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THE METABOLIC UTILIZATION OF IRON AND COPPER IN THE YOUNG SWINE ORGANISM

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Abstract

The aim of this study was to evaluate the influence of different iron and copper levels from the compound feed over the bioproductive performances of young swine, also the evolution of the contained iron and copper in blood, liver, fat and muscles, in the conditions in which during 2 weeks iron and copper marked with radioactive isotope ^{56}Fe and ^{64}Cu have been used. The researches have been made on the number of 75 pigs from the LS-345 Peris Synthetical Line, being divided in 3 batches uniformly by body weight (11.5 kg). The swine nutrition from all the 3 batches has been realized with the same compound feed, the differences being in the different proportion of the two microelements (iron and copper) from vitamino-mineral premix (batch no.1 received 95 mg iron/kg compound feed and 6 mg copper/kg, batch no. 2-85 mg iron/kg compound feed and 5 mg copper/kg, batch no. 3-75 mg iron/kg compound feed and 4 mg copper/kg). The best bioproductive performances (average daily gain, average daily consumption, specific consumption) have been obtained by the young swine in which's compound feed level has been of 85 mg iron/kg and 5 mg copper/kg. After giving the radioactive isotopes the highest values of iron have been observed in liver and muscles, moreover in case of copper, they can be found in liver. For the young swine copper is a growing biostimulating factor, influencing positively the iron metabolism.

Key words: *bioproductive performances, copper, iron, young swine.*

INTRODUCTION

Swine meat represents an important source of energy, protein, minerals and vitamins. The synthesis of the muscle and fat tissues, as well as other components of the body depends on the adequate nutrient intake through the food which the swine receive and which can be used efficiently for growth (Savu and Petcu, 2002) . Under these conditions, it is necessary to pay a special attention to food since the youth time.

Microelements are present in very small quantities in the tissues of swine, but they perform essential functions for the functioning of the organism, possessing the role of enzymes activators.

Iron is an essential element, being involved in the active transport of oxygen and in the tissue breathing (Deng et al., 2010) . The iron needs are increased during the youth period, deficiency being caused by an inadequate alimentary intake or due to the deficiency in copper, because of which iron cannot be embedded in the biologically active substances (Knutson, 2007).

Iron is an essential microelement in raising swine, playing an important part in haematopoiesis and in the synthesis of some enzymes which participate in different phases of the metabolism (Tapaloaga, 2008). The copper metabolism has interrelationships with that of iron, meaning that the first one is required in the formation of haemoglobin, in increasing the intestinal absorption of iron and in its mobilization from the deposits of ferritin (Pyatskowit J.W., Prohaska J.R., 2008).

Although the researches from the domain are numerous, many of the effects of the trace elements have remained still unclear. In this respect, the paper will present the influence of different iron and copper levels from the compound feed over the bioproductive performances of young swine, also the evolution of the contained iron and copper in blood, liver, fat and muscles, in the conditions in which iron and copper marked with radioactive isotope ^{56}Fe and ^{64}Cu have been used.

MATERIALS AND METHODS

The researches have been made on the number of 80 pigs from the LS-345 Peris Synthetical Line, being divided in 3 batches uniformly by body weight (11.5 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 starter recipe (Tabel 2).

Table 1. The experimental scheme

Specification	Batch		
	E1	E2	E3
Swine number (heads)	25	25	25
Initial weight (kg)	11.5	11.2	11.7
Iron (mg/kg feed)	95	85	75
Copper (mg/kg feed)	6.0	5.0	4.0

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

Specification	Phase I
Maize	67.00
Soya meal	22.41
Sunflower meal	4.00
Fish meal I	2.50
L-lysine	0.35
DL-methionine	0.09
Threonine	0.06
Calcium carbonate	1.19
Dicalcium phosphate	0.90
Salt	0.50
Vitamino-mineral premix	1.00
TOTAL	100.00
The recipes parameters	
ME (kcal/kg)	3155
PB (%)	18.01
Lysine (%)	1.21
Methionine+cystine (%)	0.63
Methionine (%)	0.40
Trypthofan (%)	0.58
Treonine (%)	0.67
Calcium (%)	0.89
Phosphorus (%)	0.45
Brute cellulose (%)	3.09

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 95 mg iron/kg and 6.0 mg copper/kg. The experimental batch no. 2 received the vitamino-mineral premix which assured a content of compound feed of 85 mg iron/kg and 5.0 mg copper/kg. The experimental batch no. 3 received the vitamino-mineral premix which assured a content of compound feed of 75 mg iron/kg and 4.0 mg copper/kg.

The source of iron has been represented by the iron sulphate and the source of copper by copper sulphate. During the last 24 days of the experiment in the feed of ten young swine from each batch has been introduced iron sulphate and copper sulphate, containing the radioactive isotopes ^{56}Fe and ^{64}Cu.

The main observed targets in the experiment have been the evolution of bioproductive parameters (average daily gain, average daily consumption, specific consumption). 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 20 days of the experimental period. From the each batch were sacrificed three animals at 8, 16 and 24 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.

In order to analyse from the point of view of the metabolic iron and copper usage in the body of young swine, the amount of haemoglobin and ceruloplasmin has been determined from the blood collected from five animals per batch at the beginning of the experimental period, as well as at two and three weeks from the start of the experience

RESULTS AND DISCUSSIONS

The influence of the microelements levels administrated to the young swine 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 unsignificant. It can be noticed under these conditions that copper is a growth biostimulator for swine, the levels of about 6.0 and 5.0 mg copper/kg, achieving growth gains which are relatively (395 g/head/day for the first experimental batch, respectively 400 g/head/day for the second experimental batch).

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)
E1	$395^{a} \pm 7.15$	$1.28^{a} \pm 0.22$	$3.24^{a} \pm 0.78$
E2	$400^{a} \pm 9.11$	$1.26^{a} \pm 0.20$	$3.15^{ab} \pm 1.01$
E3	$387^{ab} \pm 7.16$	$1.25^{a} \pm 0.18$	$3.23^{a} \pm 1.00$

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

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

The daily consumption of the compound feed varied between 1.25-1.28 kg/head/day at the experimental batches.

The specific consumption achieved a lower value (3.15 kg compound feed/kg gain) in the case of the second experimental batch, in which's feed have been administrated different average levels of iron and copper, the differences towards the other two batches, being significant.

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 4 and 5).

Table 4. The evolution of the total radioactivity of iron in pigs' organism (DPM/g) (x 103)

Batch	Sacrifice at:	Iron in:			
		blood	liver	small intestine	muscle
E1	8 days	211.45	93.45	180.14	88.39
	16 days	289.75	137.15	269.41	107.16
	24 days	358.16	210.28	301.84	170.64
E3	8 days	197.12	100.12	170.26	103.69
	16 days	255.87	167.34	253.32	131.65
	24 days	330.45	231.74	290.64	196.81
E3	8 days	179.56	84.17	159.28	75.37
	16 days	245.93	122.19	243.82	95.31
	24 days	304.12	183.62	274.36	149.18

Table 5. The evolution of the total radioactivity of copper in pigs' organism (DPM/g) (x 103)

Batch	Sacrifice at:	Copper in:			
		blood	liver	small intestine	muscle
E1	8 days	99.04	60.27	77.12	83.45
	16 days	135.15	85.14	98.52	104.85
	24 days	164.19	100.26	118.26	135.72
E2	8 days	85.42	54.26	69.27	77.27
	16 days	120.65	75.94	89.16	96.27
	24 days	149.51	92.63	103.26	119.36
E3	8 days	79.31	50.25	61.16	70.25
	16 days	107.14	70.25	81.23	89.74
	24 days	128.49	90.53	97.17	108.24

All in all, by analysing the evolution of the total radioactivity of two microelements in pigs' organism, at the first experimental batch, which has been administrated the biggest quantity of iron and copper, it has been established the biggest amount of microelements from blood, liver, small intestine and muscle. A progressive increase of iron and copper radioactivity in the experimental period has been observed during the 24 days of feeding.

In what matters the evolution of the total radioactivity of iron in pigs' organism it is noticed that the highest values are in blood, followed by the intestine, liver and muscle. This situation explains the fact that iron is found in the haemoglobin component from the red cells that of mioglobine from muscles. At the level of the small intestine, the absorption of iron takes place, after which a part is deposited in the intestinal epithelium, in liver, most of the quantity being used in the haemoglobin synthesis.

Higher values of the total radioactivity of iron have been registered at the end of the experimental period at the first batch with 358.16 DPM/g in blood and with 301.84 DPM/g in the small intestine, comparative to the samples from liver and muscle (231.74 DPM/g and 196.81 DPM/ml).

In the organism of swine from the second experimental batch have been registered medium values, the lowest being found at the swine from the third experimental batch, in which's food have been administrated the lowest quantities in iron and copper.

Similar results obtained by Gipp et al., 2013; Collins et al., 2010, are observed, such as the absorption of iron is negatively influenced by

the presence of big concentrations of some microelements, such as copper.
The iron radioactivity values determined from the samples taken from the liver and muscles of swine from the first experimental batch have been lower compared to the ones from the second experimental batch, even if batch E1 received a bigger quantity of iron and copper in food. As a consequence, the copper in excess influences negatively the deposit of iron in liver and muscle.
Higher values of the radioactivity of copper have been determined at the pigs from batch E1 in blood (164.19 DPM/ml), muscle (135.72 DPM/ml) and in the small intestine (118.26 DPM/ml). The lower value was observed in liver (100.26 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 absorbed in the small intestine, from where it reaches blood, being present in all the tissues, but mostly in muscle.
The established values obtained experimentally demonstrate an accumulation of radioactive iron and copper bigger in blood, where the two microelements reach after the absorption from the small intestine. The iron is deposited in liver, which copper can be found in a higher proportion in muscles.
The deposit of iron in liver and muscle is due to the medium values of copper which make the recommended levels of iron and copper to be of 85 mg iron/kg and 5.0 mg copper/kg feed for the young swine.
In order to analyse from the metabolic point of view the usage of iron and copper in the young swine organism the quantity of haemoglobin and ceruloplasmine from blood have been determined, the results being presented in Table 6.
It can be noticed the fact that in the case of the administrated iron quantities the values of haemoglobin have been close, being observed a small decade in parallel by diminishing the administrated iron quantity by the compound feed.

Ceruloplasmine, the way under which copper can be found in plasma, is a protein with a role in the iron metabolism which transforms it into bivalent iron and trivalent iron which is easy to be used by the body.

Table 6. Blood parameters determined during the experimental period

Batch	Period	Haemoglobin (g/100 ml)	Ceruloplasmine (mg/dl)
E1	Initial	11.3	46.1
	2 weeks	12.3	45.4
	3 weeks	12.7	48.5
E2	Initial	10.9	46.5
	2 week	12.2	48.6
	3 weeks	12.5	51.3
E3	Initial	11.2	46.2
	2 weeks	11.9	45.1
	3 weeks	12.3	47.8

The experimental determined values have shown that at medium values of copper administrated by the use of (5 mg/kg feed), ceruplasmine has registered a slight increase in the taken blood samples, therefore iron has been better used in the young swine organism. In this way, the values of the bioproductive performances can be explained, obtained by the second experimental batch.
In order to appreciate the influences of iron and copper fluctuations over the bioproductive performances of the young swine, an informatics program has been developed which allows the simulation program of the metabolic usage of iron and copper in the organism (Figure 1). The program has been written in the programming language Java, in NetBeans.
By the use of the primary experimental data, the program allows a simulation of the bioproductive performances and blood parameters which can be obtained in the case of use of different levels of iron and copper.
The program allows the graphical representation of the influence of iron and copper over the accumulation of the two mineral microelements in blood, liver, small intestine and muscle.

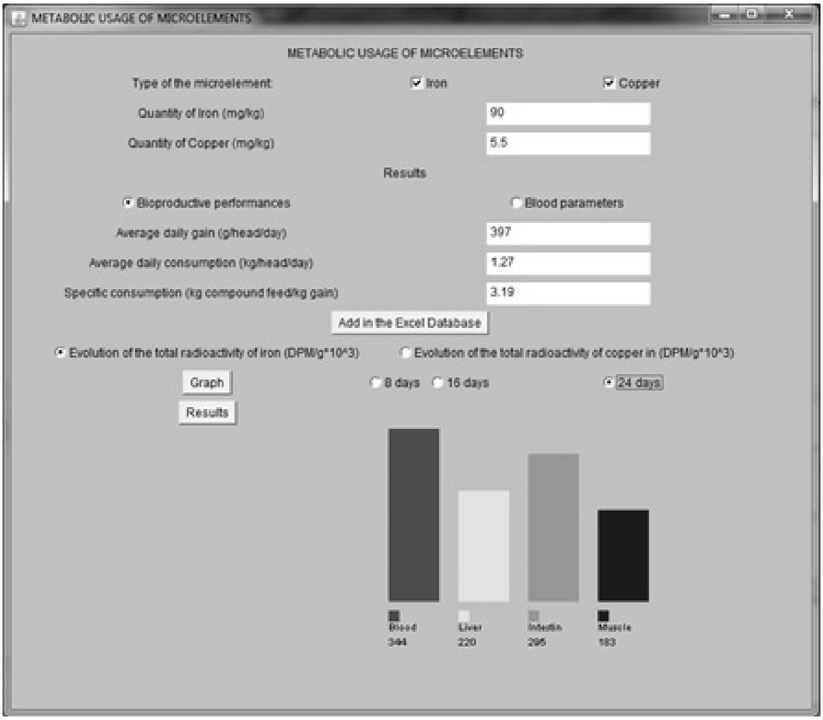

Figure 1. Simulation of metabolic usage of iron and copper in the young swine organism

CONCLUSIONS

The bioproductive performances of young swine have been positively influenced by the usage of the compound feed of a premix which assured levels of 85 mg iron/kg and 5.0 mg copper/kg feed.

The total radioactivity of iron and copper measured during the experimental period has proved an accumulation of radioactive iron and copper bigger in blood, after which the two microelements have been absorbed at the level of the small intestine.

Iron is accumulated in liver, while copper is found a higher proportion in muscle.

The intake of iron in liver and muscle is favoured by the medium values of copper, which makes that the recommended levels for the two microelements of the young swing to be of 85 mg iron/kg and 5.0 mg copper/kg feed.

Haemoglobin has obtained a slight decrease in parallel with the decrease of the iron quantity given through the compound feed.

For medium values of copper administrated in food (5 mg/kg feed) ceruplasmine has obtained a slight increase in the taken blood samples, which has shown that iron has been better valued by the young swine organism.

The metabolic usage of iron and copper in the young swine organism and the their influence over the bioproductive performances and of the blood parameters can be simulated with the help of an informatics program.

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