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Haematological and biochemical parameters during pregnancy and lactation in sows

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ABSTRACT

The aim of this research was to describe changes in serum concentrations of some micronutrients, and haematological parameters during pregnancy and lactation of sows. Data presented here were obtained by using blood samples from healthy, conventionally managed sows from a breeding herd. The samples were taken at three different points in the physiological production process: I. from the 30^{th} to 35^{th} day following artificial insemination; II. from the 81^{st} to the 87^{th} day of pregnancy; III. from the 12^{th} to the 20^{th} day of lactation. Erythrocyte count, haematocrit, MCV, leukocyte count and copper concentration decreased during pregnancy ($P<0.05$), while haemoglobin concentration decreased during both pregnancy and lactation ($P<0.05$). MCH increased at high pregnancy and decreased during lactation. Serum ALT activity, sodium concentration and inorganic phosphorus concentration decreased towards the end of pregnancy and lactation. Concentration of glucose increased during lactation. During pregnancy, zinc concentration increased. Results from this research could help to improve interpretation of laboratory data of sows during pregnancy and lactation.

Key words: normal values, biochemistry, haematology, breeding sows

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Introduction

The importance of metabolic profile in sow husbandry has been well known for a long time. Namely, metabolic disturbances caused by inappropriate feeding without clinical symptoms are significant in sow husbandry and may cause insufficiently developed breeding

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sows and impair breeding performance (FURCHT, 1988; RADOSTITS et al., 2000). Through the complex system of surveillance of metabolism it is possible to detect early aberrations in metabolic pathways and, with appropriate instructions, to correct ongoing disturbances.

Determination of "normal values" for blood haematology and biochemistry is important for the clinical interpretation of laboratory data. Published data propose erratic reference values that are often obtained from a relatively small number of animals of heterogeneous age and breed, different husbandry practices and time of gestation and lactation. There are also differences in the time of the year, the way in which samples were obtained and methods used to evaluate the samples (HEATH et al., 1991). FAUSTINI et al. (2000) also thought that "normal" values should be determined by each laboratory, considering age of subjects, sample size and methods of analysis. Especially important are trace elements, particularly copper, zinc and iron (ELBERS et al., 1994). As all animal species are sensitive to their shortage, particularly during the anabolic phase, their uctuation is of great significance (KANEKO, 1997).

The aim of this work was to determine reference values of different haematological and biochemical parameters of sows during pregnancy and lactation.

Materials and methods

Sows sampled. The research was carried out at a breeding farm in Northern Croatia and included 240 sows aged 1 to 7 years of the following breeds: Swedish Landrace, cross-breeds between Swedish Landrace and Yorkshire and German Landrace. Average mass of gilts was 90 to 95 kg, and other sows 120 to 200 kg. All sows sampled were clinically normal, lived under the same conditions and were held individually. They were fed with commercially prepared dry mixture for sows. Pregnant sows were on a restricted feeding regime (2.1 kg of mixture daily) while the lactating sows were fed ad libitum.

Sows were divided into three groups, each consisting of 80 animals. The first group comprised sows artificially inseminated 30 to 35 days earlier. The second group comprised sows pregnant 81 to 87 days, and the third group comprised sows 12 to 20 days post partum. Animals were routinely vaccinated against Erysipelas suum and treated with anthelmintic in food twice a year. Samples were taken from the animals between 7:00 and 9:00 a. m. prior to morning feeding.

Sample collection. Blood was taken from the v. cava cranialis into evacuated glass containers (Vacutainers, Becton Dickinson). For serum collection we used tubes without anticoagulants. Blood samples for the determination of haematological values were taken into containers with ethylene diaminotetra-acetic acid (EDTA) as an anticoagulant. The containers for serum were centrifuged within 2 hours at 1200 g for 10 min.

Analytical methods. Haemathological and biochemical analyses were carried out in the laboratory of the Clinic for Internal Diseases. Erythrocyte count (RBC), haemoglobin concentration (Hb), mean cell volume (MCV), haematocrit (HCT), mean cell haemoglobin (MCH), mean cell haemoglobin concentration (MCHC), and leukocyte count (WBC) were measured using an automated blood analyser «Serono» (Serono-Baker Diagnostic Inc., Allentown, Pennsylvania, USA). Sera samples were analysed by automated analyser RA-1000 «Technicon» (Technicon Instrument Corp., Tarrytown, USA) for aspartate aminotransferase (AST), alanine aminotransferase (ALT), glucose (Glu.), calcium (Ca), inorganic phosphorus (P), sodium (Na) and potassium (K). Reagents for all tests were supplied by «Randox» (Randox Laboratories Ltd., Antrim, United Kingdom). Enzyme activities were performed at 37 ºC. Iron, copper and zinc were determined by atomic-absorption spectrophotometer (Unicam SP 192, England).

Statistical analysis. The influence of age on sow groups was analysed. As no statistically significant interaction between age and group was found, in further analyses sows of a particular group were treated as being of the same age. Differences among groups for all parameters were treated by using ANOVA SAS statistical software. Differences were considered significant with P<0.05.

Results

Table 1. Haematology reference values for sows

Analyte	Unit	Group	N	Mean	SD	95% Confidence interval
		I	80	5.5^{a}	1.5	5.2-5.8
RBC	$\times 10^{12}$/L	II	77	4.1^{b}	1.2	3.8-4.4
		III	77	4.5^{b}	1.6	4.1-4.8
		I	62	155^{a}	17.4	151-159
Hb	g/L	II	77	133^{b}	17.2	129-137
		III	75	120^{c}	14.9	116-124
		I	74	78^{a}	8.2	77-80
MCV	FL	II	72	75^{b}	2.5	74-76
		III	64	75^{b}	4.3	73-76
		I	80	0.44^{a}	0.17	0.42-0.47
HCT	L/L	II	77	0.30^{b}	0.09	0.27-0.33
		III	76	0.34^{b}	0.13	0.31-0.37
		I	62	30.8^{b}	9.3	29-33
MCH	pg	II	78	34.7^{a}	8.7	33-37
		III	75	29.5^{b}	8.1	27-31
		I	61	4.2	1.6	3.9-4.6
MCHC	g/L	II	72	4.7	1.3	4.4-5.0
		III	75	4.0	1.3	3.7-4.3
		I	80	14.8	6.2	13.9-15.7
WBC	$\times 10^{9}$/L	II	73	8.7^{b}	1.7	7.8-9.7
		III	71	8.9^{b}	1.9	7.9-9.8

[a, b, c] Mean values for the same indicator that do not have the same letter in superscript are statistically significantly different (P<0.05).

Table 2. Biochemistry reference values for sows

Analyte	Unit	Group	N	Mean	SD	95% Confidence interval
AST	U/L	I	70	13.5	6.4	12.1-14.9
		II	71	12.2	4.9	10.8-13.6
		III	69	15.7	6.8	14.3-17.2
ALT	U/L	I	71	50.0[b]	15.7	46.7-53.3
		II	71	46.4[b]	16.5	43.1-49.7
		III	71	37.2[a]	10.2	33.9-40.5
Glu.	mmol/L	I	25	2.75[b]	0.66	2.5 - 3.0
		II	25	2.92[b]	0.85	2.6 - 3.2
		III	24	3.78[a]	0.49	3.5 - 4.1
Na	mmol/L	I	40	155.1[b]	7.8	152-158
		II	40	155.9[b]	10.5	153-159
		III	40	149.0[a]	12.1	146-152
K	mmol/L	I	40	5.26	0.59	5.0-5.5
		II	40	5.33	0.76	5.1-5.5
		III	40	5.13	0.76	4.9-5.4
Ca	mmol/L	I	78	2.55	0.18	2.5-2.6
		II	35	2.59	0.06	2.5-2.6
		III	28	2.57	0.11	2.5-2.6
P	mmol/L	I	78	2.19[b]	0.27	2.1-2.2
		II	77	2.19[b]	0.24	2.1-2.2
		III	79	1.90[a]	0.24	1.8-2.0
Cu	mmol/L	I	50	34.2[a]	14.8	31.0-37.3
		II	50	28.6[b]	7.6	26.4-30.8
		III	50	32.0	10.6	29.8-34.2
Zn	mmol/L	I	50	8.8[a]	2.6	7.5-10.0
		II	50	11.7[b]	4.4	10.5-12.9
		III	50	11.6[b]	5.0	10.4-12.8
Fe	mmol/L	I	50	17.9	3.7	16.5-19.4
		II	50	19.9	5.7	18.4-21.3
		III	50	21.2	6.1	19.7-22.7

[a, b] Mean values for the same indicator that do not have the same letter in superscript are statistically significantly different ($P<0.05$).

Mean value, number of animals, standard deviation and 95% confidence interval (reference range) of haematological and biochemical parameters in sow sera are presented in Tables 1. and 2. Erythrocyte count, HCT, MCV, leukocyte count and copper concentration significantly decreased during gravidity, while haemoglobin concentration decreased during gravidity and lactation. ALT activity, as well as levels of sodium and phosphorus, decreased during late gravidity and lactation. Glucose concentration increased in the same period. Zinc concentration was higher throughout gravidity.

Discussion

In swine production, determination of haematology and blood chemistry parameters is of primary interest in connection with the detection of health problems. For evaluation of laboratory results, availability of reference values is a prerequisite.

Glucose concentration remained unchanged during pregnancy period and then increased significantly during lactation. An increase in glucose concentration was also found by other authors (KUDLAČ et al., 1988). Changes in glucose concentration that occur during transition from gravidity to lactation are the result of physiological changes in metabolic processes which take place at the beginning of lactation. Glucose delivery and uptake by the mammary gland are a rate-limiting step of milk synthesis. It is thought that insulin-independent glucose uptake decreases in tissues, except for the mammary gland, and insulin resistance in the whole body increases following the onset of lactation (KOMATSU et al., 2005).

Alanin aminotransferase activity was unchanged during gestation, but decreased significantly during lactation. Aspartate aminotransferase activity was unchanged during the examination. With regard to AST activity values, our results are similar to those obtained by REESE et al. (1984). KUDLAČ et al. (1988) established a significant increase in AST activity during lactation. BENJAMINSEN and DISHINGTON (1981) found a significant increase in ALT activity after weaning. The authors concluded that increased metabolism rate after parturition, together with possible energy loss, may lead to cellular hypoxia. This, as a consequence, has increased cell membrane permeability and leaking of the enzymes out of cell.

Average values of sodium and potassium in our research did not change during pregnancy. Our results of measurement of the electrolyte level during gravidity correspond with the previous results of MRLJAK et al. (1993). HEATH et al. (1991) obtained the same results for potassium in 77 pregnant sows, while URSACHE et al. (1980) established on the 76^{th} day of pregnancy higher potassium levels that were significantly decreased on the 23^{rd} day of lactation. URSACHE et al. (1980) and REESE et al. (1984) recorded lower values then we did. The reason for lower values may partially be due to the method used in analysis. Namely, ame photometry gives 6-7% lower values in relation to the method of ion-selecting electrode (KANEKO, 1997). After parturition, sodium and potassium have a negative balance, as mentioned by RADOSTITS et al. (2000). During lactation, the requirement for these two electrolytes is increased because of high milk extraction.

Our results demonstrated unchanged calcium concentration during the research period, which suggests that homeostatic mechanisms were effective. URSACHE et al. (1980) obtained a calcium level during pregnancy and lactation similar to our results. Calcium values obtained by REESE et al. (1984) also correspond to our values. Inorganic phosphorus values were stable during gestation, whereas these values decreased significantly during lactation. Our values are lower than those obtained by URSACHE et al. (1980), but REESE et al. (1984)

obtained much lower values still. The reason for the decrease in inorganic phosphorus, according to FURCHT (1988), may be the type of diet with very low phosphorus content (animal beet leaves, silage), or components with a low portion of phosphorus that is not readily available (cereals), or a too low level of animal proteins and/or inadequate mineral supplementation. It is important to emphasize that high levels of calcium also restrict phosphorus availability and therefore necessarily lead to a too low blood phosphorus level. Sows have relatively high phosphorus level in milk (PFEFFER, 1972).

Microelement metabolism is very intensive during pregnancy and especially during late pregnancy and lactation. Through further measurements in our research it was established that copper values at the beginning of pregnancy were increased. Copper level in sera of sows pregnant up to 5 weeks is similar to values obtained by ELBERS et al. (1994). Lower values for the period between the 21st and 35th day of gestation were reported by MALINOWSKA (1986). RAINA et al. (1990) consider that hypercupremia during pregnancy is the result of mobilisation of copper from mother's tissue, especially liver. The increase in copper level during gestation is connected to increased concentration of ceruloplasmin, the production of which is induced by higher levels of oestrogen and progesterone. During lactation, copper values did not change significantly.

Zinc level at the beginning of gestation is in congruence with the results of KALINOWSKI and CHAVEZ (1986). Values that were a little higher were obtained by MALINOWSKA (1986), while ELBERS et al. (1994) reported significantly higher values. Zinc level can be in uenced by different factors such as stress, hormones, pregnancy, ovulatory cycle, fasting, starvation and changed levels of albumins, and total proteins in plasma (RADOSTITS et al., 2000). In the second group, zinc level was significantly increased (Table 2). MALINOWSKA (1986) has obtained for the pregnancy period from the 85th to the 112th day values of 11.75 μmol/L. KALINOWSKI and CHAVEZ (1986) reported higher results (14.99 μmol/L) obtained on nine sows. Lactation zinc values remained unchanged and were in congruence with values obtained by DE RUIJTER et al. (1988). During lactation a substantial amount of zinc is transferred by the mammary gland from maternal circulation into milk. Thus, secretory mammary epithelial cells must tightly regulate Zn transport to ensure optimal Zn transport to suckling neonate (KELLEHER and LONNERDAL, 2005).

Concentration of iron in sera during gestation and lactation did not change significantly. Results obtained in the first group do not differ significantly from those reported by ELBERS et al. (1994). Higher values have been measured in research carried out by CALVO et al. (1989). There can be different in uences on iron values, some of which are: method used for determination of iron; time between feeding and collecting of sample, and partially the time of the day and swine breed (PULS, 1988). Concentration of iron in the second group does not differ significantly from those reported by CALVO et al. (1989), who considered that in the first two months of pregnancy there is a constant decrease of plasmatic iron level, and afterwards the value increases until the 110th day of pregnancy. The same authors considered that a maximum degree of iron from depots in the sows occurs between 8th and 10th week of pregnancy, which is in accordance with our results. Namely, this is the time of the production of uteroferrine, the protein that is included in iron transportation from mother to foetus (BUHI et al., 1983).

In our research, erythrocyte count, Hb, HCT and MCV were significantly decreased during pregnancy. Approximately 2 weeks before parturition, red cell parameters in the sow decrease and continue to do so until the end of lactation DUNGAN et al. (1995). According to CALVO et al. (1989) haemoglobin decreased significantly during first half of gestation time, with the lowest values in the second month after insemination. Haemoglobin values decrease during pregnancy not only due to the mobilisation of the mother's haemoglobin into foetal circulation, but also due to dilution of blood which occurs as a consequence of plasma volume increase (SINGH et al., 1991) that is present in that period. In the first group the mean haemoglobin concentration was 155 g/L, and haematocrit 0.44 L/L. According to FURCHT (1988) values of haemoglobin above 140 g/L and haematocrit above 0.43 L/L indicate that the animals are fattened. During lactation the haemoglobin level decreases significantly, its concentration being approximately 120 g/L. Leukocyte count of the first group was in accordance with the values reported by ELBERS et al. (1994). In lactation, leukocyte count remains unchanged, which is in accordance with the results of URSACHE et al. (1980).

References

BENJAMINSEN, E., W. I. DISHINGTON (1981): Plasma constituents in the sow. Minerals, glucose, urea-N, protein and transaminases in relation to weaning. Acta vet. Scand. 22, 382-390.

BUHI, W. C., CH. A. DUCSAY, F. F. BARTOL, F. W. BAZER, R. M. ROBERTS (1983): A function of the allantoic sac in the metabolism of uteroferrin and maternal iron by fetal sow. Placenta 4, 455-470.

CALVO, J. J., J. R. ALLUE, A. ESCUDESO, L. J. GARCIA (1989): Plasma ferritin of sows during pregnancy and lactation. Cornell Vet. 79, 273-282.

DE RUIJTER, K., J. H. M. VERHEIJDEN, A. PIJPERS, L. A. M. G. VAN LEENGOED, J. BERENDS (1988): Fever and Changes in Plasma Zinc and Iron Concentrations in the Sow. J. Vet. Med. A 35, 247-251.

DUNGAN, L. J., D. B. WEIST, D. A. FYTE, A. C. SMITH, M. M. SWINDLE (1995): Normal hematology, serology, and serum protein electrophoresis values in fetal Yucatan miniature swine. Lab. Anim. Sci. 45, 285-289.

ELBERS, A. R., M. J. GEUDEKE, H. VAN ROSSEM, M. C. KROON, G. H. COUNOTTE (1994): Haematology and biochemistry reference values for sows kept under modern management conditions. Vet. Q. 16, 127-130.

FAUSTINI, M., E. MUNARI, C. COLOMBANI, V. RUSSO, G. MAFFEO, D. VIGO (2000): Haematology and plasma biochemistry of Stamboek pre-pubertal gilts in Italy: reference values. J. Vet. Med. A 47, 525-532.

FURCHT, G. (1988): Ernährungsbedingte Stoffwechselstörungen beim Schwein. Jena, Web Gustav Fischer Verlag.

HEATH, M. F., R. J. EVANS, A. C. J. GRESHAM (1991): Blood biochemical reference ranges for sows under modern management conditions. Br. vet. J. 147, 331-339.

KALINOWSKI, J., E. R. CHAVEZ (1986): Low dietary zinc intake during pregnancy and lactation of gilts. I. Effects on the dam. Can. J. Anim. Sci. 66, 201-216.

KANEKO, J. J., W. HARVEY, M. L. BRUSS (1997): Fluid, Electrolyte, and Acid-Base Balance. In: Clinical Biochemistry of Domestic Animals. 5th ed. (Carlson, G. P., Ed.). Academic Press. San Diego, London, Boston, New York, Sydney, Tokyo, Toronto. pp. 485-516.

KELLEHER, S. L., B. LONNERDAL (2005): Zip 3 plays a major role in zinc uptake into mammary epithel cells and is regulated by prolactin. Am. J. Physiol. Cell. Physiol. 288, 1042-1047.

KOMATSU, T., F. ITOH, S. KUSHIBIKI, K. HODATE (2005): Changes in gene expression of glucose transportes in lactating and nonlactating cows. J. Anim. Sci. 83, 557-564.

KUDLAČ, E., Z. VLČEK, A. HLOUŠEK, B. STUDENČIK, J. NEDBALKOVA (1988): Zmeny v biochemicke skladbe krve prasnic v puerperiu. Vet. Med. 33, 401-410.

MALINOWSKA, A. (1986): Zmiany zawartosci cynku, miedzi i ceruloplazminy w plynach biologicznych i tkankach macior i ich plodow podczas ciqzy. Medycyna Weterynaryina 42, 368-372.

MRLJAK, V., M. BAUER, LJ. BEDRICA, V. ZIDAR (1993): Sodium and potassium circulation in the breeder sow serum in the critical reproductive cycle phases. Vet. arhiv 63, 181-190.

PFEFFER, E. (1972): Mineralstoffbedarf in der Laktation. Handbuch der Tierernährung. Vol. 2: Leistungen und Ernährung. Eds. Lenkeit W., Breirem K., pp. 407-415.

PULS, R. (1988): Mineral levels in animal health. Diagnostic data. Clearbrook, Sherpa International.

RADOSTITS, O. M., C. C. GAY, D. C. BLOOD, K. W. HINCHCLIFF (2000): Diseases Caused by Nutritional Deficiencies. In: Veterinary Medicine. 9th ed. London, New York, Philadelphia, San Francisco, St. Louis, Sydney. pp. 1477-1559.

RAINA, V., A. P. S. NARANG, A. W. BANDAY, W. K. BHAN (1990): Copper and Zinc Levels in Maternal and Fetal Cord Blood. Trace Elem. Med. 7, 186-187.

REESE, D. E., E. R. Jr. PEO, A. J. LEWIS, A. HOGG (1984): Serum chemical values of gestating and lactating swine: Reference values. Am. J. Vet. Res. 45, 978-980.

SINGH, R., S. P. S. SINGHA, R. SINGH, M. S. SETIA (1991): Distribution of trace elements in blood, plasma and erythrocytes during different stages of gestation in buffalo (*Bubalus Bubalis*). Buffalo J. 1, 77-85.

URSACHE, O., E. MEISSONNIER, L. CHEVRIER, C. QUINCHON, J. P. TILLON (1980): Profil Biochimique des truies reproductrices. II. Resultats en elevage de type experimental. Revue Med. Vet. 131, 75-82.

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ŽVORC, Z., V. MRLJAK, V. SUŠIĆ, J. POMPE GOTAL: Hematološki i biokemijski pokazatelji u krmača tijekom suprasnosti i laktacije. Vet. arhiv 76, 245-253, 2006.

SAŽETAK

Cilj ovog istraživanja bio je opisati promjene koncentracije minerala, metabolita i aktivnost enzima te hematoloških vrijednosti za vrijeme suprasnosti i laktacije krmača. Na osnovi dobivenih rezultata moglo bi se brzo odrediti zdravstveno stanje stada. Predočeni podatci dobiveni su iz krvnih uzoraka zdravih, tradicionalno uzgajanih svinja iz jednoga stada. Uzorci su uzimani u tri različita perioda: I - od 30. do 35. dana nakon umjetnoga osjemenjivanja; II - od 81. do 87. dana suprasnosti; III - od 12. do 20. dana laktacije. Broj eritrocita, hematokrit, MCV, broj leukocita i koncentracija bakra u krvi smanjili su se za vrijeme suprasnosti ($P<0,05$). Razina hemoglobina bila je smanjena za vrijeme suprasnosti i laktacije ($P<0,05$). Razina MCH se povećala u visokom stupnju suprasnosti, a smanjila za vrijeme laktacije. Aktivnost ALT, koncentracija natrija i neorganskoga fosfora smanjivali su se prema kraju suprasnosti i laktacije. U istom razdoblju zabilježen je statistički značajan porast koncentracije glukoze. Koncentracija cinka povećavala se za vrijeme suprasnosti. Rezultati ovoga istraživanja mogu biti korisni za bolje razumijevanje laboratorijskih nalaza u svinja tijekom suprasnosti i laktacije.

Ključne riječi: fiziološke vrijednosti, biokemija, hematologija, rasplodne svinje