Supplementing volatile-flavour herbal-extract mixture to the diet of sows and their weaned offspring improves the growth performance of weaned piglets

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Abstract

A volatile herbal extract (VHE), consisting of 150 g/kg anethole, 15 g/kg bebaudioside A, 2.1 g/kg thymol, 2.0 g/kg eugenol and 2.3 g/kg cinnamic aldehyde, was fed to sows and their weaned offspring to evaluate its effect on the reproductive performance of sows and the growth performance of weaned piglets. A total of 18 sows (Landrace × Yorkshire) were randomly assigned to dietary treatments based on average parity (1.78) with nine replicates per treatment. The feeding period was 35 days, from d 7 before farrowing to d 7 after weaning. The lactation period was 21 d. A total of 96 piglets were randomly selected from each sow treatment group and allocated to 24 replicate pens with four pigs (mixed sex) per pen. The feeding period of weaned piglets was 35 days (phase 1, days 1-7; phase 2, days 8-21; phase 3, days 22-35). Dietary treatments in sows and weaned piglets consisted of a basal control diet with or without 500 mg/kg VHE. The data showed that VHE supplementation had no effect on the reproductive performance of sows, but improved the growth performance of weaned piglets, in which the increase of average daily gain during days 1-7 ($P=0.006$) and 1-35 ($P=0.032$) and feed efficiency during days 22-35 ($P=0.026$) and 1-35 ($P=0.020$) in weaned piglets were observed. Therefore, supplementing VHE to the diet of sows and their weaned offspring was beneficial to the growth performance of weaned piglets.

Keywords: swine, herbal extract, growth performance, prenatal flavour exposure

1. Introduction

Weaning is a challenging period in the modern swine industry and correct feeding and gut function is important to growth performance and welfare of the piglets (Val-Laillet *et al.*, 2016). Charal *et al.* (2016) have shown that feeding sows and their weaned offspring fed plant extracts can improve performance and facilitate weaning transition (Oostindjer *et al.*, 2011). However, information on supplementing mixed volatile herbal extracts (VHE) to the diet of sows and their weaned offspring is still limited.

The mixed VHE used in this study had a long-term odour and was composed of anethole, rebaudioside A, thymol,

eugenol, and cinnamic aldehyde. Positive effects of this mix on the growth and productive performance of pigs have been previously shown (Yan and Kim, 2012; Wang *et al.*, 2014; Diao *et al.*, 2015; Williams *et al.*, 2017; Yi *et al.*, 2021). The following trial determined whether supplementing VHE to the diet of sows during late-gestation and lactation and their weaned offspring could improve the reproductive performance of sows and the growth performance of weaned piglets.

2. Material and methods

The experimental protocol (DK-2-1913) was approved by the Animal Care and Use Committee of Dankook University (Cheonan, South Korea). The care and treatment of the

sows were according to the animal welfare legislation (Federation of Animal Science Societies, 2010).

Volatile herbal extract treatment

The VHE used in this study is obtained from a commercial company (Molimen, Barcelona, Spain / Nawbio Co., Ltd, Yongin, Korea). It consisted of 150 g/kg anethole, 15 g/kg bebaudioside A, 2.1 g/kg thymol, 2.0 g/kg eugenol, and 2.3 g/kg cinnamic aldehyde. The combination of the above substances has long-term odour, which has been classified as a flavouring agent.

Experiment design, animals and housing

A total of 18 sows (Landrace × Yorkshire) were randomly assigned to two treatments based on average parity (1.78). There were nine replicates per treatment. The feeding period was 35 d, from d 7 before farrowing to d 7 after weaning, with a lactation period of 21 days. After weaning, a total of 96 piglets were randomly selected from each group of sows and assigned to 24 replicate pens with four pigs (mixed sex) per pen. The feeding period of weaned piglets was 35 days (phase 1 1-7 d; phase 2 8-21 d; phase 3 22-35 d). Dietary treatments in sows and weaned piglets consisted of a basal diet with or without 500 mg/kg VHE. Dietary treatments were formulated to meet the recommendations of the NRC (2012) and provided in mash form (Table 1 and 2).

All sows were housed in a farrowing room on d 107 of gestation, which were equipped with auto-controlled heating and mechanical ventilation systems, with 2.20×1.60 m area individually for the 35 d feeding period. Sows were fed 3.8 kg/d of experimental feed from d 107 of gestation to farrowing and d 21 after farrowing to d 7 after weaning. During the lactation period (21 d), daily feed allowance was increased to 7 kg/d. Experimental feed was provided *ad libitum* from troughs as three equal meals per day.

Cross-fostering of piglets took place within two days of parturition and occurred only among the same experimental treatment of sows. The number of piglets per sow ranged from nine to 11 piglets and the numbers of weaned piglets were recorded. Piglets did not receive creep feed during the lactation period, and were subjected to routine management practices from three days after birth, including teeth clipping and tail docking, and received 1 ml iron dextran (50 mg/kg), and the male piglets were castrated.

In accordance with treatment group of the sows, 96 piglets that came from the same treatment were moved to an environment-controlled nursery barn allocated to 24 replicate pens with four pigs (mixed sex) per pen. The ambient temperature within the room was maintained

Table 1. Composition and nutrient levels of the experimental basal diet of sows (% , as-fed basis).

Items	
Ingredients, %	
Corn	34.01
Wheat	23.00
Rice bran	2.00
Wheat bran	8.31
Soybean meal	6.00
Dehulled soybean meal	12.96
Soybean oil	3.74
Molasses	2.00
Bakery by product	4.00
Limestone	1.23
Di-calcium phosphate	0.68
Salt	0.50
Threonine, 98%	0.05
Lysine, 25%	0.60
Choline chloride, 50%	0.12
Vitamin/mineral mixture ¹	0.80
Total	100.00
Analysed composition, %	
Digestible energy, MJ/kg	14.82
Crude protein	16.30
Crude fat	6.70
Crude ash	5.00
Crude fibre	3.60
Calcium	0.75
Phosphorus	0.54

¹ Provided per kilogram of complete diet: vitamin A, 10,000 IU; vitamin D3, 2,000 IU; vitamin E, 48 IU; vitamin K3, 1.5 mg; riboflavin, 6 mg; niacin, 40 mg; d-pantothenic, 17 mg; biotin, 0.2 mg; folic acid, 2 mg; choline, 166 mg; vitamin B6, 2 mg; and vitamin B12, 28 µg; Fe (as FeSO4·7H2O), 90 mg; Cu (as CuSO4·5H2O), 15 mg; Zn (as ZnSO4), 50 mg; Mn (as MnO2), 54 mg; I (as KI), 0.99 mg; and Se (as Na2SeO3·5H2O), 0.25 mg.

at 30 °C for the first week and reduced by 1 °C per week subsequently. The humidity was around 60%. The sows and piglets had free access to drinking water throughout the experimental period.

Sampling and measurements

The body weight and backfat thickness of sows were measured on d 107 of gestation, d 1 after farrowing, d 21 after farrowing (weaning day), and d 7 after weaning. A real-time ultrasound instrument (Piglot 105; SFK Technology, Herlev, Denmark) was used to determine the backfat thickness at the 6 cm from the mid-line at the 10th rib. Daily feed consumption was recorded to calculate the average daily feed intake (ADFI) for each sow. The number of piglets per sow was recorded at farrowing and weaning to evaluate survival rate. The number of piglets born and alive was recorded to calculate the stillbirth rate at farrowing. The individual body weight of suckling piglets was recorded on the birth day and weaning day to calculate the average daily gain (ADG). The return-to-oestrus interval was measured by the method of Wang and Kim (2019) for each sow up to 7 d after weaning. Sows not expressing oestrus within the week after weaning were assigned a value of 7 d return to oestrus (Wang and Kim, 2019).

Table 2. Composition and nutrient levels of the experimental basal diet of weaning pigs (% , as-fed basis).

Items	Phase 1 (days 1-7)	Phase 2 (days 8-21)	Phase 3 (days 22-35)
Ingredients, %			
Extruded corn	37.29	47.80	55.83
Dehulled soybean meal	12.00	18.00	24.00
Fermented soybean meal	10.00	8.00	5.00
Fish meal	7.60	2.70	-
Soy oil	3.13	3.20	3.25
Di-calcium phosphate	1.24	1.34	1.63
Limestone	0.60	0.74	0.82
Sugar	3.00	2.00	2.00
Whey protein	11.00	8.00	3.00
Lactose	12.80	6.70	3.00
L-Lysine-HCL	0.35	0.46	0.48
DL-methionine	0.18	0.17	0.19
L-threonine	0.21	0.29	0.20
Choline chloride 50%	0.10	0.10	0.10
Salt	0.10	0.10	0.10
Vitamin premix ¹	0.20	0.20	0.20
Mineral premix ²	0.20	0.20	0.20
Total	100.00	100.00	100.00
Analysed composition, %			
Digestible energy, MJ/kg	16.75	16.33	15.91
Crude protein	20.00	19.00	18.50
Crude fat	5.40	4.80	4.20
Calcium	0.80	0.75	0.75
Phosphorus	0.70	0.65	0.65
Lysine	1.60	1.50	1.40
Methionine	0.48	0.45	0.42
Lactose	20.00	12.00	5.00

¹ Provided per kilogram of complete diet: vitamin A, 11,025 IU; vitamin D3, 1,103 IU; vitamin E, 44 IU; vitamin K, 4.4 mg; riboflavin, 8.3 mg; niacin, 50 mg; thiamine, 4 mg; d-pantothenic acid, 29 mg; choline, 166 mg and vitamin B12, 33 µg.

² Provided per kilogram of complete diet: Fe (as FeSO₄·7H₂O), 80 mg; Cu (as CuSO₄·5H₂O), 12 mg; Zn (as ZnSO₄), 85 mg; Mn (as MnO₂), 8 mg; I (as KI), 0.28 mg and Se (as Na₂SeO₃·5H₂O), 0.15 mg.

After weaning, the body weight of weaned pigs was measured on days 1, 7, 21, 35 after weaning to calculate ADG. Pen-based feed consumption was calculated daily to measure the ADFI. Feed efficiency (as gain to feed ratio) was calculated using ADG and ADFI values.

Statistical analysis

All data were statistically analysed using the Student's t-test in SAS software (SAS version 9.4, 2014, SAS Inst. Inc., Cary, NC, USA). Each sow and each pen of weaned pigs were considered as the experimental unit. The data are presented as the means ± standard deviation. Values of $P < 0.05$ denoted statistical significance, while $0.05 < P < 0.10$ were considered as a trend.

3. Results and discussion

With regards to sows, supplementing VHE during late-gestation and lactation had no effect on body weight, back-fat thickness, average daily feed intake or litter size (Table 3), which agreed with the findings of Charal *et al.* (2016) and Moon (2017). They noted that dietary supplementation of aromatic substances only acted as a flavour, but did not affect the physical condition of the sows. Therefore, the reproductive performance of sows was considered not sensitive to the supplementation of VHE.

Table 3. Effects of supplementing a volatile herbal extract (VHE) mixture to the diet of sows on the reproductive performance of sows.¹

Items	VHE, mg/kg		P-value
	0	500	
Oestrus interval, days	5.44±1.51	4.44±0.53	0.122
Body weight, kg			
Day 7 before farrowing	210.30±22.66	208.30±20.49	0.845
Day 1 after farrowing	187.50±22.15	185.90±22.94	0.883
Weaning day	170.50±21.93	170.70±23.22	0.989
Day 7 after weaning	172.80±21.74	173.40±23.15	0.960
Back-fat thickness, mm			
Day 7 before farrowing	18.70±2.18	18.13±1.60	0.538
Day 1 after farrowing	16.53±3.12	16.21±2.01	0.798
Weaning day	14.49±2.96	14.41±2.02	0.949
Day 7 after weaning	15.13±2.93	15.11±2.10	0.986
Average daily feed intake, kg			
Conception	1.44±0.08	1.46±0.06	0.552
Lactation	6.89±0.18	6.94±0.14	0.509
Breeding interval	3.78±0.08	3.80±0.13	0.624
Litter size			
Number of piglets born	12.44±1.88	12.67±1.94	0.808
Number of piglets alive	11.78±1.72	12.00±1.80	0.792
Survival rate, %	94.90±6.99	95.00±6.21	0.977
Stillbirth rate, %	0.56±0.73	0.67±0.87	0.772
Birth weight, kg	1.41±0.21	1.43±0.22	0.814
Weaning weight, kg	6.01±0.62	6.18±0.66	0.586
Average daily gain, %	218.60±21.92	225.30±25.68	0.559

¹ Results were presented as mean ± standard deviation. Values represent the means of 9 pens (n=9) per treatment.

Weaned piglets receiving VHE had significantly higher ADG during d 1-7 ($P=0.006$) and 1-35 ($P=0.032$) and better feed efficiency during d 22-35 ($P=0.026$) and 1-35 ($P=0.020$). In addition, there was a tendency for improved ADG d 8-21 ($P=0.068$) and 22-35 ($P=0.068$), ADFI during d 1-7 ($P=0.068$) and 1-35 ($P=0.091$), and feed efficiency during d 1-7 ($P=0.067$) in the VHE supplemented group (Table 4).

VHE supplementation had positive effects on the growth performance of weaned piglets, which was consistent with the findings of Charal *et al.* (2016). They reported that feeding lactating sows and to weaned piglets with anise oil containing diet could increase ADG, ADFI, and feed efficiency in weaned piglets. In addition, Oostindjer *et al.* (2010) noted that feeding sows and their weaned offspring with anise extract containing diet increased growth performance of their weaned offspring, which was related to the promotion of feed intake. As reported by Oostindjer *et al.* (2009), the supplementation of olfactory test substances in sows and their weaned offspring could establish the flavour continuity around weaning, thus affecting feed intake. Feeding sows with flavoured diets during late-gestation and lactation has been reported to make offspring preference on the same flavour feed, thus stimulating intake (Hepper *et al.*, 2013). In this study, an increased tendency in ADFI in weaned piglets was observed, which could be partially linked to the increase in ADG. However, Oostindjer *et al.* (2010) showed that feeding flavoured diets to lactating sows and weaned piglets could reduce the stress around weaning in piglets. This could prevent the impairment of digestive and absorptive capacity induced by weaning events in pigs (Moeser *et al.*, 2017). Sun *et al.* (2019) reported that feeding sows and their weaned offspring with anise oil containing diet improved nutrient

digestibility and feed efficiency in weaned piglets. Therefore, supplementing VHE to the diet of sows during late-gestation and lactation and supplementing their weaned offspring was beneficial to promote the feed intake and feed efficiency of the piglets through the establishment of flavour continuity, thus improving ADG. Moreover, the ingredients in the VHE could play a role in improving digestion, stress status at weaning and gut health (Yan and Kim, 2012; Wang *et al.*, 2014; Diao *et al.*, 2015; Williams *et al.*, 2017; Yi *et al.*, 2021).

4. Conclusions

This study confirmed that supplementing VHE to the diet of sows and their weaned offspring was beneficial to the growth performance of weaned piglets, but did not affect the reproductive performance of sows. This resulted in better ADG in the piglets during weaning, which can be economically beneficial to the swine industry.

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Conflict of interest

The authors confirm that there are no conflicts of interest associated with this publication.

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Table 4. Effects of supplementing a volatile herbal extract (VHE) mixture to the diet of weaned piglets on the growth performance of weaned pigs.¹

Items	VHE, mg/kg		P-value
	0	500	
Average daily gain, g			
Days 1-7	215.00±23.17	230.60±21.45	0.006
Days 8-21	393.00±43.11	414.70±38.86	0.068
Days 22-35	514.50±72.51	545.60±66.71	0.068
Days 1-35	406.00±46.39	430.20±43.46	0.032
Average daily feed intake, g			
Days 1-7	240.30±24.17	253.40±24.75	0.068
Days 8-21	501.60±64.95	526.50±57.40	0.155
Days 22-35	741.70±88.99	771.90±82.50	0.149
Days 1-35	494.60±51.80	517.30±50.06	0.091
Gain to feed ratio			
Days 1-7	0.90±0.03	0.91±0.02	0.067
Days 8-21	0.79±0.03	0.79±0.02	0.593
Days 22-35	0.69±0.03	0.71±0.02	0.026
Days 1-35	0.82±0.02	0.83±0.02	0.020

¹ Results were presented as mean ± standard deviation. Values represent the means of 24 pens (n=24) per treatment for average daily gain, average daily feed intake, gain to feed ratio.

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