Trakia Journal of Sciences, Vol. 5, No. 3-4, pp 30-36, 2007

Available online at:
http://www.uni-sz.bg

ISSN 1312-1723

Original Contribution

EFFECT OF INTRODUCTION OF DIFFERENT PIG BREEDS ON THEIR MINERAL STATUS. II. TRACE ELEMENTS STATUS

P. Petkov*

Department of Internal Diseases; Faculty of Veterinary Medicine, Trakia University, Stara Zagora, Bulgaria

ABSTRACT

The purpose of the present study was to follow the blood mineral status in three groups of pigs and their crosses. Analysis of trace elements, Fe, Zn, Cu and Mn in the blood plasma was done. 70 pigs were used and were divided in 3 groups: group I aged 3-, 4- and 5-months female Danish Yorkshire and 4-month-old Danish Landrace; group II according to the breed and gender (Danish Duroc, Danish Landrace and Danish Yorkshire from both sexes) and group III according to the breed and gender but reared under different conditions – Big White females, male Landrace, Big White ♀× Landrace ♂ F1 crosses and English Duroc pigs. The results could serve to elaborate confidence intervals for these trace elements.

Key words: pigs, mineral metabolism, impaired balance, trace elements.

INTRODUCTION

The efforts of animal breeders and farmers to increase the animal production and thus to achieve a better output, often result in changes in the metabolism of livestock, even in clinical manifestation of some diseases

These disturbances have an impact not only on the direct deficits, but also result in impaired technologies, reproductive parameters and susceptibility of pigs to infectious and parasitic diseases.

According to Vrzgula et al., minerals – trace elements and macroelements, vitamins, enzymes and hormones, play a primary role in the metabolism.

The intake of a given mineral substance by the animal depends on its concentration in the diet, the source of minerals and the amount in them. Pigs rely on their daily ration to provide them with the necessary mineral substances. Nevertheless, minerals should not be supplemented unintentionally. It is said that "if little is good, more is better", but this is not true for mineral supplements because it could lead to serious consequences (2).

Mineral deficiencies are more common in pigs compared to other domestic animal species. The systemic stores of minerals are used in case of emergency needs, but are not sufficient to attain a maximum production (2)

Trace elements are important structural elements in the organism of animals. They participate in a number of metabolic processes in very small amounts. The role of the trace elements Fe, Zn and Cu is essential in the synthesis of many hormones and vitamins. Every excess or deficiency results in disturbed metabolism and in the so-called endemic diseases (3, 4, 5, 6).

The total content of iron in animal organisms varies according to the age, gender, nutrition, the general condition and the species. In the view of Granick, an adult man normally contains 4-5 g iron or 60-70 ppm per weight of 70 kg. The iron deficiency is manifested in the development of anaemia from a hypochromic microcytic type, accompanied by normoblastic, hyperblastic few or no haemosiderin in the bone marrow (9). In piglets and in older pigs, with the intake of rations with very high copper content that stimulates the growth, an iron-deficient anaemia is manifested (10). The piglets that refused a source of iron, another, porcine milk, develop anaemia within 2-4 weeks after birth. The minimum amount of iron needed by pigs for normal growth and synthesis of haemoglobin could not be precisely determined. It is established (11),

* **Correspondence to**: *Petko Petkov, Department of Internal diseases , Faculty of Veterinary Medicine, Trakia University, Stara Zagora 6000, Bulgaria; Tel.: +359-42-699 525*

that the piglet must maintain 21 mg Fe/kg body weight in order to keep its iron stores at a satisfactory level. This is equivalent to less than 7-11 mg Fe per day. The considerable increased needs of iron in adult pigs are caused by a diet with high copper content.

The purpose of the present study was to follow the trace element status in parent pig breeds and their crosses - their adaptation, health status and to perform clinical investigations on some mineral deficiency diseases.

MATERIAL AND METHODS

The investigations were carried out in the following commercial pig holdings: "Hibriden center po svinevadstvo" (HCS) Ltd, Shoumen city and "Invest holding" (HC) Ltd, village of Radko Dimitrievo, municipality of Shoumen. In the investigation, 70 pigs, divided in groups according to introduction variants, were included:

- First group – HCS Shoumen; according to the age – three, four and five month-old female Danish Yorkshire pigs and four–month-old male Danish Landrace pigs.
- Second group – HCS Shoumen – according to breed and sex: Danish Duroc /d. d. ♀/, Danish Duroc /d. d. ♂/, Danish Landrace /d. l. ♀/, Danish Landrace /d. l. ♂/, Danish Yorkshire /d. y. ♀/, Danish Yorkshire /d. y ♂/.
- Third group – HC- Radko Dimitrievo- according to the breed and sex: Big White female pigs /BW ♀/, Landrace /L ♂/, Big White ♀× Landrace ♂ crosses /F_1-♀/ and English Duroc males /ED ♂/.

The breeding system was free, in pens. The animals from both centres were placed under the same conditions of feeding, immunoprophylaxis and antiparasitic treatment. The blood samples were obtained from sinus ophtalmicus. The determination of trace element concentrations was performed by an atomic emission spectrometer with inductively coupled plasma excitation source (AES-ICP) Liberty 110, Varian with wavelengths for Zn -213,856 nm, Cu- 324,754 nm, Fe- 259,940 nm and Mn - 257,610 nm.

The results of per each group were analyzed, the average values, the standard deviations and the standard errors of means being calculated. The Student's t-test was used to determine the significance between means in the different groups and between the different ages.

RESULTS AND DISCUSSION

The results of iron quantitation in pigs from the 1st, 2nd and 3rd introduction variants are presented on ***Figure 1*** and ***Table 1***.

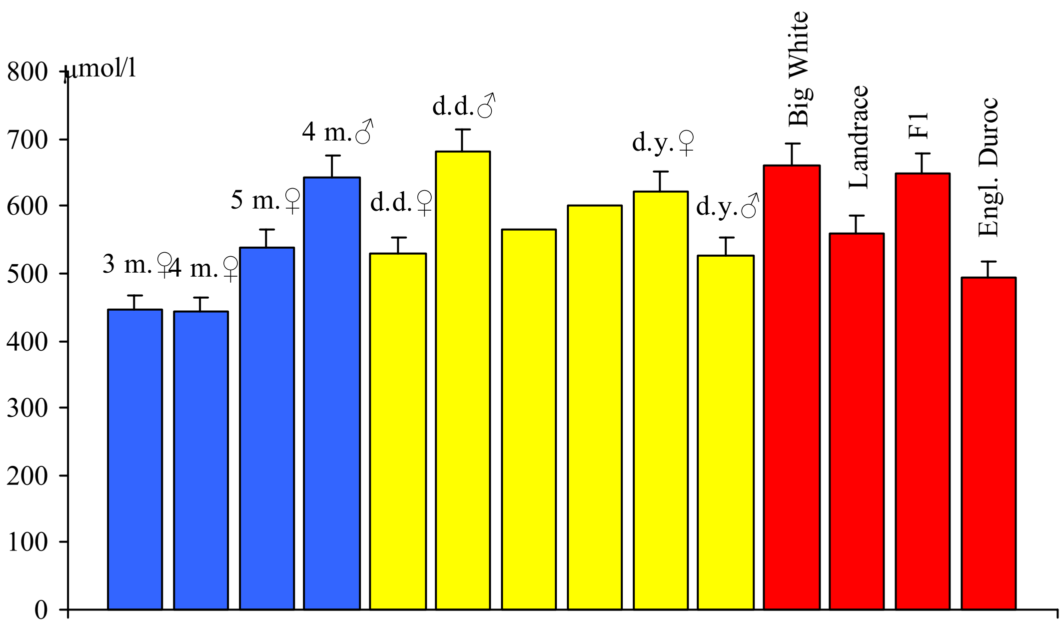

Figure 1. *Age-, breed- and sex-related variations in iron concentrations in pigs in the HCS – Shoumen and HC – Radko Dimitrievo.*

The results showed that the trace element iron in the pigs from introduction group I ranged between 442 and 642 μmol/l, and that the highest significant differences (at $p<0.01$) were observed in 4-month-old male piglets *vs.* 3- and 4-month-old female pigs. Here, there was a tendency towards increase of concentrations with age in female Yorkshire pigs.

Table 1. *Age-, breed- and sex-related variations in iron concentrations in pigs in the HCS – Shoumen and HC – Radko Dimitrievo.*

Fe	**3 m.** ♀	**4 m.** ♀	**5 m.** ♀	**4 m.** ♂	**d.d.** ♀	**d.d.** ♂	**d.l.** ♀	**d.l.** ♂	**d.y.** ♀	**d.y.** ♂	**Big White** ♀	**Landrace** ♂	**F1** ♀	**Engl. Duroc** ♂
$\bar{x}$	446	442	539	642	528	680	564	601	621	526	659	558	647	493
$S\bar{x}$	33	21	37	19	106	53	65	12	36	42	19	12	24	17

In the pigs from the 2nd introduction group, the highest iron levels were established in male Duroc pigs (680±53 µmol/l), with the nearest values being observed in female Yorkshires (621±36µmol/l), and the lowest – in female Duroc, but within the error range.

The analysis of the data about iron levels in the 3rd introduction groups revealed the highest concentrations of this analysis in female Big White breed (659±19 µmol/l), and the lowest – in male English Duroc (493±17 µmol/l), at $p<0.01$. Relatively higher concentrations were found in F_1 crosses (647±19 µmol/l) than in Landrace and Duroc pigs ($p<0.05$).

Significant differences among pigs from the three groups were observed only in 3- and 4-month-old male Yorkshire pigs *vs.* male Danish Duroc and female Big White pigs ($p<0.05$).

The analysis of data allowed us to conclude that in general, taking into consideration the sex-, age- , breed- and technological peculiarities, the absolute iron blood values were similar to or equal to those obtained by other authors (5, 6, 7, 9, 10, 12).

The differences due to gender for a given age or farm, were probably due to age alterations in iron content, as also evidenced by the studies of Henning (12). Our investigations confirmed the results of Rish, especially when the growing pigs exhibited signs of diarrhoea. The utilization of iron depends on the age, the systemic stores, the condition of the alimentary tract, the amount and the chemical formula of iron compounds. That is why, we as well as other authors (13) emphasized on other factors as well, mainly the impaired ratio between the mineral ingredients in the diet.

To summarize, the variations in the iron concentrations in the blood of studied pigs from various breeds and lines showed that they could be at a significant extent attributed to physiological mechanisms (growth and maturity) or to causes related to rearing technology (different weaning time), various schedules of treatment with iron-dextrane preparations etc., and perhaps also to the indirect influence of the various content of this mineral along the nutrient chain.

These assumptions of ours are confirmed by the research of Gabrashanski and Kovalski (5).

Considering the genetic control on the metabolism, we hypothesized that the obvious changes in iron concentrations in pigs could also be due to genetic particularities of iron metabolic pathways.

Analyzing the data from the assays of zinc in pigs from the three introduction variants (***Figure 2*** and ***Table 2***), it could be seen that they ranged between 26±2.2 µmol/l and 160±16 µmol./l.

Table 2. *Age-, breed- and sex-related variations in zinc concentrations in pigs in the HCS – Shoumen and HC – Radko Dimitrievo.*

Zn	**3 m.** ♀	**4 m.** ♀	**5 m.** ♀	**4 m.** ♂	**d.d.** ♀	**d.d.** ♂	**d.l.** ♀	**d.l.** ♂	**d.y.** ♀	**d.y.** ♂	**Big White** ♀	**Landrace**♂	**F1** ♀	**Engl. Duroc** ♂
$\bar{x}$	32.2	26.1	36.1	57.4	60.5	56.3	132	85	160	122	51	46	53.1	57.4
$S\bar{x}$	2.1	2.2	6.7	9.5	11.5	1.5	58	13	16	15	1.8	1.9	3.7	2.3

The lowest zinc concentrations were found in 2-, 3- and 4-month-old female pigs, introduced from Denmark, with observed slight but not significant tendency to increase in levels with age.

The results in the 2nd group are intriguing as they showed significant breed- and sex-related changes. The highest values were those in Yorkshire pigs from both sexes: 160±16 µmol./l in females and 122±15 µmol/l in males, whereas the lowest ones were in the Duroc breed. In male Duroc pigs, blood zinc was 56.3±1.5 µmol/l, and in females – 60.5±11.5 µmol/l, and thus, the breed-related differences in introduced pigs are clearly outlined. In the third group, zinc concentrations were between 46±1.9 μmol/l and 57.4±2.3 μmol/l. In this group, there were no differences related to the sex and the data were within the error range.

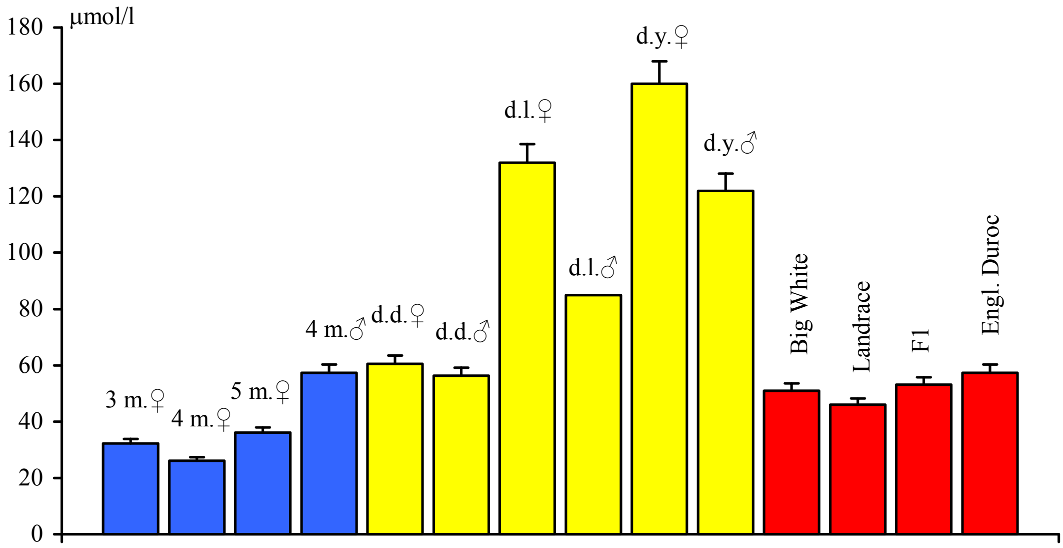

Figure 2. *Age-, breed- and sex-related variations in zinc concentrations in pigs in the HCS – Shoumen and HC – Radko Dimitrievo.*

The zinc levels observed by us in the three introduction groups were probably due to the minimum amounts of this trace elements in the soil and the vegetation in the different sub-regions. Following the results in the three groups, it could be established that female Danish Landrace had significantly higher blood zinc concentrations than 3- and 5-month-old female pigs ($p<0.05$) and 4-month-old female pigs ($p<0.01$). The differences were more defined in Danish Yorkshire compared to all animals from the 1st group and both sexes of Duroc pigs ($p<0.01$).

Taking into consideration the sex- and age-related variations, zinc levels ranged between 26,1 and 160 μmmol/l, and thus our data were similar to a certain extent to other reported data (13, 14, 15 and 16).

Our studies were indicative of a certain lability in pigs, that was also noticed and discussed by others (8, 12,1 6). The high zinc levels in both sexes of the Yorkshire breed could be attributed to agrochemical melioration and the increased amount of zinc in corn that is a principal component of compound feed for pigs. In his research done on contaminated dermatoses due to zinc deficiency during the last decade in Bulgaria, Stanchev reported cases of zinc deficiency (18). After the supplementation of the soil with zinc fertilizers, the disease had gradually faded.

The results from the quantitation of the trace element copper are shown on ***Figure 3*** and ***Table 3***.

Table 3*. Age-, breed- and sex-related variations in copper concentrations in pigs in the HCS – Shoumen and HC – Radko Dimitrievo.*

Cu	3 m. ♀	4 m. ♀	5 m. ♀	4 m. ♂	d.d. ♀	d.d. ♂	d.l. ♀	d.l. ♂	d.y. ♀	d.y. ♂	Big White ♀	Landrace♂	F1 ♀	Engl. Duroc ♂
$\bar{x}$	20.7	23.1	26.2	28.1	21.5	23.1	24.4	22.5	26.5	23.0	23.4	21.2	26.2	25.1
$S\bar{x}$	0.9	1.5	1.3	1.5	0.4	4.4	2.4	1.7	1.3	1.3	1.1	0.9	1.3	1.5

In the three introduced groups, blood copper varied in very close intervals. In the 1st introduction group, there was a tendency towards increase in copper concentrations with age with highest values in male pigs (28.1±1.5 μmol/l), indicative of the synergism of iron with copper (5).

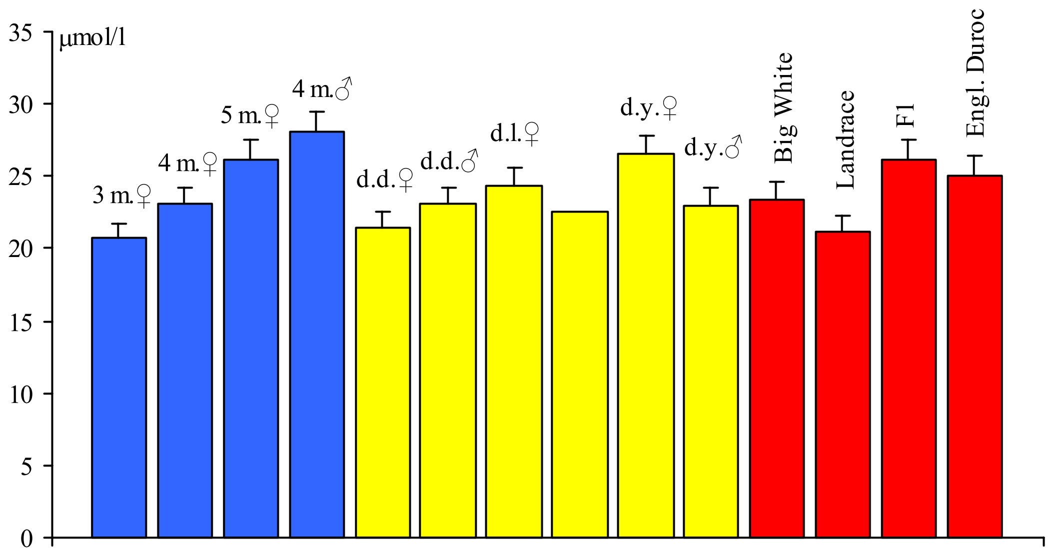

Figure 3. *Age-, breed- and sex-related variations in copper concentrations in pigs in the HCS – Shoumen and HC – Radko Dimitrievo.*

The second introduction group showed no significant differences among breeds and sexes. Here, the highest concentrations were measured in female Yorkshire pigs– 26.5±1.3 µmol/l. In the 3rd group, the values of this analysis were very close: from 21.2±0.9 µmol/l to 26.2±1.3 µmol/l. Significant difference was present only between F1 crosses and Landrace pigs (p<.,05). There were no significant differences among the pigs from the three groups.

Copper blood concentrations in pigs, accounting for the sex-, breed-, age- and rearing system-related peculiarities, varied between 20.7 and 28µmol/l. Our data are similar to those of Kovalski and Rish (16), somewhat different than the results of Kolomiytseva et al. (1990), according to which the copper content was more than 0.360 mg per 100 kg live body weight.

The differences due to age-dependent changes in the first group were probably due to the fact that pigs had lower copper content than adult pigs. This could be explained by the relatively increased muscle mass and the reduced copper levels in the main organ where this element is stored – the liver, as confirmed by Wiseman et al. (19).

Accounting for the biological role of this trace element, we focused our attention to changes in blood-forming organs. As evidenced by our results, there are differences between studied groups. In the feedback that was made as advised by Lamand (16) it was determined that the ration consisted of forages mainly corn and barley, rich in copper (6), originating from the respective region. Compared to some neighbouring countries, the copper deficiency is not encountered among pigs in Bulgaria.

The data from the analysis of manganese content are shown on ***Figure 4*** and ***Table 4***. In all three introduced groups, the levels were similar (between 0.07±0.03 and 0.12±0.01 µmol/l) within the statistical error. Manganese levels were within the reference range for this trace element and there were no considerable deviations observed with the exception of 4-month-old females that had lower concentrations than male Danish Duroc (p<0.01) and Yorkshires from both genders (p<0.05). According to Lloyd et al. (20) the small amounts of manganese in the body of pigs, about 0,2-0,3 mg/kg body weight, are mainly concentrated in bones. It is essential for bone growth and fertility and is primarily involved in amino acid metabolism.

Because of the poor utilization of manganese in the alimentary tract and its low concentration in body tissues, the great concern is to ensure the normal amounts of manganese in the ration. Manganese deficiencies are generally related to poor skeletal development.

On the basis of our results, considering the age-, sex-, breed- and technology-related peculiarities of pig rearing systems, we could make confidence intervals for iron, zinc, copper and manganese, ensuring a physiological optimum for parent pig lines and their crosses with regard to their adaptation in the Republic of Bulgaria.

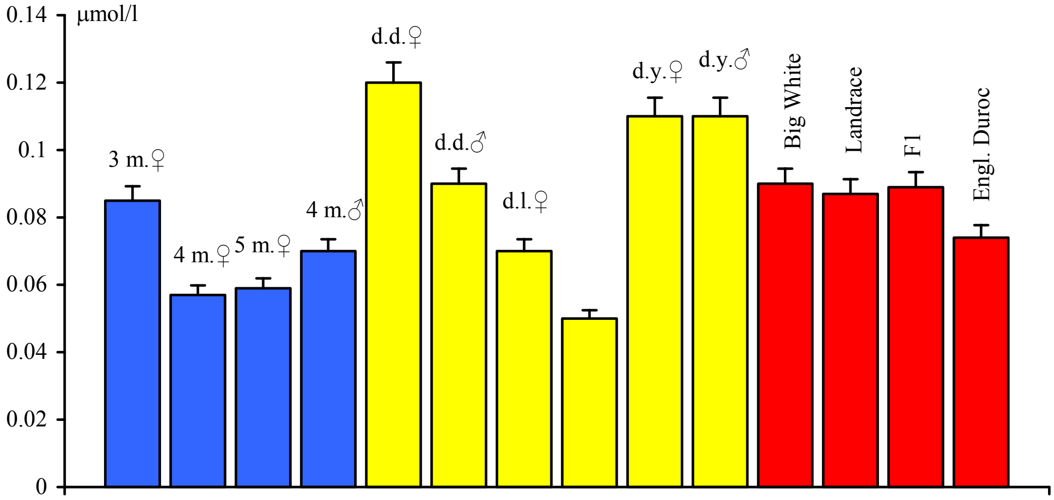

Figure 4. Age-, breed- and sex-related variations in manganese concentrations in pigs in the HCS – Shoumen and HC – Radko Dimitrievo.

***Table 4**. Age-, breed- and sex-related variations in manganese concentrations in pigs in the HCS – Shoumen and HC – Radko Dimitrievo.*

Mn	**3 m. ♀**	**4 m. ♀**	**5 m. ♀**	**4 m. ♂**	**d.d. ♀**	**d.d. ♂**	**d.l. ♀**	**d.l. ♂**	**d.y. ♀**	**d.y. ♂**	**Big White ♀**	**Landrace♂**	**F1 ♀**	**Engl. Duroc ♂**
$\bar{x}$	0.085	0.057	0.059	0.07	0.12	0.09	0.07	0.05	0.11	0.11	0.09	0.087	0.089	0.074
$S\bar{x}$	0.008	0.010	0.005	0.004	0.01	0.006	0.03	0.002	0.003	0.01	0.008	0.01	0.005	0.004

CONCLUSIONS

The observed breed-, age- and sex-related differences in blood iron concentrations during the different introduction periods, specified by the genotypic variations in Fe metabolism in pigs, confirmed the breed-, age- and sex-related diversity in the physiological adaptation potential with regard to this trace element in the course of their introduction.

The strong variations in zinc levels during the I and II introduction periods supported the hypothesis for its lability in pigs, that, during the 3rd introduction period became stable in both purebred pigs and crosses. This proved the good adaptive potential of pigs related to zinc metabolism, essential for the structure and the functioning of enzyme systems.

The lack of significant differences in blood Cu and Mn concentrations in pigs from different breeds, age groups and gender during the three periods of introduction evidenced the stability of these trace elements from one part, and the good acclimatization ability of pigs with regard to these trace elements during their introduction.

On the basis of our results, it would be necessary to develop and suggest a plan for application of Fe, Zn, Cu and Mn during the different introduction periods of pigs with regard to their better adaptation during their introduction in our country.

REFERENCES

1. Aliev, A. A., B. Barey, P. Bartko, Y. Bouda, R. Dvorzhak, P. Gabrashanski, Y Ilek, P. Yagosh, F. Karsay, E. Kona, G. Kovach, L. Nedkova, Z. Sova, M. Shefer, L. Vrzgula, Methabolic Diseases in Domestic Animals. Priroda, Bratislava, Czechoslovakia, 1982.
2. Carlson S. Marcia and Courtney A. Boren, Mineral Requirements for Growing Swine, missouri.edu/exporepdf/agguides/ansci/g02322.pdf, 21.09.2001.
3. Voynar, A. I. Biological role of trace elements in the organism of animals and men, 2nd edition, Moscow High Shcool, Russia, 544-548, 1960.
4. Dinevich, L. S. BIological role of trace elements and their utilization in

agriculture. Proceedings of the VIth All-Russia Meeting, Latvia, 14, 2, 1970.
5. Gabrashanski, P., V. Kovalskii M. Rish, L. Nedkova, A. Daskalova, J. Raecka and D. Abdulaev, Trace elements and trace elementosis in industrial animal husbandry, Zemizdat, Sofia, Bulgaria, 1979.
6. Petkov, P., P. Georgiev, D. Zlatev. Changes in some trace and macroelements, related to the sex and age, in hybrid pigs. Veterinarna Sbirka, 7, 13-14, 1982.
7. Petkov, P., K. Ganchev, Metabolic diseases in farm animals and birds, Veterinary Medical News, 20-23, 1998.
8. Grigoriev, V. S. Investigations on the mineral metabolism in pigs. Actual problems of animal foodstuff production, 106-107, 2001.
9. Dilov, P. Pharmacological properties and biostandardization of iron dextrane preparations. Dissertation, 1984.
10. Petrichev, M., Investigation upon toxicity bioavailability and antianaemic of food aditiv ferrum complex of methionin in laboratory animals and pigs. PhD Thesis, 2006.
11. Miller, E. R., Ullrey, D.E., Baby pig anemia (Iron deficiency anemia) University of Kentucky, USA, 1980.
12. Hennig A; Gumz W; von Gagern W Effect of endogenous factors on ash, calcium, magnesium, potassium, sodium, phosphorus, zink, iron, copper and manganese concentration in the *pig* bristle Archiv Für Tierernährung [Arch Tierernahr]; Vol. 28 (2), pp. 91-8. Feb 1978
13. Rish, M. A. Physiological role and practical use of trace elements, VII trace elements conference Riga, USSR 193-210, 1976.
14. Miller ER; ET. Kornegay, Mineral and vitamin nutrition of swine, Journal of Animal Science [J. Anim Sci], Vol. 57 Suppl 2, 315-329, 1983.
15. Abullaev, D. V. Zinc in animals and men, Tashkent, USSR, 1979.
16. Lamand, M., C. Lab, J. C. Tressol. Annales de Recherches Veterinaires, 11, 147-149. 1987.
17. Kovalski, V. V. Biological role of trace elements. USSR Academy of Sciences, 3-16, 1983.
18. Stanchev, H. Metabolism of trace elements in animals, NAPS, Sofia, Bulgaria, 1979.
19. Wiseman, T.G. Mahan, D.C. Peters, J.C. Fastinger, N.D. Ching, S. Kim, Y.Y. Body mineral composition of gilts and barrows from two genotypes of *pigs* from 18 to 127 kg body weight. Journal of Animal Science; Supplement 2, Vol. 81, p83-83, 1/4p, Oct,2003
20. Lloyd, L.E, B. E. McDonald, E. W. Crampton, Fundamentals of Nutrition, The Quarterly Review of Biology, Vol. 54, No. 3, p. 352, Sep., 1979