The Digestive Utilization of Iron and Copper in the Fattening Swine Organism

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Abstract

The previous results have shown that the pork meat may become a part of a dietetical nutrition, because the pork meat is a superior source of protein, the best source of thiamine, a good source of iron and zinc, lower as calories, less lipids and an ideal ratio between polyunsaturated and saturated fat acids.

The aim of this study was to evaluate the influence over the bioproductive performances of fattening swine, also the evolution of the contained of iron and copper in blood, liver, fat, muscles, in the conditions in which during the finisher period iron and copper marked with radioactive isotope ^{56}Fe and ^{64}Cu have been used. The bioproductive performance registered by the fattening swine have proved that the optimal levels of iron are of 60 mg/kg compound feed in the first stage of fattening and of 40 mg/kg in the second stage, respectively the copper's level is of 4 mg/kg in the first stage and 3 mg/kg in the second stage. The established values obtained experimentally demonstrates an accumulation of radioactive iron and copper bigger in liver, blood and muscles. Regarding the organoleptical properties, the colour of the meat at these levels of iron and copper considered optimal, had the corresponding values of a quality meat (2.8-3.0 according to the Canadian standard).

Keywords: bioproductive performances, copper, fattening swine, iron, meat

1. Introduction

Swine alimentation represents a complex problem which constrains the efficiency in the production of swine's growing and fattening, being connected to genetics, microclimate factors, the animal health, biosecurity and environmental protection.

Although the fattening swine have less pretentions than the other categories of swine, applying care-wise feeding technology is recommended in order to obtain a superior weight gain with a less consumption of feed, moreover the carcass and quality meat [1].

In the curent paper the influence of iron and copper over the bioproductive results obtained by the fattening swine has been studied, the oligoelements having mostly an active effect (metabolical and physiological), in the group of aditives because of the proportions of use, moreover because of the determinated efects.

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2. Materials and methods

The researches have been made on the number of 30 pigs from the LS-345 Peris Synthetical Line, being divided in 3 batches uniformly by body weight (25.3 kg) and the ratio between sexes (Table 1).

The swine nutrition from all the 3 batches has been realised with the same compound feed, with the recipe 0-3 in the first phase (25-60 kg) and 0-4 in the second phase (60-110 kg) (Table 2) [2]. The differences are in the different proportion of microelements (iron and copper) from vitamino-mineral premix utilised. The experimental batch no. 1 received the vitamino-mineral premix which assured a content of compound feed of 70 mg

iron/kg and 4.5 mg copper/kg in the first phase, respectively 50 mg iron/kg and 3.5 mg copper/kg in the second phase. The experimental batch no. 2 received the vitamin-mineral premix which assured a content of compound feed of 60 mg iron/kg and 4.0 mg copper/kg in the first phase, respectively 40 mg iron/kg and 3.0 mg copper/kg in the second phase. The experimental batch no. 3 received the vitamin-mineral premix which assured a content of compound feed of 50 mg iron/kg and 3.5 mg copper/kg in the first phase, respectively 30 mg iron/kg and 2.5 mg copper/kg in the second phase.

The source of iron has been represented by the iron sulphate and the source of copper by copper sulphate. During the last 28 days before slaughtering iron sulphate and copper sulphate have been added, containing the radioactive isotopes ^{56}Fe and ^{64}Cu.

Table 1. The experimental scheme

Specification	Batch		
	E1	E2	E3
Swine number (heads)	10	10	10
Experimental period (days)	123	123	123
Iron (mg/kg feed) – I phase	70	60	50
Coppe (mg/kg feed) – I phase	5.0	4.0	3.0
Iron (mg/kg feed) – II phase	50	40	30
Copper (mg/kg feed) – II phase	4.0	3.0	2.0

Table 2. The structure and the parameters of the compound feeds used in experiment

Specification	Phase I	Phase II
Maize	67.00	69.35
Barley	8.30	8.30
Soya meal	11.00	6.50
Pea	7.00	11.50
Fish meal I	1.50	-
Yeast	2.40	2.40
L-lysine	0.15	0.18
DL-methionine	0.06	0.05
Choline premix	0.10	0.10
Calcium carbonate	0.69	0.30
Dicalcium phosphate	0.80	0.32
Salt	0.50	0.50
Vitamino-mineral premix	0.50	0.50
TOTAL	100.00	100.00
The recipes parameters		
ME (kcal/kg)	3155	3286
PB (%)	15.21	13.42
Lysine (%)	0.67	0.56
Methionine+cystine (%)	0.43	0.35
Methionine (%)	0.28	0.21
Trypthofan (%)	0.14	0.10
Treonine (%)	0.57	0.48
Calcium (%)	0.79	0.65
Phosphorus (%)	0.45	0.43
Brute cellulose (%)	3.09	3.08

The main observed targets in the experiment have been the evolution of bioproductive parameters (average daily gain, average daily consumption, specific consumption), the obtained results at the slaughtering (slaughtering yield, average thickness of fat, meat in carcass) and organoleptical properties represented by the colour of the meat measured with Gofo ware and evalued using the Canadian standard. The evolution of the content of iron and copper in blood, liver, fat,

muscles, has been determined using iron and copper marked with radioactive isotopes ^{56}Fe and ^{64}Cu which have been used during the last 28 days before slaughtering. From the each batch were sacrificed two animals at 8, 16 and 28 days from the beginning of feeding to establish the way of repartition of marked iron and copper in the pigs' organism. The radioactivity of iron and copper marked with the ^{56}Fe and ^{64}Cu isotopes from blood, liver, intestine, muscles samples have been measured with the spectrometer with liquid scintillation Beckman LS-6500.

3. Results and discussion

The influence of the microelements levels administrated to the swine at fattening over the bioproductive performances unregistered by them during the whole experimental period is presented in Table 3.

From the analyses of the obtained results it can be observed that the experimental batch no. 3 in which's feeding the recipe with the lowest values in iron and copper content has been used, registered average daily gains less than the other two experimental batches, between which the differences have not been insignificant. Therefore, the gain register by the batch no. 3 of swine has been significantly influenced, during the both fattening phases significant differences have been registered between the third batch and the first and second batch, because the level of the oligoelements has been less than the recipes given to the first and second batch.

It has been observed that the deficiency of copper from the premix has been much more felt. At swine, copper is considered a growing biostimulator, an addition of copper determining an increase in the weight gain. This action of copper is due to the antimicrobial effect of copper in the alimentary canal [3].

The daily consumption of the compound feed varied between 2.12-2.25 kg/head/day at the experimental batches in the first phase and 2.98-3.05 kg/head/day at the experimental batches in the second phase. The specific consumption has been the same at the three batches (2.82-2.89 kg compound feed/kg gain in first phase and 3.20-3.22 kg compound feed/kg gain in the second phase).

Table 3. The bioproductive performances of swine registered in the experimental period

Batch	Average daily gain (g/head/day)	Average daily consumption (kg/head/day)	Specific consumption (kg compound feed/kg gain)
Phase I of fattening			
E1	$776^{a}\pm8.25$	$2.25^{a}\pm0.35$	$2.89^{a}\pm0.87$
E2	$770^{a}\pm10.31$	$2.17^{a}\pm0.17$	$2.82^{a}\pm1.02$
E3	$751^{ab}\pm8.16$	$2.12^{a}\pm0.25$	$2.82^{a}\pm1.00$
Phase II of fattening			
E1	$951^{a}\pm8.67$	$3.05^{a}\pm0.17$	$3.21^{a}\pm0,98$
E2	$937^{a}\pm8.28$	$3.00^{a}\pm0.23$	$3.20^{a}\pm1.03$
E3	$925^{ab}\pm9.12$	$2.98^{a}\pm0.20$	$3.22^{a}\pm1.04$

***** a – there are no significant differences between the batches ($P>0.05$)

** ab – there are significant differences between the batches ($P<0.05$)

The results obtained after slaughter and the organoleptical properties represented by the colour of the meat are presented in table 4.

The slaughter yield was bigger at the E2 batch (77.43%), which received the intermediate addition of microelements, the differences being significant between E3 batch and the experimental batches E1 and E2.

The meat proportion from the carcass has been bigger at the swine from the batch where have been administrated 60 mg iron/kg and 4.0 mg copper/kg in the first phase, respectively 40 mg iron/kg and 3.0 mg copper/kg in the second phase. This mixture of two elements determinates a smaller deposit of fat tissue.

Table 4. The results obtained at the slaughter

Batch	Slaugh-tering randament (%)	Average thickness of fat (cm)	Meat in carcass (%)	Colour	
				Gofo	Canadian standard
E1	76.01^{a}±3.89	2.03 ^{a}±0.14	56.5 ^{a}±0.41	66	3.0
E2	77.43^{a}±2.98	1.96 ^{a}±0.24	57.3 ^{a}±0.30	65	3.0
E3	75.21^{ab}±4.01	2.31 ^{ab}±0.19	54.5 ^{ab}±0.36	63	2.8

***** a - there are no significant differences between the batches (P > 0.05)
** ab – there are significant differences between the batches (P < 0.05)

For looking after the way of repartition of iron and copper in the pigs' organism after the ingest of the marked microelements has been measured the evolution of the iron and copper radioactivity from blood, liver, fat and muscles (Tables 5 and 6).

Table 5. The evolution of the total radioactivity of iron in pigs' organism (DPM/g) (x 10^3)

Batch	Sacrifice at:	Iron in:			
		blood	liver	fat	muscle
E1	8 days	235.17	119.75	85.17	225.68
	16 days	311.75	153.58	98.85	309.49
	28 days	398.05	227.34	125.57	366.78
E2	8 days	231.56	112.35	80.46	211.75
	16 days	309.37	145.62	94.94	289.47
	28 days	391.75	199.45	110.68	357.35
E3	8 days	219.46	103.56	76.40	201.38
	16 days	299.05	122.35	89.48	261.83
	28 days	364.15	185.48	100.35	331.93

Table 6. The evolution of the total radioactivity of copper in pigs' organism (DPM/g) (x 10^3)

Batch	Sacrifice at:	Copper in:			
		blood	liver	fat	muscle
E1	8 days	99.05	124.31	76.57	90.03
	16 days	115.67	150.12	91.35	112.47
	28 days	137.48	187.23	100.18	128.75
E2	8 days	92.27	119.20	71.23	85.12
	16 days	104.26	138.46	88.46	106.37
	28 days	116.87	168.12	94.23	119.25
E3	8 days	89.05	110.31	68.35	79.01
	16 days	93.67	120.45	79.92	95.32
	28 days	102.59	142.94	88.90	102.27

At the first experimental batch, which has been administrated the biggest quantity of iron and copper in both phases of fattening, it has been established the biggest amount of microelements from blood, liver, fat and muscle. A progressive increase of iron and copper radioactivity in the experimental period has been observed during the 28 days of feeding.

Regarding the evolution of iron radioactivity in the pigs' organism, bigger values have been registered at the end of the experimental period at the first batch with 398.05 DPM/g in blood and with 366.78 DPM/g in muscle, comparative to the samples from liver and fat (227.34 DPM/g and 125.57 DPM/ml).

During the experimental period it has been measured the iron radioactivity from the organism pigs from experimental batch no. 3, established a decrease of radioactivity determined because of a small diminution of food consumption.

It is observed that the biggest quantity of iron in the organism is located in blood (haemoglobin from the red cells of the blood) and in the muscles (mioglobine from muscles), a less quantity being in liver and fat.

Similar results have been obtained by Overland

M., who said that the absorption of iron may be negatively, influenced by the presence of big concentrations of some microelements, such as copper, zinc, manganese, cadmium [4]. This observation is verified and in the case of the present experiment, the amounts of iron being relatively close to the ones of the experimental batches E1 and E2, even if batch E1 received feed in a bigger proportion and also copper.

Higher values of the radioactivity of copper have been determined at the pigs from batch E1 in liver (187.23 DPM/ml), blood (137.48 DPM/ml) and in muscle (128.75 DPM/ml). The lower value was observed in fat (100.18 DPM/ml). Progressive developments of radioactivity of copper have been observed at all the batches.

At the second experimental batch, at which the copper and iron have been in intermediate limits, lower values of radioactivity have been observed compared to batch E1, but bigger than batch E3. Copper is a compound of some enzymes, which are implied in the enzymatic activity from the organism associated to the iron's metabolism, copper being implied in forming red blood cells [5].

The established values obtained experimentally demonstrates an accumulation of radioactive iron and copper bigger than in liver, respectively for the iron in blood and muscle, the resulted microelements after digestion passing through the mucous membrane of the small intestine, from where by porta vein are transported to the liver and from here by the general blood circulation reaching at the level of tissue and cells [6]. Also, the two mineral elements have a better action when they are used together in swine feeding, the optimal levels of iron being of 60 mg/kg compound feed in the first stage of fattening and of 40 mg/kg in the second stage, respectively the copper's level is of 4 mg/kg in the first stage and 3 mg/kg in the second stage.

4. Conclusions

The measured values of the radioactivity of iron and copper marked with the isotopes ^{56}Fe and ^{64}Cu indicates that in the organism are amounts of iron in bigger quantities in blood and muscle and copper in liver.

The two mineral elements – iron and copper - have a better action when they are used in fattening pigs feeding in the optimal levels of iron are of 60 mg/kg compound feed in the first stage of fattening and of 40 mg/kg in the second stage, respectively the copper's level is of 4 mg/kg in the first stage and 3 mg/kg in the second stage.

The obtained results at the slaughtering have been significant influenced by the supply with an intermediate quantity of microelements, a positive effect having over the average fat thickness and the meat proportion from the carcass.

Regarding the organoleptical properties, the colour of the meat at these levels of iron and copper considered optimal, had the corresponding values of a quality meat (2.8-3 according to the Canadian standard).

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