Philipp J Vet Anim Sci 2020 46(2):115-123

EFFECT OF A PLANT EXTRACT MIXTURE AS AN ALTERNATIVE TO RACTOPAMINE HYDROCHLORIDE ON GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF FINISHING PIGS

Hannah Mae A. Rustia[1], Krystalene S. Decena[1],
Marie Fe M. Iranzo[1] and Rommel C. Sulabo[1]

ABSTRACT

A plant extract mixture (PEM) composed of garlic (*Allium sativum*), licorice (*Glycyrrhiza glabra*), ginger (*Zingiber officinale*), and myrobalan (*Terminalia chebula*) was evaluated as an alternative to ractopamine-HCl (RAC) in finishing pigs. Thirty growing pigs (initial BW=46.8±4.6 kg; PIC 337×C24) were allotted to five treatments using a randomized complete block design. Diets were fed on a 3-phase diet series (grower, d 0 to 21; finisher 1, d 22 to 42; and finisher 2, d 43 to 65). The treatments were: 1) negative control, 2) diets with 0.20% PEM, 3) diets with 0.20% PEM from finisher 1 to finisher 2, 4) diet with 0.20% PEM in finisher 2, and 5) diet with 0.05% RAC in finisher 2. Each treatment had 6 replicates. From d 43 to 65, RAC or PEM tended (*P*=0.09) to improve F/G compared with PEM fed for the entire 65 d. Overall (d 0 to 65), growth performance and carcass characteristics did not significantly differ among the treatments. In conclusion, 0.20% PEM does not improve the carcass quality of finishing pigs; however, PEM in the late finisher phase may replace the feed efficiency effects of RAC.

Key words: plant extracts, carcass quality, growth performance, finishing pigs, ractopamine

INTRODUCTION

Ractopamine-HCl (RAC) is a phenethanolamine ß-adrenergic agonist used as a feed additive that improves growth performance and carcass leanness in finishing pigs by repartitioning nutrients from fat deposition toward protein deposition (Anderson *et al*., 1987). Similar to the natural catecholamines epinephrine and norepinephrine, RAC increases blood flow to skeletal muscles, which increases substrates and energy sources for protein synthesis (Bergen *et al*., 1989). In adipose cells, RAC stimulates β-adrenergic receptors (βAR) which increases lipolysis and inhibits the synthesis of fatty acids and triglycerides (Mersmann, 1998). There is, however, increasing public health concerns with the use of ß-agonists as carcass modifiers in swine diets, since salbutamol and clenbuterol are also ß-agonists similar to RAC and are used in human medicine. Pending revision of government regulations, RAC

[1]Institute of Animal Science, College of Agriculture and Food Science, University of the Philippines Los Baños, College, Laguna 4031 Philippines (email: rcsulabo@up.edu.ph).

is currently legal for use in swine diets in numerous countries including the Philippines but there is a need to identify safe but effective alternatives.

A mixture of plant extracts from garlic (*Allium sativum*), licorice (*Glycyrrhiza glabra*), ginger (*Zingiber officinale*), and myrobalan (*Terminalia chebula*) was proposed to improve the growth and carcass quality of finishing pigs. Extracts from dietary garlic are the primary component of the mixture, which is known to have potent and selective bacteriostatic effect in the gut (Rees *et al*., 1993) that may promote growth and improve feed efficiency in growing pigs. The plant extracts may also affect carcass characteristics of pigs by reducing lipid synthesis (Adetumbi *et al*., 1986) or enhancing protein deposition (Nath *et al*., 2017) similar to the effects of RAC. However, there is no previous research on the effect of this plant extract mixture when supplemented to growing-finishing pig diets. Therefore, the objective of this study was to determine the effect of a plant extract mixture composed of garlic (*Allium sativum*), licorice (*Glycyrrhiza glabra*), ginger (*Zingiber officinale*), and myrobalan (*Terminalia chebula*) as an alternative to RAC on growth performance and carcass characteristics of finishing pigs.

MATERIALS AND METHODS

The test material was obtained from a commercial source (VetNext Agri Products, Inc., Baliuag, Bulacan). It is a proprietary feed additive mainly composed of a mixture of plant extracts from *Allium sativum* (40 g/kg), *Glycyrrhiza glabra* (20 g/kg), *Zingiber officinale* (20 g/kg), and *Terminalia chebula* (20 g/kg).

Thirty, individually-fed growing pigs (initial BW=46.8 kg; PIC 337 × C24) were used in a 65-d growth assay. Pigs were allotted to 1 of 5 experimental treatments using a randomized complete block design with initial weight and sex as blocking factors. Each treatment had 6 replications. Pigs were housed in an open-sided finishing building with 3 × 1.5 m pens and solid concrete flooring. Each pen had one self-feeder and one nipple waterer to provide feed and water on *ad libitum* basis.

The experimental treatments were as follows: 1) standard corn-soy diet (NC; negative control), 2) NC + 0.20% plant extract mixture (PEM; Alphalean, AlphaSan Health Solutions, Herentals, Belgium) from d 0 to 65 (grower to finisher 2), 3) NC + 0.20% PEM from d 22 to 65 (finisher 1 to finisher 2), 4) NC + 0.20% PEM from d 43 to 65 (finisher 2), and 5) NC + 0.05% ractopamine HCl (RAC; Paylean 20% premix, Elanco Animal Health, USA) from d 43 to 65 (finisher 2).

Basal diets were formulated (Table 1) fed in a 3-phase diet series in meal form. Phase 1, 2 and 3 were from d 0 to 21 (grower), d 22 to 42 (finisher 1), and d 43 to 65 (finisher 2), respectively. Diets were prepared by manufacturing one single batch of each basal diet and then the basal diet was divided equally among the treatments. This was to reduce the variation between the treatment diets. Afterwards, PEM or RAC were added to the diet at the expense of yellow corn, and then re-mixed to create the treatment diets. All the diets were formulated to meet or exceed NRC (2012) requirements for 40 to 80 kg pigs. In finisher 2 (80 to 100 kg), diets were formulated to contain 0.96% standardized ileal digestible (SID) Lys with a minimum CP of 16% as recommended by the manufacturer (Elanco Animal Health, USA) to maximize the response to RAC. The same was done to the PEM diets so that the only difference among the dietary treatments was the supplement. The rest of the nutrients were formulated to meet or exceed NRC (2012) requirements for 80 to 100 kg

Table 1. Ingredient and nutrient composition (as-fed basis) of basal diets[1].

Item	Basal Diet		
	Grower (d 0 to 21)	**Finisher 1 (d 22 to 42)**	**Finisher 2 (d 43 to 65)**
Ingredient, %			
Corn, yellow dent	69.287	71.296	69.055
Soybean meal	16.280	13.340	18.000
Wheat pollard	10.000	10.000	10.000
Coconut oil	1.000	2.000	--
L-lysine HCl	0.413	0.376	0.375
L-HMTBA	0.100	0.110	0.100
L-threonine	0.134	0.122	0.136
L-tryptophan	0.026	0.025	0.030
Monocalcium phosphate	0.520	0.430	0.224
Limestone	1.380	1.450	1.500
Salt	0.400	0.400	0.400
Choline chloride 60%	0.050	0.050	0.050
Vitamin premix[2]	0.030	0.020	0.020
Mineral premix[2]	0.100	0.100	0.100
Mold inhibitor	0.050	0.050	--
Antioxidant	0.020	0.020	--
Toxin binder	0.200	0.200	--
Phytase	0.010	0.010	0.010
Total	100.000	100.000	100.000
Calculated composition, %			
DM	89.6	89.5	89.4
ME, kcal/kg	3,254	3,262	3,210
CP (N × 6.25)	15.2	13.8	16.0
SID Lys	0.95	0.84	0.96
Ca	0.62	0.58	0.56
P, available	0.27	0.24	0.24
Analyzed composition, %			
DM	90.8	89.3	90.4
CP (N × 6.25)	15.8	14.4	16.3

[1]The plant extracts mixture was added to the basal diet (0.20% of the diet) at the expense of yellow corn to create the treatment diet. In finisher 2, ractopamine HCl (Paylean 20%, Elanco Animal Health, USA) was added (0.05% of the diet) at the expense of yellow corn to create the treatment diet.

[2]Provided the following quantities of vitamins and micro minerals per kg of complete diet: vit A, 11,128 IU; vit D3, 2,204 IU; vit E, 66 IU; vit K, 1.42 mg; thiamin, 0.24 mg; riboflavin, 6.58 mg; pyridoxine, 0.24 mg; vit B12, 0.03 mg; D-pantothenic acid, 23.5 mg; niacin, 44 mg; folic acid, 1.58 mg; biotin, 0.44 mg; Cu, 10 mg as copper sulfate; Fe, 125 mg as iron sulfate; I, 1.26 mg as potassium iodate; Mn, 60 mg as manganese sulfate; Se, 0.3 mg as sodium selenite; and Zn, 100 mg as zinc oxide.

pigs. Samples of all experimental diets were collected and properly labeled for subsequent analyses. At the end of the experiment, diet samples were analyzed in triplicates for DM (method 930.15; AOAC, 2007) and CP (method 990.03; AOAC, 2007).

Daily feed allotments were recorded and individual pig BW was measured at d 0, 21, 42 and 65. Data were summarized and ADG, ADFI, and F/G were calculated for each treatment in each feeding phase and for the overall period. Uniform care and management were given to all the pigs throughout the feeding trial.

Pigs were shipped approximately 140 km to the processing plant (Philippine Abattoir Development Corp., San Fernando, Pampanga). Pigs were slaughtered under commercial conditions with electrical stunning. After exiting the kill floor, carcasses (with head and feet on) were then weighed to calculate for HCW and sent through deep chill chambers (approximately −40°C) for about 90 min and placed in a holding cooler. Afterwards, individual carcass data, including backfat thickness (first rib, last rib, and last lumbar), loin eye area, and 10th rib backfat depth, were collected. Carcass yield was calculated as HCW divided by BW obtained at the plant immediately before slaughter. Standardized fat-free lean was calculated according to NPPC (2000) procedures.

Data were analyzed using the MIXED procedure (SAS Institute Inc., Cary, NC) of SAS with pig as the experimental unit. The model included diet as the main effect and block as random effect. Least squares means were calculated for each independent variable. When the diet was a significant source of variation, least square means were separated using the PDIFF option of SAS. The α-level that was used to determine significance and tendencies between means were ≤0.05 and <0.10, respectively.

RESULTS AND DISCUSSION

There were no significant differences in ADG, ADFI and BW in all feeding phases and for the overall period (Table 2). Likewise, F/G did not significantly differ in the grower, finisher 1 and the overall period. However, a tendency (P=0.09) for better F/G was observed in pigs fed diets supplemented with PEM or RAC in the finisher 2 phase compared with those fed diets supplemented with PEM for 65 d. This trend in F/G was a result of a non-significant but numerical increase in ADG and a decrease in ADFI in the finisher 2 phase.

The response to RAC observed in the present experiment conforms with previous findings. A meta-analysis of 23 different published studies using RAC in finishing pigs from doses between 5, 10 and 20 ppm showed significant improvements in ADG by 11 to 12% and F/G by 10 to 17%, respectively, compared to untreated controls (Apple *et al*., 2007). The observed response in the current experiment was 19% improvement for F/G. The improvement in F/G observed in most studies with RAC may be due to the repartitioning of nutrients. Ractopamine HCl is a phenethanolamine β-adrenergic agonist that directs nutrients away from fat deposition (Watkins *et al*., 1990; Dunshea *et al*., 1993) towards increased muscle protein synthesis (Bergen *et al*., 1989) without negatively affecting pork quality (McKeith *et al*., 1988; Stoller *et al*., 2003). This leads to more efficient use of dietary nutrients for lean gain, which influences growth rate and F/G.

There are other β-adrenergic agonists such as salbutamol and clenbuterol that have similar effects when fed to pigs (Ricks *et al*., 1984; Marchant-Forde *et al*., 2012); however, these compounds are illegal for use in swine diets due to health concerns as they are used in human medicine (e.g. bronchodilators; Lu *et al*., 2017). Though RAC belongs to the same

Table 2. Effect of a plant extract mixture on growth performance of finishing pigs[1,2] .

Item	Treatment[3]					SEM	*P*-value
	1	2	3	4	5		
BW, kg							
d 0	46.87	47.92	45.96	46.70	46.83	1.94	0.99
d 21	67.33	67.36	67.24	67.07	66.80	2.28	1.00
d 42	87.43	88.40	89.84	88.43	87.47	2.56	0.82
d 65	108.00	109.20	109.96	110.37	110.07	2.97	0.97
Grower (d 0 to 21)							
ADG, kg	0.975	0.926	1.013	0.970	0.951	0.07	0.77
ADFI, kg	2.513	2.676	2.514	2.526	2.527	0.93	0.93
F/G	2.605	2.896	2.510	2.626	2.669	0.12	0.16
Finisher 1 (d 22 to 42)							
ADG, kg	0.957	1.002	1.076	1.017	0.984	0.06	0.43
ADFI, kg	2.697	2.868	2.672	2.536	2.656	0.18	0.77
F/G	3.006	3.068	2.688	2.577	2.852	0.29	0.63
Finisher 2 (d 43 to 65)							
ADG, kg	0.894	0.904	0.875	0.954	0.983	0.08	0.77
ADFI, kg	2.277	2.450	2.110	2.013	2.137	0.23	0.66
F/G	2.814	2.994	2.619	2.301	2.414	0.20	0.09
Overall (d 0 to 65)							
ADG, kg	0.941	0.943	0.985	0.979	0.973	0.04	0.87
ADFI, kg	2.548	2.720	2.473	2.351	2.472	0.19	0.68
F/G	2.708	2.884	2.511	2.402	2.541	0.19	0.11

[1]Data are least square means of 6 replicates per treatment.
[2]Plant extracts mixture composed of 40 g/kg of *Allium sativum*, 20 g/kg of *Glycyrrhiza glabra*, 20 g/kg of *Zingiber officinale*, and 20 g/kg of *Terminalia chebula*.
[3]Experimental treatments were: 1) Negative control (NC), 2) NC + 0.20% plant extracts mixture (Alphalean, AlphaSan Health Solutions, Belgium; PEM), 3) NC + 0.20% PEM from finisher 1 to finisher 2, 4) NC + 0.20% PEM in finisher 2, and 5) NC + 0.05% ractopamine-HCl (Paylean 20%, Elanco Animal Health, USA; RAC) in finisher 2.

family of compounds but is not used in any human medicine, it is altogether included in the ban with contrasting scientific and regulatory opinions regarding its safety. As a result, the use of RAC is not authorized in the European Union or China as a growth-promoting feed additive for swine, while it has regulatory approval in the United States, Canada, Brazil and the Philippines (de Almeida *et al*., 2012). Nevertheless, there is a need to identify and evaluate safe and effective alternatives to RAC.

To the best of our knowledge, this is the first study that evaluated the effect of PEM used in the current experiment. There is, however, some research on the effects of the individual plant extracts or other herbal mixtures. Garlic is the primary material used in PEM, which is known to possess potent anti-microbial properties for centuries (Bayan *et al*., 2014).

However, response to dietary garlic fed to growing-finishing pigs has been equivocal, with studies showing positive (Cullen *et al*., 2005), neutral (Chen *et al*., 2008), or even negative effects (Omojola *et al*., 2009) on growth rate or F/G. There are also other studies that evaluated different plant extract mixtures in growing-finishing pigs with contrasting results (Grela *et al*., 1998; Yan *et al*., 2011; Ahmed *et al*., 2016). In the present experiment, PEM did not affect growth performance in the grower and early finisher phases, but the positive effect observed on F/G when PEM was fed only in the late finisher phase suggests that extended feeding of PEM negatively affects the response. The contrasting responses observed among different studies are not fully understood but may be due to the complexity of interactions between plant-based extracts and the gut of the animal. Because bioavailability and complexity of interactions in the animal play very important roles in determining the dosage required of a plant-based extract to be given to an animal (Greathead, 2003), variation in performance may occur if these factors are unaccounted.

There were no significant differences in carcass characteristics among the treatments (Table 3). In previous studies, the fat-free lean percentage increased between 0.4 to 5.3% (Watkins *et al*., 1990; Brumm *et al*., 2004; Apple *et al*., 2007; Apple *et al*., 2008) and 10th-rib fat depth was reduced by 6% in pigs fed 10 ppm RAC compared with the untreated controls (Apple *et al*., 2007). The lack of any significant response to RAC in lean percentage

Table 3. Effect of a plant extract mixture on carcass characteristics of finishing pigs[1,2].

Item	Treatment[3]					SEM	*P*-value
	1	2	3	4	5		
Live weight, kg	115.4	115.0	112.9	116.8	115.5	2.82	0.89
HCW, kg	92.8	93.2	94.9	93.8	94.2	2.77	0.98
Carcass yield, %	80.4	81.0	84.1	80.2	81.5	1.27	0.22
Backfat thickness, cm							
First rib	3.50	3.58	3.19	3.39	3.04	0.31	0.61
Last rib	2.39	2.45	2.39	2.60	2.55	2.70	0.91
Last lumbar	1.75	1.89	1.68	2.10	2.14	3.07	0.65
Average	2.55	2.64	2.42	2.70	2.57	0.26	0.92
10th rib backfat depth, cm	16.1	15.8	16.1	17.8	21.2	2.02	0.17
Loin eye area, cm^2	20.9	20.3	20.7	22.0	21.1	2.08	0.98
SFFL[4], kg	48.72	48.93	43.90	49.06	47.57	1.53	0.62
SFFL, %	56.0	55.7	55.9	55.8	53.8	1.63	0.56

[1]Data are least square means of 6 replicates per treatment.

[2]Plant extracts mixture composed of 40 g/kg of *Allium sativum*, 20 g/kg of *Glycyrrhiza glabra*, 20 g/kg of *Zingiber officinale*, and 20 g/kg of *Terminalia chebula*.

[3]Experimental treatments were: 1) Negative control (NC), 2) NC + 0.20% plant extracts mixture (Alphalean, AlphaSan Health Solutions, Belgium; PEM) from Grower to Finisher 2, 3) NC + 0.20% PEM from Finisher 1 to Finisher 2, 4) NC + 0.20% PEM in Finisher 2, and 5) NC + 0. 05% ractopamine HCl (Paylean 20%, Elanco Animal Health, USA; RAC) in Finisher 2.

[4]SFFL = Standardized fat free lean.

and backfat depth may be related to the dose used in the experiment, as there is greater variation in the response to RAC when fed at 5 ppm compared with using at a higher dose (Apple *et al*., 2008). The recommended dose for RAC ranges from 5 to 20 ppm and in the present study, the lowest dose was used for practical and economic reasons (additional cost of 5 ppm RAC was +₱33,000 per ton of feed).

It was hypothesized that PEM improves carcass quality of finishing pigs. The plant extracts used were selected for potential carcass effects either by reducing lipid synthesis (Adetumbi *et al*., 1986), reducing serum triglycerides (Chan *et al*., 2013) or enhancing protein deposition (Nath *et al*., 2017). Previous studies with dietary garlic, despite its lipolytic properties, did not improve the carcass quality of finishing pigs (Cullen *et al*., 2005; Chen *et al*., 2008). Another plant extract mixture composed of pomegranate, Ginkgo biloba, and licorice at 0.40% of the diet negatively affected feed intake but increased lean percentage and reduced backfat of finishing pigs (Ahmed *et al*., 2016). The lack of an effect in neither carcass leanness nor backfat thickness of finishing pigs suggests that the PEM at the dose tested (0.20%) regardless of feeding duration does not affect carcass quality and therefore, may not be used as a carcass modifier in finishing pigs.

Within the conditions under which the study was conducted, it can be concluded that PEM at 0.20% of finishing pig diets does not affect growth performance and carcass characteristics. However, using PEM in the late finisher phase may replace the feed efficiency effects of ractopamine-HCl. Future research may focus on validating this response and testing the PEM at higher doses.

ACKNOWLEDGEMENT

The authors would like to acknowledge the support of VetNext Agri Products, Inc. for funding this study and RDF Feed, Livestock and Foods, Inc. for the use of their processing plant and assistance in carcass evaluation.

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