs fed the Control diet. Four pigs were removed from the study for treatment of infectious arthritis: two from the Oregano 1.5 treatment, one from the Oregano 1.0 treatment, and one from the Oregano 0.5 treatment.

Discussion

In Experiment One, the growth and feed-utilization data demonstrate that oregano oil was inferior to carbadox at promoting growth and enhancing feed utilization of nursery-age pigs. The poor growth and feed utilization of pigs fed the diet supplemented with oregano oil was assumed to be related to diet preference. Although a preference or "cafeteria" study was not part of our experimental protocol, the issue is raised here because feed intake data shows that consumption of the Oregano 1.5 diet was significantly less than consumption of the Control and Carbadox diets. Therefore, growth and feed utilization of pigs consuming the Oregano 1.5 diet was less than maximal.

In both experiments, the oregano oil feed additive made the diets strongly aromatic. Oregano is a member of the mint family and is described as having a pungent odor and taste. The prominent odor of the product was apparent prior to mixing in the diet. After mixing, the odor did not abate, and this is assumed to have exerted a negative effect on feed intake and subsequent pig growth. After conclusion of Experiment One, we speculated that a lower rate of oregano oil inclusion might have been more tolerable to the pigs and promoted better feed intake and growth rates.

The results of Experiment Two failed to support our assumptions regarding lower inclusion rates, because pigs consuming the diet with the highest level of oregano oil supplementation (1.5 kg per tonne) achieved the highest ADFI and ADG. A medicated diet was not formulated for Experiment Two because the primary intent was to evaluate whether palatability of the diets supplemented with oregano oil suppressed feed intake. The remarkable difference in ADG and overall performance between the two studies is in part ascribed to the difference in health status of the pigs in Experiments One and Two. The pigs in Experiment One were obtained from a commercial swine herd that practiced early weaning, while the pigs in Experiment Two had a conventional weaning age of 21 days. Antimicrobials were not used during processing of piglets at either swine farm and were not used as part of the early-wean program for pigs obtained from the commercial swine farm (Experiment One). Therefore, suppression of the pigs' microflora was not a factor in either experiment. The more nutrient-dense diet fed in Experiment Two (assessed on the basis of calculated nutrient composition) did not support growth and feed intake responses equivalent to those obtained in Experiment One. The pigs in Experiment One were heavier at the start of the study and demonstrated the capacity to consume more feed on a daily basis, resulting in heavier bodyweights at the termination of the study. On the subject of overall performance of pigs fed diets supplemented with oregano oil, the results of Experiment One agree with recent results described by other investigators.[14] However, in Experiment Two, different levels of oregano oil supplementation promoted higher responses in ADG, ADFI, and feed utilization than the unsupplemented, unmedicated Control diet. Although possible, the prospect of a toxic effect being responsible for the poor growth and feed intake responses of pigs fed the diet supplemented with oregano oil in Experiment One is doubtful. A toxic effect is considered unlikely because the pigs in Experiment Two, at the highest level of oregano oil supplementation, did not experience poor responses in growth and feed intake as did the pigs in Experiment One. Royal Powder 75 and Royal Nutrizyme both contain 75 g oregano oil per kg of product, and both experiments included dietary treatments that contained 1.5 kg per tonne of each product. The carriers used in each product formulation are highly digestible feed ingredients that should not precipitate impaired growth and feed-intake responses in pigs consuming the product in the recommended amounts. Moreover, signs of an infectious process

Table 1: Diet composition for nursery pigs fed either a basal diet or the same diet supplemented with oregano oil at three levels of inclusion

	Phase 1 basal diet*		Phase 2 basal diet*	
	Experiment 1	**Experiment 2**	**Experiment 1**	**Experiment 2**
Ingredients (kg/tonne)				
Corn	538.58	518.94	691.02	653.02
Soybean meal	272.07	280.56	270.37	307.61
Dicalcium phosphate	7.42	5.01	12.93	11.02
Limestone	3.91	6.56	7.22	8.82
Salt	2.51	2.51	3.51	3.51
Soybean oil	30.06	20.04	NA	NA
Animal fat†	NA	NA	10.02	10.02
Lysine-HCl‡	1.50	2.30	1.50	2.74
DL-methionine§	0.50	0.50	NA	NA
Swine vitamin premix¶	2.50	2.51	2.51	2.51
Swine TM Premix**	1.25	1.25	1.25	1.25
Selenium 600 Premix††	0.50	0.50	0.50	0.50
Dried whey	100.21	100.22	NA	NA
Select menhaden fish meal	40.08	50.10	NA	NA
Phytase‡‡	1.00	1.00	1.00	1.00
Calculated nutrient composition				
Digestible energy (kcal/kg)	3.6	3.6	3.5	3.5
Crude protein (%)	21.0	22.0	18.5	20.0
Lysine (%)	1.40	1.50	1.10	1.31

* Experiment One: phase 1 diets were fed Days 0 to 20 and phase 2 diets, Days 21 to 35. Experiment Two: phase 1 diets were fed Days 0 to 17 and phase 2 diets, Days 18 to 35.

† Choice white grease.

‡ 78.5% L-lysine.

§ 99% methionine.

¶ Supplied per kg of complete diet Days 0 to 20 (Experiment One) or Days 0 to 17 (Experiment Two): vitamin A, 6105 IU; vitamin D, 611 IU; vitamin E, 44 IU; vitamin B_{12}, 40 μg; menadione, 2.0 mg; riboflavin, 7.2 mg; d-pantothenic acid, 22.2 mg; niacin, 44 mg. Supplied per kg of complete diet Days 21 to 35 (Experiment One) or Days 18 to 35 (Experiment Two): vitamin A, 5990 IU; vitamin D, 599 IU; vitamin E, 43.6 IU; vitamin B_{12}, 30 μg; menadione, 2.0 mg; riboflavin, 7.0 mg; d-pantothenic acid, 21.8 mg; niacin, 43.6 mg.

** Supplied per kg of complete diet Days 0 to 20 (Experiment One) or Days 0 to 17 (Experiment Two): copper, 11.2 ppm; iodine, 0.42 ppm; iron, 120 ppm; manganese, 14.9 ppm; zinc, 120 ppm. Supplied per kg of complete diet Days 21 to 35 (Experiment One) or Days 18 to 35 (Experiment Two): copper, 11.4 ppm; iodine, 0.42 ppm; iron, 122.6 ppm; manganese, 15.2 ppm; zinc, 122.6 ppm.

†† Selenium, 0.301 g/tonne.

‡‡ Natuphos 600 (BASF Animal Nutrition, Florham Park, New Jersey), phytase, 600 phytase units/g.

NA = not applicable.

Table 2: Bodyweight, average daily gain (ADG), average daily feed intake (ADFI), and feed:gain ratio (least squares means) of nursery pigs fed diets containing oregano oil or carbadox or the unsupplemented basal diet (Experiment One; Days 0–35)*

Variable	Control†	Oregano oil‡	Carbadox§	SE
Bodyweight Day 0 (kg)	5.6	5.6	5.6	0.01
Bodyweight Day 35 (kg)	19.8[a]	18.9[b]	20.6[c]	0.13
ADG (g/day)	405[a]	380[b]	428[c]	3.59
ADFI (g/day)	673[a]	625[b]	694[c]	6.96
Feed:gain (kg/kg)	1.66[a]	1.68[b]	1.62[c]	0.01

* Pigs approximately 17 days of age at weaning (Day 0).

† The Control diet served as the basal diet, to which Royal Powder 75 and carbadox were added at the expense of corn in the two test diets.

‡ Royal Powder 75 (Van Beek Scientific, Orange City, Iowa), containing 75 g of oregano oil/kg of product, was added to the basal diet at 1.5 kg/tonne.

§ Added to the basal diet at 55 mg/kg.

[abc] Values within a row with different superscripts differ ($P < .05$; unbalanced ANOVA).

Table 3: Bodyweight, ADG, ADFI, and feed:gain ratio (least squares means) in nursery pigs fed diets containing oregano oil at three levels or the unsupplemented basal diet (Experiment Two; Days 0–35)*

		Oregano oil‡ (kg/tonne)			
Variable	Control†	0.5	1.0	1.5	SE
Bodyweight Day 0 (kg)	5.2	5.2	5.2	5.2	0.01
Bodyweight Day 35 (kg)	14.7[a]	14.2[b]	14.8[a]	15.7[c]	0.25
ADG (g/day)	271[a]	256[b]	274[a]	300[c]	7.10
ADFI (g/day)	452[a]	438[b]	435[b]	471[c]	10.5
Feed:gain (kg/kg)	1.68[a]	1.79[b]	1.63[c]	1.63[c]	0.02

* Pigs approximately 21 days of age at weaning (Day 0).

† The Control diet served as the basal diet, with Royal Nutrizyme added at the expense of corn in the three test diets.

‡ Royal Nutrizyme (Van Beek Scientific, Orange City, Iowa), containing 75 g of oregano oil/kg of product, was added to the basal diet at 0.5, 1.0, and 1.5 kg/tonne.

[abc] Values within a row with different superscripts differ ($P < .05$; unbalanced ANOVA).

were not observed during the study and exerted no effect on the growth and feed utilization responses of pigs fed oregano oil. Therefore, an exact cause of the poor performance of the pigs fed the diet supplemented with oregano oil in Experiment One is not apparent.

Implications

- Under the conditions of Experiment One, the growth-promoting potential of oregano oil is likely to be inferior to that of antimicrobials.
- Experiment Two results suggest that palatability may not be responsible for the poor feed intake of pigs fed a diet supplemented with oregano oil.
- More research is warranted to determine how oregano oil can be used most effectively in swine nutrition programs.

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