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LEVEL OF GLUCOSE, CALCIUM AND PHOSPHORUS IN BLOOD SERUM OF THE FIRST LITTER SOWS WITH NORMAL AND DISTURBED LACTATION

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Abstract: The main task in intensive pig production is animal welfare, particularly the preservation of their physiological function, homeostasis and homeorhesis and lactation, where the level of glucose, calcium and phosphorus in blood plays an important role in protecting the physiological status. This research has been carried out on a modern farm, of closed type in Zitoradja, in order to show the level of glucose, calcium and phosphorus in the blood serum of the first farrowing gilts and sows during pregnancy and post partum. In investigation, 30 pregnant gilts took part from insemination to partus. Blood was taken from the jugular vein on the thirtieth day after insemination, ten days before farrowing, one day after farrowing, and seven days after farrowing. The concentration of glucose in the blood serum of gilts with normal lactation was significantly higher ten days before farrowing (4.62 mmol/l) and on the first (4.92 mmol/l) and seventh day after farrowing (4.94 mmol/l) in relation to the concentration of glucose on the thirtieth day prior to farrowing (4.12 mmol/l), but this increase could not be found in gilts with disorders of lactation. The concentration of calcium before of partus (2.16 mmol/l) and post partum (2.55 mmol/l), in sows with normal lactation, showed a significant difference compared to the calcium concentration at the beginning of pregnancy ($p < 0.05$) and in gilts with disturbed lactation. Phosphorus concentration showed no significant difference in gilts with normal and disturbed lactation (2.26 : 2.25 mmol/l).

Key words: glucose, calcium, phosphorus, blood serum, first farrowing.

Introduction

The main prerequisite for successful breeding of piglets is high lactation of sows. In literature, the descriptions of the importance of genetic and paragenetic

factors on lactogenesis, lactopoiesis and lactation of sows, can be found, especially related to first litter sows. A large number of papers has described the importance and influence of certain hormones, the effect of certain macro-and microelements and vitamins, the impact of certain nutrients and their relations in meals to the level of milk capacity of sows. In our work we wanted to determine how certain minerals, precisely calcium and phosphorus and glucose carbohydrate affect milk yield of first litter sows. The functions and influence of these minerals, Ca and P and glucose to the physiological functions of an organism have been known.

Calcium is quantitatively the most represented cation in the body. The biggest part of blood calcium is in the plasma. The calcium in the blood plasma can be found in three forms: ionized (diffusible), protein bound (non- diffusible) and small amounts of complex bound with citrate. All three forms of calcium in the plasma are in equilibrium with each other. Usual methods for the determination of calcium concentration in plasma (serum) define the concentration of total calcium. The total concentration of calcium in the blood serum is 2.5 mmol/l. Ionized calcium has a number of significant roles in an organism *(Stojic, 1996)*.
Calcium is essential for many physiological processes such as neuromuscular irritability, changes in cell membrane permeability, muscular contractions, cardiac activity, the synthesis and release of acetylcholine, activation of enzyme systems (ATP-ase, lipase, succinate dehydrogenase), blood coagulation etc. The needs are greater for calcium during pregnancy and lactation *(Cunningham et al., 2007)*.

Phosphorus is mostly found in the body (80%) bound to calcium in bones and teeth. About 10% of phosphorus is embedded in proteins, nucleic acids, lipids, carbohydrates and other constituents of blood and muscles. The remaining 10% is embedded in other compounds. After resorption, a portion of phosphate remains in the blood plasma in the form of inorganic phosphate, the other part goes to the bones, which is, together with calcium, being deposited. A significant part of the resorbed phosphates is being embedded in organic compounds. Of particular importance are the organic phosphate compounds that are rich in energy (ATP and creatine phosphate) and coenzymes of some enzymes *(Rowen at al., 2009)*. Normal concentration of inorganic phosphorus in blood serum is 0.9 to 1.5 mmol/l. Phosphates have numerous significant functions in the body. Together with calcium, they contribute to the bone density, forming part of many organic compounds in cells, taking part in depositing and transferring energy, taking part in decomposition of carbohydrates (a lot of intermediates of carbohydrate decomposition are phosphate esters), and they are also ingredients of some enzymes and compounds enriched in energy *(Stojic, 1996)*.

Glucose is the only form of sugar in the blood. The concentration of glucose in the blood of most farm animals is 4-6 mmol/l, and in ruminants it is half of that amount, that is 2.3 to 3.5 mmol/l. In the body there are a number of homeostatic mechanisms to maintain blood glucose in the physiological range and therefore its control is of great medical and diagnostic significance. Glucose within

cells is used primarily as fuel. Its energy is obtained by oxidation. Glycolysis process and metabolic pathways of enzyme decomposition of glucose to two molecules of pyruvate (under aerobic conditions) or lactate (under anaerobic conditions) with the release of energy. Glycolysis occurs in the cytoplasm, and all the intermediates of glycolysis are phosphorylated compounds *(Stojić, 1996)*.

Mammary gland is an organ, characteristic only for mammals, and it is the part of the reproductive apparatus, as lactation is practically the last act of process of reproduction, because if there is no lactation there is no reproduction. Parenchyma is made up by the alveoli (acini), built from one layer of glandular cells on the basal membrane. Cells in lactation are high or low prismatic (this depends on the amounts of milk in the lumen) and below them, within a common basal membrane, there are myoepithelial cells located *(Gledić, 1996)*.

Milk contains all the nutrients necessary for survival and initial growth of newborn mammals. Nutrients in milk provide sources of energy (fat and carbohydrates), proteins that provide amino acids, vitamins, minerals (ash), electrolytes and water. The relative amounts of these nutrients in milk vary by species.

Materials and Methods

Investigations were conducted on pig farms in Zitoradja. The test involved 30 pregnant gilts, from which the blood was taken four times from the jugular vein. The first blood taking was on day of insemination, the second intake was 30 days after insemination, the third was 10 days before farrowing, the fourth intake was 1 day after farrowing and the fifth intake was on the seventh day after farrowing. Given that we are prepared to view a number od gilts, the results are followed by other samplingblood of pregnant gilts. Because we have in the results II, III, IV and V blood sempling. In serum we determined the concentrations of glucose, calcium and phosphorus. Spectrophotometric assay of the level of calcium, phosphorus and glucose was carried out on a biochemical analyzer of the Health Centre in Leskovac. The results were grouped into appropriate series - tables and statistically analyzed. For all parameters, the basic variational statistical parameters were calculated: mean value, standard deviation and coefficient of variation. The most important indicator of the average feature level is the arithmetic mean. The data were analyzed using statistical method of analysis of variance and achieved differences were tested by t - test. All data related to analysis of variance are presented in the form of tables in the text, as well as testing the differences for the same data, if the established difference showed some statistical significance.

Results

We have presented test results according to the parameters that were determined in pregnant gilts and sows of first farrowing with normal and disturbed lactation. Among 30 first farrowing gilts and sows, we noticed different forms of disorders in lactation in 8. With 3 first farrowing gilts and sows hypogalactia was observed, so we were forced to take away the pigs from those gilts and underlay them to another lactating sow. Udder of such - first farrowing sows was poorly developed, without clearly expressed mammary complex. The temperature was within normal limits, and general health status was regular. We have added large pigs to such gilts with hypogalactia, with no signs of MMA syndrome, in order to try by sucking and through neurohormonal regulation to stimulate milk ejection and achieve better blood flow through mammary complex by udder massage. In the morning, and evening, those gilts were administered oxytocin at a dose of 2.5 ml i.m. In addition, the udder was massaged several times a day with warm water with the addition of disinfecting agent. Next group of 3 first farrowing sows was made of those that suffered from agalactia and the occurrence of mastitis. In these gilts, the inflammation of several mammary complexes appeared and with one it was even observed the occurrence of endometritis and general health disorder. There were some cases with first farrowing sows when the piglets were immediately taken away, and there were some that it happened after a few days. We applied with these first farrowing sows antibiotic and symptomatic therapy, which is identical as with the case of hypogalactia. With two first farrowing sows, we had difficulty in farrowing (partus gravis), where the pigs were disproportionately greater than parturient channel. In those cases, manual extraction was applied for foetus extraction by application of forceps pliers and hooks. As a result of contusion and partial damage of parturient channel there was the appearance of mastitis and endometritis with complete MMA syndrome signs such as fever (39 - 410ºC), tachycardia, tachypnoea, or general health disorder, so we were forced to take away the pigs from such agalactous sows. By applying the described treatment we succeeded in normalizing the state of health of those gilts, but, according to the technology of work on the farm, they are not left for further breeding.

Table 1. The concentration of glucose in the blood serum of gilts with normal lactation (mmol / l)

Time	$\overline{X}$	Sx	SD	CV%	P<0,05 for groups
II	4,12	0,12	0.54	12,75	III,IV,V
III	4,62	0,12	0,52	11,03	II,IV,V
IV	4,92	0,12	0,62	11,65	II,III
V	4,94	0.12	0,62	11,76	II,III

From the results obtained it is shown that the concentration of serum glucose is statistically significantly higher ten days before partus and on the first and seventh day after farrowing in relation to the concentration of glucose on the thirtieth day of pregnancy. The increase in glucose concentration can be explained by the higher needs for glucose in proportion to the growth and development of the foetuses and higher energy needs of the mother.

Table 2. The concentration of glucose in the blood serum of gilts with disturbed lactation (mmol/l)

Time	$\overline{X}$	Sx	SD	CV%	P<0,05 for groups
II	4,10	0,16	0.60	14,12	NSS
III	4,21	0,15	0,56	12,92	NSS
IV	4,20	0,14	0,52	11,94	NSS
V	4,07	0.12	0,40	9,35	NSS

The table shows that the concentration of glucose had the same dynamics of movements in different periods of reproductive cycle and in control gilts, but at a lower level, especially towards the end of pregnancy and after farrowing.

Table 3. The concentration of total serum glucose in gilts with normal lactation and hypo and/or agalactia (mmol/l)

Time	Normal lactation	Hypo and/or agalactia	P<0,05
II	4,09 ± 0,54	4,14 ± 0,60	NSS
III	4,62 ± 0,52	4,21± 0,56	YSS
IV	4,89 ± 0,62	4,19 ± 0,52	YSS
V	4,87 ± 0,62	4,07 ± 0,40	YSS

Statistical analysis of results of glucose in the blood serum of gilts with normal lactation and those with hypo-and/or agalactia has shown that there is a significant difference in the pre-farrowing (III) period, on the first and on the seventh day after farrowing (IV, V).

Table 4. The concentration of calcium in the blood serum of gilts with normal lactation (mmol/l)

Time	$\overline{X}$	Sx	SD	CV%	P<0,05 for groups
II	2,16	0,05	0.21	9,04	III,IV,V
III	2,48	0,05	0,20	7,38	II
IV	2,39	0,05	0,24	9,21	II,V
V	2,55	0.06	0,31	11,51	II,IV

From the results obtained it is shown that the concentration of calcium in the blood serum is statistically significantly higher immediately before and after

partus compared to the period of early pregnancy. Calcium is essential for skeleton and teeth development, so its level is being increased during pregnancy.

Table 5. The concentration of calcium in the blood serum of sows with lactation disturbed (mmol/l)

Time	$\overline{X}$	Sx	SD	CV%	P<0,05 for groups
II	2,19	0,07	0.24	10,08	III,IV,V
III	2,47	0,07	0,14	4,92	II
IV	2,47	0,07	0,26	9,76	II,V
V	2,48	0.07	0,22	8,19	II

From the obtained result it is shown that the concentration of total serum calcium in gilts with hypo and/or agalactia had the same dynamics of movements in different periods of reproductive cycle, as well as in control gilts, without disorders of lactation.

Table 6. Total serum calcium concentration in gilts with normal lactation and hypo and/or agalactia (mmol/l)

Time	Normal lactation	Hypo and/or agalactia	P<0,05
II	2,16 ± 0,21	2,19 ± 0,24	NSS
III	2,48 ± 0,20	2,47 ± 0,14	NSS
IV	2,39 ± 0,24	2,47 ± 0,26	NSS
V	2,55 ± 0,31	2,48 ± 0,22	NSS

Statistical processing of results of serum calcium for individual time intervals of the reproductive cycle did not establish significant differences between control gilts with normal lactation and those with hypo and/or agalactia.

Table 7. The concentration of phosphorus in the blood serum of gilts with normal lactation (mmol/l)

Time	$\overline{X}$	Sx	SD	CV%	P<0,05 for groups
II	2,16	0,14	0.81	33,42	III,IV,V
III	2,18	0,06	0,27	11,53	II,IV
IV	2,24	0,06	0,29	11,80	II,V
V	2,26	0.07	0,34	15,09	II,III;IV

From the results obtained it can be seen that the serum phosphorus concentration has been increasing at all stages of the reproductive cycle.

Table 8. The concentration of phosphorus in the blood serum of gilts with disturbed lactation (mmol/l)

Time	$\overline{X}$	Sx	SD	CV%	P<0,05 for groups
II	2,12	0,20	0.74	29,43	NSS
III	2,16	0,10	0,33	13,44	NSS
IV	2,22	0,14	0,52	21,20	NSS
V	2,25	0.17	0,60	24,72	NSS

Serum phosphorus concentrations in gilts with hypo and/or agalactia had the same dynamics of movements in different periods of the reproductive cycle as in control gilts without disorders of lactation.

Table 9. Serum concentrations of total phosphorus in gilts with normal lactation and hypo and/or agalactia (mmol/l)

Time	Normal lactation	Hypo and/or agalactia	P<0,05
II	2,16± 0,81	2,12 ± 0,72	NSS
III	2,18 ± 0,27	2,16± 0,33	NSS
IV	2,24 ± 0,29	2,22 ± 0,52	NSS
V	2,26 ± 0,34	2,25 ± 0,60	NSS

Statistical processing of results of serum phosphorus concentrations for some time intervals in gilts with normal lactation and in gilts with disturbed lactation did not establish significant differences.

Discussion

The results we obtained, were compared with those in literature, especially with the results obtained by *Sattler et al. (2005)*. The results we obtained by determining the concentration of calcium and phosphorus in serum of farrowed sows correspond to obtained levels of concentration of those authors. The obtained results of calcium and phosphorus concentrations in the tested serum samples of pregnant gilts and first farrowing sows showed that the homeostatic and homeorhetic mechanisms of regulation of calcemia and phosphatemia of tested gilts were preserved, and so the concentration of calcium and phosphorus were within normal limits in all investigated periods of reproduction *(Nitovski, 1993).* This applies to gilts with normal lactation, as well as to gilts where some disorders of lactation were registered. Interestingly, the concentration of serum calcium was statistically significantly higher in peripartum period than in early pregnancy. With the start of lactation there was an increase of calcemia and on the seventh day after farrowing it was 2.5 mmol/l in sows with normal lactation and about the same in the sows with disturbed lactation (2.46 mmol/l).

For our investigations it is important to point out that the analyses of the results of calcemia and phosphatemia in gilts with normal lactation and those with disturbed lactation indicate that the concentrations of calcium and phosphorus were within normal limits with both groups of gilts, and that they did not cause formation of hypo and/or agalactia.

Concentration of glucose levels in blood was also discussed with regard to the appearance of hypo and/or agalactia of sows, because glucose is a precursor in the synthesis of lactose in mammary gland. Glucose metabolism has been regulated by, inter alia, lactogenic hormones (insulin, glucocorticosteroids, ACTH, STH, thyroid hormone) *(Nitovski, 1993)*. In our studies, the concentration of glucose in the blood serum of gilts with normal lactation ranged from 4.07 to 4.85 mmol/l depending on the period of reproduction. Glycemia was significantly lower at the start of pregnancy that in the end of pregnancy and in the first days of lactation (Table 1) The results were within the values that got in their research *Koricki (1986)*. However, we did not find such dynamics of glycemia in gilts with hypo and/or agalactia. In those gilts the glucose concentration was at the start of pregnancy at the same level as in gilts with normal lactation (4.12/4.07), but unlike gilts with normal lactation, in gilts with disturbed lactation the glucose concentration was not increased during pregnancy and the first days after farrowing. Since we have found, concerning the gilts with disorders of lactation, even lower concentration of cortisol compared to gilts with normal lactation in some other papers, such lower glycemia could be explained as a result of reduced gluconeogenesis in those animals due to hypocorticalism. Since the glucose is the precursor in the synthesis of lactose in mammary gland, its synthesis was also reduced and thus lactation. Binding of cortisol in cells of mammary gland has been positively correlated with the consumption of glucose in mammary gland *(Gorewit et al., 1977).*

Conclusion

Concentration of serum glucose in gilts with normal lactation was in the range of 4.12 to 4.94 mmol/l depending on the period of reproduction. It was at a lower level in the beginning of pregnancy, than it was at the end of pregnancy and after partus. Such increase of glycemia was not found in gilts with disturbed lactation, even they had almost the same glycemia as the control ones 4.12/4.10.
Statistically significant lower glucose concentration in serum of gilts with hypo and/or agalactia must be borne in mind when considering the etiopathogenesis of those disorders of lactation.

Concentrations of serum calcium and phosphorus ranged within normal limits in all investigated time periods of reproduction in both gilts with normal lactation and in gilts with disturbed lactation. This suggests that the homeostatic

and homeorhetic mechanisms for those two elements were preserved and that they did not take part in the development of hypo and/or agalactia in gilts.

Nivo glukoze, kalcijuma i fosfora u krvnom serumu prvopraskinja sa normalnom i poremećenom laktacijom

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Rezime

Glavni zadatak u intenzivnom svinjogojstvu je dobrobit životinja, posebno očuvanje njihovih fizioloških funkcija, homeostaze i homeoreze i laktacije. Nivo glukoze, kalcijima i fosfora u krvi ima važnu ulogu u zaštiti fiziološkog statusa.

Ovo istraživanje je urađeno na jednoj modernoj farmi zatvorenog tipa u Žitorađi sa ciljem da prikaže nivo glukoze, kalcijuma i fosfora u krvnom serumu nazimica i krmača prvopraskinja tokom graviditeta i post partum. U ogledu je učestvovalo 30 suprasnih nazimica od osemenjavanja do partusa. Krv je uzimana iz vene jugularis tridesetog dana posle osemenjavanja, deset dana pre prašenja, jedan dan posle prašenja i sedam dana posle prašenja.

Koncentracija glukoze u krvnom serumu nazimica sa normalnom laktacijom je bila signifikantno viša deset dana pre prašenja (4,62 mmol/l) i prvog (4,92 mmol/l) i sedmog dana posle prašenja (4,94 mmol/l) u odnosu na koncentraciju glukoze tridesetog dana pre prašenja(4,12 mmol), ali ovo povećanje nismo mogli naći kod nazimica sa poremećajem laktacije. Koncentracija kalcijuma pre partusa (2,16 mmol) i post partum (2,55 mmol/l), kod krmača sa normalnom laktacijom, pokazivala je signifikantnu razliku u odnosu na koncentraciju kalcijuma na početku graviditeta ($p<0,05$) kao i kod nazimica sa poremećenom laktacijom. Koncentracija fosfora nije pokazivala signifikantnu razliku kod nazimica sa normalnom i poremećenom laktacijom (2,26: 2,25 mmol/l).

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