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THE EFFECT OF DIETARY SUPPLEMENTATION WITH A HERBAL PRODUCT, A BLEND OF ORGANIC ACIDS AND ZINC OXIDE ON NUTRIENT DIGESTIBILITY AND GROWTH PERFORMANCE IN WEANED PIGLETS

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K e y w o r d s: herbal product, organic acids, zinc oxide, nutrient digestibility, growth performance, weaned piglets.

A b s t r a c t

The objective of this study was to determine the effect of dietary supplementation with a blend of organic acids, zinc oxide and the B-Safe® herbal product on nutrient digestibility, nitrogen balance and growth performance in weaned piglets. Nutrient digestibility was determined by a simple balance method, on 24 weaners (PIC) with average body weight of 28 kg, divided into four groups of six animals each. A five-day experimental period was preceded by a seven-day adjustment period. A production trial was carried out on 1279 weaned piglets that were fed four experimental diets: a control diet without feed additives (*A*), a diet supplemented with a blend of organic acids at 5 kg t^{-1} (*B*), a diet supplemented with zinc oxide at 3 kg t^{-1} (*C*), and a diet supplemented with the B-Safe® herbal product at 3 kg t^{-1} (*D*). The experiment lasted 19 days. A mashed starter diet was offered *ad libitum*. The body weights of piglets and feed intake were determined at the beginning and at the end (day 19) of the experiment.

The inclusion of an organic acid blend, zinc oxide and the B-Safe® herbal product in weaner diets highly significantly improved the digestibility of crude protein, crude fat ($P \leq 0.01$) and organic matter ($P \leq 0.05$). Nitrogen retention was higher in weaners fed a diet supplemented with zinc oxide at 3 kg t^{-1} (group *C*) than in control group animals (20.15 vs. 17.59 g, $P \leq 0.01$). The feed conversion ratio (FCR) was highly significantly lower in weaned piglets fed zinc oxide or B- Safe® at 3 kg t^{-1}, compared with the control group (1.50 and 1.47 vs. 1.70 kg kg^{-1}).

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WPŁYW DODATKU PREPARATU ZIOŁOWEGO, MIESZANINY KWASÓW ORGANICZNYCH I TLENKU CYNKU NA STRAWNOŚĆ SKŁADNIKÓW POKARMOWYCH ORAZ WYNIKI ODCHOWU WARCHLAKÓW

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Słowa kluczowe: dodatki ziołowe, kwasy organiczne, tlenek cynku, strawność składników pokarmowych, wyniki odchowu, warchlaki.

Abstrakt

Celem doświadczenia było określenie wpływu dodatków: mieszaniny kwasów organicznych, tlenku cynku i preparatu B-Safe® na strawność składników pokarmowych, bilans azotu oraz wyniki produkcyjne warchlaków. Strawność składników pokarmowych określono za pomocą bezpośredniej metody bilansowej, na 24 warchlakach (PIC) o średniej masie ciała 28 kg, podzielonych na 4 grupy, po 6 sztuk w każdej. Pięciodniowy właściwy okres doświadczalny poprzedzono siedmiodniowym okresem przygotowawczym. Badaniami produkcyjnymi objęto 1279 warchlaków, u których zastosowano cztery mieszanki paszowe eksperymentalne: kontrolną bez dodatków paszowych (*A*), tę samą mieszankę paszową z dodatkiem kwasów organicznych, w ilości 5 kg t^{-1} (*B*), tlenek cynku w ilości 3 kg t^{-1} (*C*) i preparat B-Safe® w ilości 3 kg t^{-1} (*D*). Badania trwały 19 dni. Mieszankę starter zastosowaną w doświadczeniu wyprodukowano w formie sypkiej i podawano prosiętom *ad libitum*. Na początku i na końcu doświadczenia (19 dzień) mierzono masę ciała warchlaków. Analizowano również ilość pobranej mieszanki paszowej.

Suplementacja dawki pokarmowej dla warchlaków dodatkiem: mieszaniny kwasów organicznych, tlenku cynku oraz preparatu B-Safe® wysoce istotnie poprawiła strawność białka ogólnego, tłuszczu surowego ($P \leq 0{,}01$) i substancji organicznej ($P \leq 0{,}05$). Stwierdzono wysoce istotną (20,15 vs 17,59 g, $P \leq 0{,}01$) poprawę retencji azotu u zwierząt otrzymujących w diecie dodatek tlenku cynku (*C*) w ilości 3 kg t^{-1} w stosunku do warchlaków z grupy kontrolnej. Świnie otrzymujące dodatek tlenku cynku lub produktu B-Safe® w ilości 3 kg t^{-1} charakteryzowały się wysoce istotną poprawą wykorzystania paszy na kg przyrostu (1,50; 1,47 vs 1,70 kg kg^{-1}) w stosunku do zwierząt z grupy kontrolnej.

Introduction

A ban on the use of antibiotic growth promoters (AGPs) in animal feed entered into effect in the European Union on 1 January 2006 (VONDRUSKOVA et al. 2010). The ban was introduced, among others, due to concerns about the emergence of multiple drug-resistant bacteria in the digestive tract of farm animals and the possibility of cross-resistance with therapeutic antibiotics used in humans (RIEMENSPERGER et al. 2012, THACKER 2013). The economic effects of the ban on AGPs in livestock production include reduced growth rate and deterioration in animal health (CASEWELL et al. 2003, GRELA and SEMENIUK 2006). Recent years have witnessed an increasing interest among food producers, animal breeders and farmers in natural feed additives as alternatives to AGPs (VERSTEGEN and WILLIAMS 2002). Growing consumer

awareness of food safety and quality issues, including the health benefits and quality of animal products, is also an important consideration (MONTESISSA and CALINI 2006).

Feed additives used in pig diets include organic acids, phytobiotics and microelements such as zinc (THACKER 2013), which can positively affect gut microbiota thus improving nutrient digestibility and increasing productivity (PETTIGREW 2006, VONDRUSKOVA et al. 2010). Organic acids are found naturally in herbs and animal tissues. They exert bacteriostatic effects by maintaining a low pH of the digesta, which prevents the colonization of the gastrointestinal tract by pathogens (KIL et al. 2006, COSTA et al. 2013). They also reduce the risk of diarrhea and improve nutrient utilization (LALLES 2008, GERRITSEN et al. 2010). Zinc oxide has also been shown to increase daily gains and reduce the incidence of intestinal diseases in weaned piglets (SHELTON et al. 2011, PIEPER et al. 2012, HU et al. 2013). Herbal extracts improve nutrient digestibility and utilization, and exhibit antibacterial and antioxidant properties thus increasing livestock production efficiency (WANG et al. 2007, LIU et al. 2008, COSTA et al. 2013).

The aim of this study was to determine the effect of dietary supplementation with a blend of organic acids, zinc oxide and the B-Safe® herbal product on growth performance and nutrient digestibility in weaned piglets.

Materials and Methods

The experiment was conducted on a commercial pig farm. The experimental materials comprised weaned piglets of a PIC line, divided into four groups with eight replicates per treatment and 34 to 44 animals per replicate. The weaners were kept on a slatted floor, in a building equipped with an automatic feeding system and mechanical ventilation. The animals had free access to feed and water. After weaning, the piglets were weighed and allocated to dietary treatment groups by body weight and sex.

The weaners were fed a mashed starter diet formulated to meet their nutrient requirements (Table 1). The control diet contained maize grain, wheat grain, barley grain, soybean meal, soybean oil, Specilac (a product containing modified soybean protein), and a premix. The diet fed to control group *A* did not contain feed additives affecting gut microflora. The diet for experimental group *B* was supplemented with a blend of organic acids (propionic, formic, fumaric, lactic and citric) and their salts at 5 kg t^{-1} feed. The diet for experimental group *C* was supplemented with zinc oxide at 3 kg t^{-1} feed. Group *D* animals were fed a diet supplemented with the B-Safe® herbal product (3 kg t^{-1} feed) that contains plant extracts and synthetic clays

(*Satureja montana* leaves, chestnut tannins, *Trigonella foenum graecum*, mineral clays (sepiolite & zeolite), copper sulfate, vegetable oil, limestone, dextrose, soft wheat white shorts, clays (E 562, E554) and chicory pulp as processing aids).

Table 1

Composition and nutritional value of the control diet

Specification	Starter
Maize [%]	25.0
Wheat [%]	20.0
Barley [%]	15.0
Soybean meal [%]	24.0
Specilac (soybean replacer) [%]	5.0
Soybean oil [%]	1.0
Starter premix* [%]	10.0
Nutritional value	
Metabolizable energy [MJ/kg]	13.6
Crude protein [%]	20.5
Lysine [%]	1.36
Methionine+cystine [%]	0.76
Threonine [%]	0.84
Tryptophan [%]	0.25
Calcium [%]	0.80
Digestible phosphorus [%]	0.40
Sodium [%]	0.15

* crude protein – 12.5%, Ca – 5.8%, P – 2.1%, Na – 1.5%, lysine – 3.6% methionine – 1.2%, threonine – 1.4%, lactose – 25.0%, Vit. A – 200 000 IU, Vit. D_3 – 20 000 IU, Vit. E – 1 400 mg, Vit. K_3 – 30 mg, Vit. B_1 – 30 mg, Vit. B_2 – 80 mg, Vit. B_6 – 60 mg, Vit. B_{12} – 0.5 mg, niacin 400 mg, pantothenic acid – 200 mg, folacin – 40 mg, biotin – 2 mg, choline chloride – 6 000 mg, Zn – 1 400 mg, Mn – 800 mg, Cu – 1 600 mg, Fe – 1 500 mg, J – 12 mg, Co – 6 mg, Se – 3 mg, antioxidant (+), xylanase + β-glucanase + phytase (+)

The body weights of piglets and feed intake were determined at the beginning and at the end (day 19) of the experiment. The data were used to calculate feed conversion ratio (FCR) measured as kg feed intake per body weight gain. The nutrient content of diets was determined by the Weende analysis (AOAC 2000). The chemical composition of diets is presented in Table 2.

Table 2

Chemical composition of experimental diets

Specification	Diets			
	A	*B*	*C*	*D*
Dry matter [%]	88.96	88.65	88.69	88.87
Crude ash [%]	4.93	5.37	5.45	4.74
Crude protein [%]	21.25	21.71	21.08	21.27
Ether extract [%]	4.32	4.31	4.25	3.94
Crude fiber [%]	3.02	2.86	3.02	2.65
N-free extracts [%]	55.44	54.4	54.89	56.27

Nutrient digestibility was determined by a simple balance method, on 24 weaners with average body weight of 28 kg, divided into four groups of six animals each. The animals were kept in individual metabolism cages. A five-day experimental period was preceded by a seven-day adjustment period. The weaners were fed twice daily, at 7.00 a.m. and 3.00 p.m., and they had free access to drinking water.

The results were processed statistically by one-way ANOVA and Duncan's test. Arithmetic means (x), standard errors of the mean (SEM) and significance level (P) were determined. All calculations were performed using STATISTICA 10 software.

Results and Discussion

The coefficients of nutrient digestibility are shown in Table 3. Dietary supplementation with a blend of organic acids, zinc oxide and the B-Safe® herbal product had a statistically significant effect on nutrient digestibility. The tested supplements highly significantly ($P \leq 0.01$) improved the digestibility of total protein (by 2.5, 2.6 and 3%, respectively) and crude fat (by 19.6, 23.8, 24.7%, respectively), compared with the control group. No significant differences were noted between groups in the digestibility of crude fiber and N-free extractives. Different results were reported by GERRITSEN et al. (2010) who supplemented weaner diets with a blend of organic acids (formic, propionic, lactic, citric and sorbic). The cited authors demonstrated that the diet containing organic acids improved crude fiber digestibility, in comparison with the control diet (25.7 vs. 22.7%, $P \leq 0.01$), but organic acids had no effect on the digestibility of crude protein and crude fat. In a study by HAN and THACKER (2009), the digestibility of crude protein and dry matter did not increase in response to zinc oxide added to weaner diets at 1500 mg kg^{-1} and 2500 mg kg^{-1}.

In our study, the digestibility of organic matter improved significantly in weaned piglets fed diets with the tested feed additives (83.0; 83.0; 83.1 vs. 82.0%, $P \leq 0.05$). An increase in organic matter digestibility in pigs weighing 22 to 45 kg fed diets supplemented with lactic acid and formic acid (82.47; 82.66 vs. 81.80% $P \leq 0.05$) was also reported by JONGBLOED et al. (2000).

An analysis of nitrogen balance (Table 3) revealed that zinc oxide at 3 kg t^{-1} contributed to a highly significant increase in nitrogen retention, in comparison with the control group (20.15 vs. 17.59 g). Diet supplementation with zinc oxide increased the efficiency of nitrogen utilization relative to nitrogen intake and digestion, but the noted differences were statistically non-significant.

Table 3

Apparent fecal digestibility coefficients and N-balance

Specification	Control *A*	Organic acids *B*	Zinc oxide *C*	B-Safe® *D*	SEM	*P*
Digestibility coefficients	–	–	–	–	–	–
Crude protein [%]	75.9^{B}	78.4^{A}	78.5^{A}	78.9^{A}	0.22	0.006
Ether extract [%]	55.1^{B}	74.7^{A}	78.9^{A}	79.8^{A}	0.55	0.004
Crude fiber [%]	36.8	41.2	38.8	40.8	0.25	0.234
N-free extractives [%]	89.2	88.5	89.3	88.5	0.29	0.291
Organic matter [%]	82.0^{b}	83.0^{a}	83.0^{a}	83.1^{a}	0.22	0.002
Nitrogen balance	–	–	–	–	–	–
Retention [g]	17.59^{B}	18.83	20.15^{A}	18.65	0.12	0.009
N utilization/N intake [%]	45.9	46.2	49.7	46.4	0.35	0.125
N utilization/N digestion [%]	61.0	58.0	63.7	61.6	0.48	0.339

a, b – $P \leq 0.05$
A, B – $P \leq 0.01$

The results of a growth trial are summarized in Table 4. The average initial body weight of weaned piglets in all groups was around 9.5 kg. After 20 days of the experiment, higher body weights were determined in animals fed diets supplemented with a blend of organic acids (16.54 kg), zinc oxide (17.17 kg) and the B-Safe® herbal product (17.08 kg), compared with the control group, but the observed differences were not confirmed by a statistical analysis. Body weight gains tended to increase in experimental groups, in comparison with the control group (380, 404 and 395 vs. 355 g/day). Despite an absence of significant differences between groups, the inclusion of zinc oxide and B-Safe® in weaner diets contributed to higher weight gains.

Table 4

Growth performance of weaned piglets during the starter phase

Specification	Control 5 kg t^{-1}	Organic acids 3 kg t^{-1}	Zinc oxide 3 kg t^{-1}	B-Safe® 3 kg t^{-1}	SEM	*P*
No. of pigs	319	312	328	320		
Initial body weight [kg]	9.50	9.38	9.37	9.59	0.181	0.975
Final body weight [kg]	16.51	16.54	17.17	17.08	0.358	0.884
Feed intake [g d^{-1}]	580	570	589	565	11.939	0.906
Daily gain [g d^{-1}]	355	380	404	395	9.448	0.283
FCR [kg kg^{-1}]	1.70^{Aa}	1.53^{b}	1.50^{B}	1.47^{B}	0.026	0.004
Mortality [%]	2.53	1.56	1.89	1.57	0.408	0.834

a,b – $P < 0.05$

Our results corroborate the findings of HU et al. (2013) who observed a significant difference in final body weight between weaners fed zinc oxide at 2250 mg kg^{-1} for 14 days and control group animals (10.11 vs. 9.62 kg, $P \leq 0.05$); the average initial body weight of piglets was 6.12 kg. In a study by RIEMENSPERGER et al. (2012), piglets weaned at 28 days of age were fed a diet supplemented with a blend of formic, acetic and propionic acids, which resulted in a highly significant difference in final body weight (day 56) between experimental and control animals (37.71 kg vs. 35.54 kg, $P \leq 0.01$). There was also a significant difference in daily gains, determined during the entire experiment, between weaners fed a blend of organic acids and their control counterparts (516 vs. 483 g/day). SHELTON et al. (2011) observed a significant difference in final body weight (day 42 of the experiment) between weaned piglets receiving zinc oxide at 3,000 mg kg^{-1} and control group animals (26.2 vs. 24.6 kg, $P \leq 0.05$). The above authors noted also a significant ($P \leq 0.05$) difference in average daily gains, which reached 473 and 440 g in the experimental and control group, respectively.

In the present study, average daily feed intake was comparable in all animals, at 580 g in the control group, 570 g in group *B* fed a diet supplemented with organic acids, 589 g in group *C* fed zinc oxide, and 565 g in group *D* that received the B-Safe® herbal product.

Control group animals were characterized by the highest FCR – 1.70 kg kg^{-1}. The inclusion of organic acids in weaner diets (group *B*) improved FCR (1.53 vs. 1.70 kg kg^{-1}, $P \leq 0.05$), compared with the control group. The lowest FCR was noted in piglets fed zinc oxide (group *C*) and B-Safe® (group *D*) at 3 kg t^{-1} (1.53 and 1.48 vs. 1.70 kg kg^{-1}, $P \leq 0.01$). HAN and THACKER (2010) demonstrated that FCR decreased in weaned piglets fed 1500 mg kg^{-1} ZnO, but the difference relative to the control group was not statistically significant (1.50 vs. 1.55 kg kg^{-1}). RIEMENSPERGER et al. (2012) did not observe significant differences in FCR between groups, either, but in their study FCR was lower (1.99 kg kg^{-1}) in weanlings fed an organic acid blend than in animals fed a diet without feed additives (2.04 kg kg^{-1}).

Dietary treatments had no effect on the health status and mortality rates of weaned piglets.

Conclusions

The inclusion of an organic acid blend, zinc oxide and the B-Safe® herbal product in weaner diets highly significantly improved the digestibility of crude protein, crude fat ($P \leq 0.01$) and organic matter ($P \leq 0.05$). Nitrogen retention was highly significantly higher in weaners fed a diet supplemented with zinc

oxide at 3 kg t^{-1} (group *C*) than in control group animals (20.15 vs. 17.59 g, $P \leq 0.01$). FCR was highly significantly lower in weaned piglets fed zinc oxide or B-Safe® at 3 kg t^{-1}, compared with the control group (1.50 and 1.47 vs. 1.70 kg kg^{-1}).

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