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ORIGINAL PAPER

EFFECT OF THE SUPLEMENTATION OF MEDIUM-CHAIN FATTY ACIDS TO MIXTURES CONTAINING ZINC OXIDE NANOPARTICLES ON THE GROWTH PERFORMANCE AND SELECTED BIOCHEMICAL PARAMETERS OF BLOOD SERUM IN PIGS*

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Abstract

Piglets around weaning are susceptible to diarrhoea. One of the feed additives which have a beneficial effect on animals are MCFA. These substances can affect the gastrointestinal tract microflora, performance of animals and regeneration of the epithelium. The aim of the experiment was to determine the effect of feed supplementation with MCFAs at different concentrations in mixtures containing nano-ZnO zinc oxide nanoparticles on the growth rate and selected physiological indices. Piglets were assigned to four experimental groups, 115 animals on average in each treatment group. The animals were fed a prestarter diet from the 10 to 45 day of life and a starter diet from the 46 to 75 day of life. The preparation containing nano-ZnO (in an amount corresponding to 0.033%) was given to all the groups as the source of zinc and as an antidiarrhoeal agent. The feed mixtures offered to the piglets differed in the level of MCFAs. Control group I received a diet without MCFAs, while the animals of groups II, III and IV were fed mixtures supplemented with MCFAs in concentrations 0.1, 0.2 and 0.3%. The piglets and weaners fed diets supplemented with MCFAs at 0.1 and 0.2% showed a higher body weight ($p < 0.05$) at 45 and 75 day of life, and a higher feed intake from 28 to 45 day of life in comparison with the control and piglets from the experimental group given 0.3% of medium-chain fatty acids. The addition of MCFA to a feed had no significant effect ($p > 0.05$) on feed conversion in the experimental groups. The use of MCFAs at these levels increased nitrogen utilization and depressed the blood serum haptoglobin concentration connected with an inflammatory pro-

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cess. Application of these acids limited the incidence of diarrhoea, but did not affect the colour and consistency of faeces.

Keywords: medium-chain fatty acids, growth rate, diarrhoea, piglets, blood biochemical parameters.

INTRODUCTION

Piglets around weaning are at a higher risk of intestinal disturbances, which can be manifested by more frequent diarrhoea. Different solutions have been used to counteract it and reduce the incidence of diarrhoea. Prestarter diet supplementation with ZnO at pharmacological doses is one such measure. However, the use of this method is limited by many regulations (Commission Regulation (EU) No. 1095/2016 of 6 July 2016). Our earlier studies indicated that the addition of a ZnO nanoparticle preparation (nano-ZnO) at a level of 0.033% to prestarter feed mixtures could be an alternative to the supplementation of therapeutic doses of ZnO (SZUBA-TRZNADEL et al. unpublished data). Supplementation of MCFAs is another method for increasing the efficiency of the digestive tract in piglets during the weaning period. At present, a range of preparations more or less eliminating this negative phenomenon is available.

MCFAs acidify the digestive tract, which is beneficial for the development of symbiotic microflora (GEDEK et al. 1992, PARTANEN, MROZ 1999, ZENTEK et al. 2013). These acids are absorbed from the small intestine directly to the circulation, and are then transported to the liver, where they are subject to β-oxidation. Via oxidation they become a source of energy, which is quickly utilized by the young animal's body (SZEWCZYK, HANCZAKOWSKA 2010). The acids also exhibit strong bactericidal action (SKRIVANOWA et al. 2006, HEJDYSZ et al. 2012), especially towards *Escherichia coli* (BERGSSON et al. 2001). In addition, they increase feed conversion and absorption of nutrients in the small intestine (RÓŻAŃSKI, DRYMEL 2009), and improve the regenerative capacity of the small intestine epithelium (TANG et al. 1999). Other studies (MARION et al. 2002) indicated that in piglets on the third day after weaning, the height of the intestinal villi was reduced by as much as 59% compared to the pre-weaning value. MCFA supplementation limited reduction in the length of villi, thus increasing the absorption of nutrients, which was reflected by an improvement of production indices.

Some problems using feed supplementation with MCFAs can be related to their level in the dose. Studies by CERA et al. (1989) indicated that an excessivley high contribution of MCFAs causes deterioration of feed flavour and decreases its intake, thus reducing animal production parameters.

The aim of the present study was to determine the best level of MCFAs (contributing to better production and physiological indices) as a supplement to feeds for piglets and weaners. Furthermore, a constant and equal supplement of ZnO (nano-ZnO) was also used to reduce diarrhoea in the piglets.

MATERIAL AND METHODS

The experimental design, animal housing and experimental feed mixtures

The experiment was performed in separate locations on a pig farm, where it was included in the normal day-to-day production cycle conducted on the farm in compliance with all the applicable guidelines of animal husbandry and veterinary care.

The study was carried out on Polish Large White (wbp) x Polish Landrace (pbz) piglets born to 40 sows and included in the experiment from birth. They were allocated to 4 experimental groups (in each 115 animals on average, the male to female ratio 55:45) and offered feeds of different compositions.

On the second day of life, the piglets were weighed and runts were removed, which is a standard procedure at this farm. The remaining piglets designated for rearing were individually marked with an ear tag (each group having a different colour of the ear tag). On the same day, the piglets were administered iron via an intramuscular injection. All the animals were maintained under similar conditions i.e. in the same farrowing facility and then weaner facility. The veterinary procedures were identical for all the animals.

The suckling piglets remaining with the nursing sows were offered prestarter feed mixtures beginning from 10^{th} day of life (Table 1). The piglets were fed prestarter diets until weaning (28^{th} day of life) and the feeding was continued until 45^{th} day of life. When the piglets were maintained in the farrowing facility, the prestarter feed mixtures were given with the use of a cup feeder. The feeders were cleaned every 8 hours to eliminate bacterial contamination of the feed. After transferring the animals to the weaner facility, from 45^{th} until 75^{th} day of life, all the groups were fed starter diets according to the experimental design (Table 1). The feed mixtures were available *ad libitum* from self-feeders. The weaners had constant access to waterers with the controlled flow of water, adjusted to their needs.

All the feed mixtures were produced in the form of fine granulate in a commercial feed manufacturing plant. The preparation which contained zinc oxide nanoparticles (nZnO) was added to all the feed mixtures at the level of 330 g $t^{-1}$of feed, as the source of zinc and as an antidiarrhoeal agent. The feed mixtures offered to the piglets differed in the level of MCFAs. Feed mixture I (control) did not contain MCFAs. Groups II, III and IV were provided feed mixtures supplemented with increasing content of MCFAs: 1000, 2000 and 3000 g t^{-1}, respectively. ZnO nanoparticles were supplemented to experimental feeds in the form of the preparation Adizox®, while medium-chain fatty acids were derived from the Fortibac® preparation. Both preparations were produced by the Delacon Poland Sp. z o.o. (www.delacon.pl).

The prestarter and starter feed mixtures were prepared according to the experimental design. The nutritional value of prestarter and starter mixtures (Table 1) complied with the Polish Nutrient Requirements of Swine

Table 1

Composition and nutritive value of basic prestarter and starter mixtures

Specification (%)	Experimental mixtures	
	prestarter	starter
Extruded wheat	51.2	-
Extruded soya	10.4	-
Wheat	10.0	10.0
Barley	10.0	15.0
Maize	-	25.0
Triticale	-	24.9
Dry whey	5.5	-
Fish meal (> 65% CP)	5.0	-
Soya bean meal (46% CP)	2.9	18.0
Fodder yeast	-	3.0
Fodder salt (NaCl)	-	0.1
Premix*	5.0	-
Premix**	-	4.0
Nutritive value (in 1 kg of mixture):		
Metabolic Energy (MJ)	14.9	13.1
Crude protein (g)	180	170
Calcium (%)	0.83	0.80
Total phosphorus (%)	0.59	0.66
Lysine (%)	1.36	1.38
Methionine with cystine (%)	0.80	0.86
Threonine (%)	0.89	0.84
Tryptophan (%)	0.26	0.20
Zinc (Zn) (mg)	157	150

* Content of Premix 5% (in 1 kg): in %: Ca 11.60, P 2.00, Na 2.35, lysine 9.90, methionine 3.00, threonine 5.00, tryptophan 0.80%; in IU.: Vit. A 400 000; Vit. D_3 40 000; in mg: Vit. E 3 000, Vit. K 100, Vit. C 2 000, Vit. B_1 70, Vit. B_2 140, Vit. B_6 100, niacin 600, folic acid 60, pantothenic acid 300, choline 10 400; in mcg: Vit. B_{12} 1 200, biotin 5 000; in mg: Mn 1 200, Fe 3 000, Cu 3 000, I 20; in mcg: Se 9 000.

** Content of Premix 4% (in 1 kg): in %: lysine 11.5, methionine 4.5, threonine 5.0, P 3.5, Na 4.5, Mg 1.0; in IU: Vit. A 400 000, Vit. D_3 50 000; in mg: Vit. E 3 500, Vit. K 100, Vit. B_1 100, Vit. B_2 250, Vit. B_6 200, niacin 900, folic acid 75, calcium panthoteicum 625, choline, 10 000; in mcg: Vit. B_{12}, 1 100, biotin 5 000; in mg: Mn 2 000, Fe 3 500, Cu 4 000, I 30, Co 20, Se 10.

(1993). All feeds had isoenergetic and isoprotein composition. Zn levels in the prestarter and starter feed mixtures were 150 mg kg^{-1}, which complied with the maximum permissible level of zinc (Commission Regulation (EU) No. 1095/2016 of 6 July 2016).

On 19^{th} day of life the piglets were injected with the second dose of iron. On 28^{th} day of life, all the piglets were weighed and transferred to a weaner facility (by analogy, they were assigned to 7 pens for each group). On 45^{th} day of life, all the weaners were weighed again.

The experiment was continued until 75^{th} day of life, when the animals were assigned for fattening. On that day, all the animals were weighed, the feed conversion rate was calculated and the losses of animals were counted.

Sampling and measurements

During the experiment, animals were weighed on 2^{nd}, 28^{th}, 45^{th} and 75^{th} day of life. The exact intake of the prestarter feed mixtures until weaning (on 28^{th} day of life) and after weaning (from 29^{th} to 45^{th} day of life) and starter mixtures (from 46^{th} to 75^{th} day of life) was recorded. Moreover, feed conversion rates were calculated for each pen. During the experiment, cases of diarrhoea, culled or dead animals were also registered. During the weaning period, the incidence and duration of diarrhoea caseswere noted. Beside recording the cases of diarrhoea, fecal consistency was determined based on the German score methodology developed in the GRUB Institute near Monachium. It is based on the description of fecal consistency on a 5-degree scale, as: hard (1), compact (2), normal (3), soft (4) and watery (5).

On 45^{th} day of life, blood samples were collected from the jugular vein (*vena jungularis externa*) from 10 animals per group in order to determine biochemical indicators (glucose, alkaline phosphatase, urea, haptoglobin) of the health status of the animals. The blood serum was used to plot a proteinogram (total protein and albumins) and to determine the content of zinc according to the standard procedure.

Chemical analysis

The analysis of the basic feed mixtures was carried out by standard methods of the Association of Official Analytical Chemists (2012).

The zinc (Zn) content in the mixtures was determined after dry mineralization by atomic absorption spectrometry using an atomic absorption spectrometer Varian AA240FS.

Blood samples were collected from the *vena jugularis externa* into serum tubes for determinations of total protein and its fractions. The blood zinc concentration was assayed on an atomic absorption spectrometer Varian AA240FS. The level of total protein was estimated with the BCA test, and its fractions such as albumins, α-, β- and γ-globulins were assayed using the filter paper electrophoresis method. Aditionally, the haptoglobin level was assessed by the guaiacol test (Jones, Mould 1984). Using a Pentra 400 analyzer (Horiba ABX Diagnostics, Fraction), alkaline phosphatase (ALP) activity was determined by a kinetic method, glucose (PAP) concentration was measured by a colorimetric method with glucose oxidase and, the urea level was determined by a colorimetric method using Pentra reagents (ALP – cat. no. A11A01654, PAP – cat. no. A11A01668; Urea CP – A11A01641) in order to estimate the nitrogen balance.

Statistical analysis

The results calculated as the means for each pen were analyzed by one-way ANOVA using Statistica 12 (Statsoft Inc. 2014). The significance of differences between the experimental groups was evaluated by the Duncan's test. The following experimental model was applied:

$$y_{ij} = \mu + a_i + e_{ij},$$

where: y_{ij} is the observed dependent variable, μ – the mean for general population, a_i – the effect of the feeding group and e_{ij} – the effect of random factors.

RESULTS AND DISCUSSION

The productive performance data for the piglets and weaners are presented in Table 2. The growth rate of the piglets until weaning (28th day of life) was very similar, ranging from 225 g to 245 g per day. A slightly lower feed intake in group I did not have a significant effect on body weight (BW) at weaning. In the later period, (from 29th to 45th day of life) the growth rate showed greater diversity. The animals from groups II and III showed a significantly better weight gain (323 g and 332 g per day, respectively) than those from groups I and IV (294 g and 288 g per day, respectively). These

Table 2

Performance of piglets (n = 7)

Specification	Treatments				p-value
	I - control	II	III	IV	
Number of piglets, head/ treatment					
live born	115	114	118	114	
on 28th day	107	107	110	107	
on 45th day	103	104	107	105	
on 75th day	103	104	106	104	
Average body weight (kg)					
on 2nd day	1.60±0.57	1.47±0.39	1.58±0.49	1.60±0.52	0.89
on 28th day	7.50±1.16	7.80±1.07	7.95±1.03	7.60±1.17	0.75
on 45th day	12.50a±0.92	13.30b±0.90	13.60b±0.88	12.50a±0.92	0.01
on 75th day	29.50a±2.96	31.12b±0.73	31.50b±1.29	30.00a±2.26	0.03
Daily gain (g)					
2nd to 28th day	225±23.34	243±26.42	245±22.66	230±28.02	0.18
29th to 45th day	294a±45.66	323b±29.89	332b±27.55	288a±35.86	0.01
46th to 75th day	567±43.35	594±46.23	596±45.25	580±49.41	0.67
29th to 75th day	468±68.76	496±25.43	501±41.87	476±65.39	0.20
Feed intake, kg/head					
to 28th day of life	0.25±0.05	0.30±0.09	0.30±0.08	0.30±0.08	0.17
from 29th to 45th	8.71a±0.70	9.30b±0.49	9.60b±0.85	8.57a±1.01	0.01
from 46th to 75th day	32.20±2.19	31.50±1.98	32.05±1.42	31.50±2.05	0.61
Feed conversion ratio, kg^{-1} kg^{-1} BW					
from 29th to 45th day	1.74±0.08	1.69±0.09	1.70±0.10	1.75±0.07	0.75
from 46th to 75th day	1.89±0.29	1.80±0.28	1.79±0.25	1.80±0.27	0.98

Means with different subscripts within a row significant at: a, b – $p \leq 0.05$.

results can be attributed to a significantly better feed intake by the group II and III animals, which were on average from 0.59 kg per animal to 0.73 kg per animal higher than in groups I and IV. It can be expected that a greater feed intake in these groups and the subsequent higher growth rate were dependent on the experimental factors. In addition, feed conversion efficiency was also found to be higher in groups II and III, where the rates reached 1.69 kg kg^{-1} and 1.70 kg kg^{-1}, respectively. Therefore, the best productive performance in piglets was achieved with an MCFA supplement to feed at a concentration of 0.1% to 0.2%.

The lower feed mixture intake and related reduced growth rate in group IV, which received 0.3% MCFAs in the feed, can be explained by the worse palatability of the feed (CERA et al. 1989, MABAYO et al. 1992). The reduced intake of feed supplemented with 0.3% MCFAs could result from the excessive concentration of cholecystokinin and other hormones causing superfluous feeling of satiety. This was demonstrated by studies of HEJDYSZ et al. (2012), who observed that an excessively high level of MCFAs in feed limited its intake. However, there are also reports indicating that MCFAs only slightly affect cholecystokinin secretion (SYMERSKY et al. 2002). Overall, the results obtained in the period from 29th to 45th day of life revealed that the MCFA level had a significant effect on the digestive processes in the piglets.

The results can be compared with the ones reported by KUANG et al. (2015), who analyzed effects of feed additives (ZnO and MCFAs) separately on 21 or 28 day of life. According to their study, the weaning of piglets at 28th day of life did not affect performance parameters in the following weeks after separating the animals from sows. When piglets were weaned on 21st day of life, the cited authors obtained similar results as in our experiment. Application in feed MFCA preparation (3 kg t^{-1}) significant increased body weight and feed intake in each from 4 weeks after weaning in comparison with group of piglets received ZnO. However, according to our experiment, an excess of MCFAs (exceeding 2 kg t^{-1} of feed) in combination with ZnO negatively affects the body weight of animals. ZENTEK et al. (2011) also mention that MCFAs when used in rat nutrition in amounts exceeding 15% of required metabolic energy or 50% of total fat may have a weakly toxic effect. In a study of KUANG et al. (2015) better feed conversion in the first week was noted for a group fed a diet with MCFAs. In our experiment no such difference was observed. In turn, HANCZAKOWSKA et al. (2011), supplementing a feed for piglets with caprylic or capric acid or their mixture from 7th day of life and separating them from sowso on 35th day, observed at that stage a difference in body weight reaching 1-2 kg in comparison with the control group. The difference in body weight conttinued to increase until the end of the experiment. No differences between groups in FCR were noted. DIERICK et al. (2002) observed a 10% increase of average daily gains of body weight when modified MCTAG oil was used as a source of MCFAs in comparison with coconut or soybean oil.

In the later period, from 46th to 75th day of life, the growth rate of the weaners equalised in all the groups. Daily weight gains (DWG) in animals in this period ranged from 476 g to 501 g with no significant differences. The intake of the feed mixtures in all the groups per one pig was very similar, ranging from 31.5 kg to 32.2 kg. Therefore, it can be concluded that MCFA supplementation in the second nutritional stage had no significant effect on the productive performance data. However, the impact of MCFAs in the pre-weaning period, produced a significant effect on the final BW of the weaners on 75th day of life. The BW of the weaners at the end of the experiment in groups II and III averaged 31.12 kg and 31.50 kg, respectively, and were higher on average by 1.62 kg to 2.00 kg than in groups I and IV.

Hanczakowska et al. (2011) using MCFAs in feed noted significantly higher (p < 0.05) body weight in all groups where additives were used in comparison with the control animals fed standard feed mixture (from 35th to 84th day of life). Additionally, better feed conversion rates were recorded in this period between piglets fed a diet with caprylic acid and the control group (difference of 0.46 kg kg^{-1}). Kuang et al. (2015) observed better performance of animals when MCFA (lauric, myristic and capric acid) were used as one of the components of the diet in an amount of 130 g kg^{-1} in the case of piglets weaned at 21st day of life. Lan and Kim (2018) noted significant differences (p < 0,05) in BW when MCFA were used in feed in comparison with the control group. Hong and Kim (2012) recorded significant higher (p < 0.05) BW when MCFA were used in a diet during the first two weeks of their experiment.

Table 3 presents mortality data, diarrhoea incidence (up to moderate diarrhoea) and the colour and consistency of faeces. Short-term diarrhoea noted during breeding had moderate severity. Faeces were determined as watery (5 – according to the score methodology) with cream or pale yellow colour. In the case of other pigs, fecal consistency was determined as normal with gray-brown colour. A low percent of diarrhoea cases can be explained by maintaining proper zoohygienic conditions and avoiding nutritional problems.

Mortality of piglets in the pre-weaning period (until 28th day of life) were similar in all groups (6.50% on average). These were usually caused by being crushed by sows and due to anatomical defects. Losses of weaners in the post-weaning period were low – from 1.79% (group IV) to 3.69% (control group) and were caused mainly by non-infectious agents and differentiation of feed mixtures. These animals were removed as not suitable for further production. No significant losses (p < 0.05) of weaners were noted in the period from 46th to 75th day of life. Two animals were culled due to anatomical defects. In general, losses until 75th day of life varied from 8.72 to 10.40% per group, which complies with commonly accepted standards of estimating losses in industrial facilities. After weaning (from 29th to 75th day), losses of animals did not exceed 4%, which can be considered as a good result.

In summary, it can be stated that losses of piglets in all the groups resulted mostly from crushing by sows, which indicates that the care of pig-

Table 3

Losses of pigs (%) during rearing period and incidence of diarrhoea, faeces consistency and its colour (n = 7)

Specification	Treatments				p-value
	I - control	II	III	IV	
Losses (%)					
to 28th day	6.93±0.33	6.14±0.29	6.78±0.28	6.14±0.32	0.94
29th to 45th day	3.69±0.19	2.68±0.12	2.74±0.11	1.79±0.16	0.87
46th to 75th day	0	0	0.89±0.45	0.95±0.47	0.58
to 75th day	10.4±0.49	8.72±0.42	10.19±0.55	8.77±0.42	0.77
29th to 75th day	3.69±0.17	2.68±0.13	3.63±0.19	2.68±0.12	0.96
Diarrhoea incidence, after weaning (%)					
29th to 45th day	3.47±3.25	0.84±2.22	0	0.98±2.36	0.05
46th to 75th day	0	0	0	0	
Faeces consistency, scale 1-5					
29th to 45th day	3.17±0.14	3.12±0.11	3.10±0.17	3.12±0.12	0.05
46th to 75th day	3.09±0.11	2.95±0.17	3.11±0.12	2.97±0.18	0.14
Faeces colour	grey-brown matte colour				

Means with different subscripts within a row significant at: a, $b - p \leq 0.05$.

lets, especially at night, was adequate. Diarrhoea in piglets and weaners occurring mostly in the weaning period was efficiently reduced by the application MCFA, which was added into the diets with zinc oxide nanoparticles (nZnO). In our earlier experiment, the effectiveness of nZnO (as an experimental factor) in reducing diarrhoea was also confirmed (SZUBA-TRZNADEL et al., unpublished data). MCFA supplementation in the feeds in groups II, III and IV could have contributed to a reduction of diarrhoea cases, as suggested also by the studies of ZENTEK et al. (2013). While in a study by HANCZAKOWSKA et al. (2011), no loses to 35th day of life were recorded in treatments where MCFAs were used. In the control group and in the case of piglets fed a diet with a mixture of MCFAs, mortality has reached 7.5 and 7.9%, respectively. However, these authors did not specify whether the high mortality was an effect of diarrhoea or mechanical injury. In the period from 35th to 84th day of life, the lowest mortality is noted in treatments fed a diet with caprylic acid and its mixture with capric acid (1.6 and 0.0%, respectively). While in the case of piglets fed capric acid and in the control group mortality was 4.7 and 7.2%, respectively.

Table 4 presents the results of selected biochemical indicators of the health status of the animals. Notably, serum albumin in the piglets receiving MCFAs in the diets was significantly higher. A higher blood albumin level by ca. 6 g l^{-1} occurred with high regularity. This can indicate a better supply of nutrients. MOHANA DEVI and KIM (2014) observed higher digestibility coef-

Table 4

Biochemical indices in blood serum on 45th day of life ($n = 10$)

Specification		Treatments				p-value
		I - control	II	III	IV	
Total protein	(g dm^{-3})	45.00±7.76	47.70±3.81	52.20±9.07	51.40±8.64	0.07
Albumine,	(g dm^{-3})	25.80a±5.66	31.50b±3.92	31.20b±2.83	30.40b±4.75	0.01
Globulines (α, β, γ)	(g dm^{-3})	19.20±4.37	16.20±3.31	21.00±3.83	21.00±3.73	0.05
Glucose	(mmol dm^{-3})	4.60±1.56	5.20±1.11	5.73±1.97	5.10±1.32	0.41
Alkaline phosphatase	(U dm^{-3})	256.00±44.70	287.90±55.79	310.20±57.66	305.60±54.00	0.08
Urea	(mmol dm^{-3})	5.30b±0.89	5.10b±0.73	4.30a±0.64	4.70a±0.50	0.02
Zinc	(µmol dm^{-3})	17.00±1.05	16.60±2.07	17.10±1.37	16.80±1.52	0.35
Haptoglobin	(g dm^{-3})	0.834a±0.366	0.439b±0.344	0.432b±0.318	0.520ab±0.328	0.04

Means with different subscripts within a row significant at: a, $b - p \leq 0.05$.

ficients in the case of dry matter and nitrogen when MCFAs were used in comparison with control group. Additionally, Hanczakowska et al. (2013) reported better digestibility of crude protein and crude fiber when MCFAs were used in a diet for piglets in comparison with SCFA.

Significant differences were also observed in the serum urea concentration ($p < 0.05$). The urea level in groups III and IV ranged from 4.30 mmol dm^{-3} to 4.70 mmol dm^{-3}, while the respective values in groups I and II were 5.30 mmol dm^{-3} and 5.10 mmol dm^{-3}, respectively. This resulted from better nitrogen utilization in the groups receiving MCFAs, which was also indicated by Han et al. (2010), who observed improved nitrogen utilization after MCFAs administration.

The haptoglobin levels demonstrated significant differences in inflammatory states in the weaning period. The haptoglobin level determined in the serum of the piglets of group I was twice as high as in groups II, III, and IV. This indicates that the animals of the latter groups were characterized by better health status than the pigs from the control group.

CONCLUSIONS

The research data indicate that MCFA supplementation (at a concentration of 0.1% and 0.2%) in prestarter feed mixtures resulted in a higher feed intake and, consequently, greater weight gains. The MCFA content in a feed mixture at a concentration of 0.3% was too high, reducing feed intake. In the second part of the experiment, when the weaners were fed starter diets, no differences in productive performance indices were noted between the study groups. However, the impact of MCFA addition to prestarter feed mixtures manifested itself at the end of the experiment, when the weaners from groups II and III given feeds supplemented with MCFAs at 0.1% to 0.2% were heavier by 1.62 kg to 2.00 kg, respectively, than the group I and IV animals.

The application of ZnO nanoparticles at a concentration of 0.033% in feed mixtures efficiently reduced diarrhoea frequency, while the additional support of an MCFA supplement in feeds at the level from 0.1% to 0.3% of ZnO nanoparticles eliminated diarrhoea completely. MCFA supplementation increased the serum albumin level, which indicates a better supply of nutrients in the animals belonging to these groups. In addition, better nitrogen utilisation was noted in groups receiving prestarter diets supplemented with MCFAs at 0.1% and 0.3%. In the MCFA-treated groups (from 0.1% to 0.3%), the haptoglobin level was over two-fold lower, indicating that the inflammatory response characteristic of the weaning period was alleviated in these groups.

In conclusion, the piglets from the groups fed diets supplemented with MCFAs were characterised by a better health status, which corresponded with superior productive performance data.

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