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CHEMICAL COMPOSITION OF THE COLOSTRUM AND MILK OF SOWS FED DIETS CONTAINING NAKED OATS

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Key words: sow nutrition, milk composition, lactoglobulins, milk fatty acids.

Abstract

The aim of the study was to determine the chemical composition of the colostrum and milk of sows fed diets containing naked oats. The study was carried out on 45 Polish Landrace sows assigned to three groups, 2 experimental and one control, with 15 individuals in each group. In the late gestation period the sows were also fed a diet including naked oats. The ration fed to the experimental groups contained 20% (D_1) and 40% (D_2) naked oats of the *Akt* variety. The chemical composition of the colostrum and milk of the sows was tested during the first, second and third lactation. Colostrum and milk for chemical analysis were collected on days 1, 7 and 21 of lactation (basic composition) following prior administration of 2 ml of oxytocin. The level of lactoglobulins in the colostrum and milk was determined on days 1 and 7 of lactation, and the fatty acid profile on day 7. On both days 7 and 21 of lactation the milk of the sows in the experimental groups had a higher percentage of fat than in the control. The milk of the experimental sows also contained higher percentages of linoleic and linolenic acids. Statistically significant differences ($P < 0.01$) were shown in the percentages of these acids in the milk of sows during each lactation between the D_2 groups and the control groups.

SKŁAD CHEMICZNY SIARY I MLEKA LOCH ŻYWIONYCH DIETĄ Z UDZIAŁEM OWSA NAGIEGO

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Abstrakt

Celem pracy było określenie składu chemicznego siary i mleka loch żywionych dietą zawierającą owies nagi. Badanie przeprowadzono na 45 lochach rasy polskiej białej zwisłouchej, przydzielonych do trzech grup: dwóch doświadczalnych i jednej kontrolnej – po 15 osobników w każdej. W okresie wysokiej ciąży badane lochy były również żywione dietą z udziałem owsa nagiego. Mieszanka podawana grupom doświadczalnym zawierała 20% (D_1) i 40% (D_2) owsa nagiego odmiany *Akt*. Skład chemiczny siary i mleka loch badano w trzech kolejnych laktacjach, począwszy od pierwszej do trzeciej laktacji włącznie. Siarę i mleko do analiz chemicznych pobierano w 1., 7. i 21. dniu laktacji (skład podstawowy) po uprzednim podaniu 2 ml oksytocyny. Poziom laktoglobulin w siarze i mleku określono w 1. i 7. dniu laktacji, natomiast profil kwasów tłuszczowych w 7. dniu. W obu dniach laktacji (w 7. i 21.) mleko loch z grup eksperymentalnych wykazywało wyższy odsetek tłuszczu niż z grupy kontrolnej. Mleko loch z grup doświadczalnych zawierało również wyższy odsetek kwasu linolowego i linolenowego. Wykazano statystycznie istotne różnice (P < 0,01) w procentowej zawartości tych kwasów w mleku loch w poszczególnych laktacjach między grupami D_2 a grupami kontrolnymi.

Introduction

Milk production by sows is one of the most important performance characteristics affecting the development of piglets. Changes in the chemical composition and the milk yield of sow are the result of genetic (WALKIEWICZ at al. 2000) and environmental factors (MIGDAŁ and KACZMARCZYK 1990, BUCZYŃSKI at al. 2003), but depend mainly on nutrition (KOKETSU at al. 1996b, MIGDAŁ 1996, KIM and EASTER 2001, WOLTER at al. 2002). KIM and EASTER (2001) note that complete fulfilment of the nutritional needs of sows during pregnancy and lactation are reflected in a substantial increase in the content of protein, amino acids and fat in their milk, particularly in the early stage of lactation. Many authors (BOYD at al. 1979, MOSER and LEVIS 1981, PETTIGREW 1981) confirm the beneficial effect of adding fats to feed rations for sows on lipid content in the colostrum and milk and on milk yield. When vegetable oils are included in the diet of sows, either during advanced pregnancy or during the entire pregnancy and lactation, fat content in the colostrum and milk increases and the ratio of essential unsaturated fatty acids to saturated fatty acids in the fat is more beneficial to piglets (COFFEY at al. 1994, MIGDAŁ 1996). KOKETSU et al. (1996a) used high-energy feed rations during lactation and observed increased secretion of insulin, glucose and luteotropic hormone (LH), both during lactation and after the piglets were weaned.

One of the valuable components of feed rations for pigs is oats. Due to the genetic lack of a hull, naked oats have a different chemical composition from that of hulled oats. The greatest differences are in the content of fibre, protein and fat – the components that primarily determine the nutritional and energy value of fodder (PELTONEN-SAINIO 1997, CZUBASZEK 2003, DUBIS and BUDZYŃSKI 2003). Naked oats have higher energy value and protein content than other cereals regarded as the most beneficial for feeding monogastric animals (PETKOV at al. 2001). An important component of oats with and without hulls is fat, the content of which ranges from 6% to 8% of dry matter (PIECH at al. 2003, PISULEWSKA at al. 2011). The fat of naked oats is dominated by unsaturated fatty acids (UFA), which account for 80% of the fat (PISULEWSKA at al. 1999). The lipids in oats have been found to contain compounds with strong antioxidant properties, such as tocopherols, ferulic acid, caffeic acid, polyphenolic compounds, their esters and amides, alkylphenols, flavonoids and avenanthramides (PETERSON 2001). Studies by STASIAK et al. (2000), MAZUR and STASIAK (2006) found that feed rations containing naked oats had a beneficial effect on reproductive performance indicators in gilts and sows.

The aim of the study was to determine the chemical composition of the colostrum and milk of sows fed diets containing naked oats.

Material and Methods

The study was carried out on 45 Polish Landrace sows assigned to three groups, 2 experimental and one control, with 15 individuals in each group. The sows were fed complete feed rations in amounts consistent with the requirements given in *Nutrient requirements of pigs* (1993). The feed ration fed to the experimental groups contained 20% (D_1) and 40% (D_2) naked oats of the *Akt* variety. In the late gestation period the sows were also fed a diet including naked oats. The chemical composition of naked oat was determined before the experiment on the animals was begun. The following were determined in the samples:

– content of crude protein, ether extract, crude ash, and crude fibre according to AOAC (2000);

– content of mineral nutrients Ca and Na by atomic absorption spectroscopy (ASA) and total phosphorus according to FISKE and SUBBAROW (1925);

– protein amino acid content by ion-exchange chromatography in an automatic amino acid analyser;

– fatty acid composition by gas chromatography using a chromatograph (Varian GC3800). The fatty acid profile of the fat of the naked oats was as follows: unsaturated fatty acids – 81.17%, including monounsaturated fatty acids – 44.45% (mainly oleic acid) and polyunsaturated fatty acids – 36.72% (mainly linoleic acid – 35.27% and linolenic acid – 1.41%). The composition and nutritional value of the diet fed to the sows during pregnancy and lactation is presented in Table 1.

Table 1

The composition and nutritive value of the diets for pregnant and lactating sows

Feed [%]	Before 90^{th} day of gestation			Lactation		
	K	D_1	D_2	K	D_1	D_2
Naked oats meal	–	20.00	40.00	–	20.00	40.00
Wheat meal	40.00	20.00	–	40.00	20.00	–
Barley meal	48.40	48.45	48,50	40.00	40.05	40.10
Soybean meal	9.00	9.00	9.00	17.00	17.00	17.00
2-Ca phosphate	0.90	0.90	0.90	1.00	1.00	1.00
Fodder chalk	1.30	1.30	1.30	1.30	1.30	1.30
Premixture L-lysine 50%	0.10	0.05	–	0.30	0.25	0.20
NaCl	0.30	0.30	0.30	0.40	0.40	0.40
Calculated analysis [g kg^{-1}]:						
EM MJ	12.75	12.89	13.03	12.72	12.87	13.01
crude protein [g]	136.32	137.18	138.03	159.00	159.85	160.71
crude fat [g]	20.32	30.17	39.98	20.39	30.24	40.10
lysine [g]	5.96	5.97	5.98	8.56	8.57	8.58
methionine+cystine [g]	4.84	4.95	5.06	5.40	5.51	5.62
Ca [g]	7.78	7.73	7.69	8.53	8.48	8.43
P [g]	5.55	5.64	5.73	6.09	6.18	6.27
Na [g]	1.35	1.36	1.37	1.77	1.78	1.79

The chemical composition of the colostrum and milk of the sows was tested during the first, second and third lactation. Colostrum and milk for chemical analysis were collected on days 1, 7 and 21 of lactation (basic composition) following prior administration of 2 ml of oxytocin. The level of lactoglobulins in the colostrum and milk was determined on days 1 and 7 of lactation, and the fatty acid profile on day 7. The samples collected were stored at -20°C. The percentage of fat, protein and lactose were determined in a Milko-Scan infrared milk analyser. The concentration of immunoglobulin (IgG) was determined by radial immunodiffusion (RID) with the Binding Site RID kit manufactured by the British company Binding Site Limited. The content of fatty acids was determined by gas chromatography.

Statistical analysis of the results was carried out using one-way analysis of variance (effect of group). The tables present mean values for the characteristics tested and the standard deviation. Differences between means from each group were tested by Duncan's range test.

Results and Discussion

The chemical composition of the colostrum and milk of sows fed different diets is presented in Table 2. The amount of protein in the colostrum and milk of the sows showed little variation between groups. No statistically significant differences were noted for the traits analysed. The colostrum collected on the first day of the third lactation contained somewhat more protein and lactoglobulin (group D_2 – 12.38% and 106.42 mg ml^{-1}). The content of milk protein in sows milk at 7 and 21 days of lactation was higher than 5%. According to studies by MIGDAŁ and KACZMARCZYK (1990) and COFFEY et al. (1982), milk contains 5–6% proteins, which is in agreement with the values obtained in the present study.

Table 2

Chemical composition of the colostrum and milk of sows (mean ± SD)

Lactation number	Sampling date	Experimental groups	Total protein [%]	Fat [%]	Lactose [%]	Lactoglobulins [mg ml^{-1}]
I	1st day	K	10.90 ± 0.95	4.52 ± 0.50	3.42 ± 0.37	94.21 ± 7.11
		D_1	11.00 ± 1.01	4.71 ± 0.59	3.31 ± 0.30	94.50 ± 7.54
		D_2	11.24 ± 0.98	4.97 ± 0.69	3.28 ± 0.32	95.82 ± 8.43
	7th day	K	5.37 ± 0.48	6.59 ± 0.73	5.01 ± 0.44	0.95 ± 0.25
		D_1	5.26 ± 0.46	7.00 ± 0.90	5.10 ± 0.42	1.10 ± 0.21
		D_2	5.45 ± 0.52	7.17 ± 0.81	4.90 ± 0.43	1.09 ± 0.16
	21st day	K	5.19 ± 0.42	6.00 ± 0.79	5.10 ± 0.37	–
		D_1	5.17 ± 0.45	6.05 ± 0.84	5.07 ± 0.36	–
		D_2	5.31 ± 0.48	6.30 ± 0.80	5.00 ± 0.39	–
II	1st day	K	12.00 ± 1.02	5.20 ± 0.95	3.35 ± 0.35	99.87 ± 9.43
		D_1	11.93 ± 1.07	5.39 ± 0.90	3.21 ± 0.32	100.22 ± 9.94
		D_2	12.16 ± 1.00	5.58 ± 0.85	3.14 ± 0.30	101.76 ± 10.14
	7th day	K	5.32 ± 0.44	7.00 ± 0.85	5.00 ± 0.41	1.10 ± 0.26
		D_1	5.42 ± 0.43	7.14 ± 0.81	4.90 ± 0.39	1.27 ± 0.23
		D_2	5.48 ± 0.49	7.41 ± 0.79	4.85 ± 0.43	1.24 ± 0.20
	21st day	K	5.26 ± 0.48	6.15 ± 0.71	5.20 ± 0.34	–
		D_1	5.35 ± 0.46	6.31 ± 0.72	5.10 ± 0.36	–
		D_2	5.55 ± 0.44	6.50 ± 0.78	4.80 ± 0.37	–
III	1st day	K	12.10 ± 1.10	5.49 ± 0.85	3.24 ± 0.33	100.40 ± 8.94
		D_1	12.21 ± 1.09	5.64 ± 0.79	3.11 ± 0.30	104.51 ± 9.67
		D_2	12.38 ± 1.04	5.81 ± 0.84	3.03 ± 0.27	106.42 ± 10.34
	7th day	K	5.42 ± 0.48	6.95 ± 0.82	4.96 ± 0.41	1.35 ± 0.37
		D_1	5.32 ± 0.47	7.01 ± 0.84	5.05 ± 0.40	1.39 ± 0.31
		D_2	5.48 ± 0.50	7.22 ± 0.83	4.84 ± 0.39	1.42 ± 0.24
	21st day	K	5.15 ± 0.42	5.90 ± 0.79	5.21 ± 0.39	–
		D_1	5.20 ± 0.40	6.36 ± 0.80	5.04 ± 0.30	–
		D_2	5.28 ± 0.43	6.45 ± 0.81	5.05 ± 0.31	–

Fat content varied considerably between groups. The milk of the sows in the experimental groups contained more fat than the milk from the control on both the 7th and 21st days of lactation. Fat content was highest in group D_2, ranging on day 7 from 7.16% (first lactation) to 7.41% (second lactation), while on day 21 it ranged from 6.30% (first lactation) to 6.50% (second lactation).

The transition from colostrum to milk causes the level of protein to fall and that of fat and lactose to rise (MIGDAŁ and KACZMARCZYK 1990). This also confirms our findings.

Lactoglobulins noted an upward trend in the colostrum of sows fed a diet containing oats naked. The highest values included colostrums from group D_2 (101.76 – 106.42 mg ml^{-1}) in second and third lactations. BLAND et al. (2003) and RZĄSA (2007) found that colostrum contained on average 61–93 g l^{-1} IgG. The level of IgG in the colostrum of the sows in the present study should be regarded as very good.

The fatty acid profile of the milk lipids on day 7 of lactation is presented in Table 3. Among saturated fatty acids the highest proportion was that of palmitic acid – from 29.30% to 31.84%. The highest content of this acid, 31.84%, was found in the milk from the first lactation of the sows of the control group. The percentage of saturated fatty acids in the milk was highest in the control, at 41.21%. Unsaturated fatty acids were predominant in the total pool of analysed fatty acids. The highest percentage of oleic acid, 40.18%, was found in the milk of the group D_2 sows during their third lactation. Analysis of the results presented in Table 3 reveals higher percentages of this fatty acid in the experimental groups in which the sows were fed diets containing naked oats. The milk of the experimental sows also contained higher percentages of linoleic

Table 3

The fatty acid profile of the milk lipids on the 7th day of lactation of sows

Fatty acids	I Lactation			II Lactation			III Lactation		
	K	D_1	D_2	K	D_1	D_2	K	D_1	D_2
SFA:									
Lauric $C_{12:0}$	0.35	0.33	0.30	0.33	0.31	0.29	0.29	0.28	0.26
Myristic $C_{14:0}$	3.22	3.05	2.99	3.15	3.08	2.86	3.00	2.95	2.80
Pentadecanoic $C_{15:0}$	0.10	0.10	0.09	0.09	0.09	0.08	0.10	0.08	0.08
Palmitic $C_{16:0}$	31.84	31.42	30.40	31.65	31.05	30.02	31.38	30.74	29.81
Margaric $C_{17:0}$	0.49	0.45	0.42	0.45	0.43	0.41	0.47	0.43	0.41
Stearic $C_{18:0}$	5.01	5.08	4.97	4.95	5.12	5.01	5.00	5.14	5.06
Arachidic $C_{20:0}$	0.20	0.17	0.15	0.19	0.17	0.14	0.18	0.17	0.15
Total SFA	41.21	40.60	39.32	40.81	40.25	38.81	40.42	39.79	38.57
UFA:									
Myristooleic $C_{14:1}$	0.20	0.16	0.17	0.18	0.15	0.16	0.19	0.17	0.18
Palmitooleic $C_{16:1}$	10.15	9.80	9.72	10.02	9.76	9.86	10.20	9.92	9.81
Oleic $C_{18:1}$	38.52	38.79	39.75	38.83	39.10	39.99	38.92	39.27	40.18
Linoleic $C_{18:2}$	7.98^{Bb}	8.61^{a}	8.91^{A}	8.25^{B}	8.65	9.01^{A}	8.31^{B}	8.74	9.10^{A}
Linolenic $C_{18:3}$	0.36^{B}	0.47	0.49^{A}	0.37^{B}	0.48	5.52^{A}	0.40^{B}	0.49	0.50^{A}
Eicosenoic $C_{20:1}$	0.32	0.31	0.34	0.31	0.32	0.33	0.30	0.33	0.32
Cis11, 14-eicosenoic $C_{20:2}$	0.37	0.36	0.38	0.36	0.38	0.39	0.36	0.38	0.39
Arachidonic $C_{20:4}$	0.89	0.90	0.92	0.87	0.91	0.93	0.90	0.91	0.95
Total UFA	58.79	59.40	60.68	59.19	59.75	61.19	59.58	60.21	61.43

Means within a row with no common letters (A,B) differ significantly at $p \leq 0.01$
Means within a row with no common letters (a,b) differ significantly at $p \leq 0.05$

and linolenic acids. Statistically significant differences ($P < 0.01$) were shown in the percentages of these acids in the milk of sows during each lactation between the D_2 group and the control treatment.

The quantity and quality of milk produced by sows determines the health condition and body weight of their piglets and the number of piglets weaned per litter. Changes in the amount of milk produced by the sow and in its chemical composition depend mainly on nutrition (WIELBO 1995, MIGDAŁ 1996, KIM and EASTER 2001, PIETRAS and BAROWICZ 2002). DARRAGH and MOUGHAN (1998) report that the nutrients contained in milk remain at a constant level (with slight fluctuations in the case of optimal nutrition), which remains unchanged even when the level of one of the components is increased in the feed. According to REKIEL (2003), the level of nutrients in milk may increase only when an optimal diet is introduced for sows that are in poor condition or are inadequately nourished during lactation. Kim and EASTER (2001) state that complete fulfilment of nutritional needs during pregnancy and lactation leads to an increase in the content of protein, amino acids and fat in the milk of sows, particularly in the early stage of lactation. The chemical composition of colostrum and milk also depends on the stage of lactation, litter number, and number of piglets in the litter (BELSTRA at al. 1999, HODBOD and ZEMAN 2001, KIM and EASTER 2001). Milk composition does not stabilize until the second week of lactation (CSAPO et al. 1996). The albumin fraction of whey proteins in colostrum contains immunoglobulins IgG, IgA and IgM. The basic antibodies of colostrum are immunoglobulins G(IgG) (BLECHA 1998), which determine passive immunity in piglets. Piglets fed colostrum with a higher concentration of immune lactoglobulins are more resistant to post-natal stress, have a higher survival rate and a faster growth rate. Research has been conducted for many years aimed at developing feeding systems that enhance immunity, e.g. the use of immune proteins as a feed supplement to prevent diarrhoea in piglets (STEFANIAK 2006) or administration of immunostimulants to pregnant sows to improve the immune parameters of colostrum (KRAKOWSKI at al. 1999). Fat content in the milk was highly variable, and somewhat higher in the experimental groups. MIGDAŁ (1996) found that as the amount of fat consumed by the sow increases, the amount of fat secreted by the sow increases as well. BUCZYŃSKI et al. (2003) determined that piglets consuming milk with higher fat content had higher body weight on their 21st day of life. BAIDOO et al. (1992) also found that high-energy feed rations had a beneficial effect on the chemical composition of sows; milk. The addition of fat caused an increase in its content in the milk of the sows, which in turn positively affected the development of the piglets.

Milk fat is the most concentrated source of energy, hence the importance of its fatty acid composition, which determines its nutritional value (MIGDAŁ

1996). The present study showed a slightly higher percentage of unsaturated fatty acids, including essential ones, in the milk of sows from the experimental groups in comparison with the control. MIGDAŁ (1996) found a higher concentration of unsaturated fatty acids in the milk of sows whose feed rations were supplemented with rapeseed oil in comparison with those receiving the feed without oil. Similar results were obtained by WIELBO (1995) and VAN DEN BRAND et al. (2000). High content of polyunsaturated fatty acids in the colostrum and milk of sows receiving vegetable oil in their diet had a beneficial effect on the growth and development of their piglets (MIGDAŁ 1996, BABINSZKY 1998, PIETRAS and BAROWICZ 2002, BAROWICZ et al. 2003).

Conclusions

There were no significant differences in the amount of protein in colostrum and sows milk from control and experimental groups. Colostrum and milk of sows fed a diet involving naked oats had a slightly higher percentage of protein and fat.

Unsaturated fatty acids constituted the highest proportion of the lipid fraction of the milk on the 7^{th} day of lactation. The level of these acids was highest in the group of sows fed a ration with 40% naked oats. A highly significant difference was noted in the concentrations of linoleic and linolenic acids between the control and D_2 groups in three successive lactations. The 40% of dietary inclusion of naked oats contributed to the highest level of UFA in milk and improved its nutritive value.

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References

AOAC. 2000. *Official Methods of Analysis*. International, 17th ed., AOAC Inter., Gaitherburg, MD, USA.

BABINSZKY L. 1998. *Dietary fat and milk production.* In: *The lactating sow*. Eds. M.W.A. Verstegen, P.J. Moughan, J.W. Schrama. Wageningen Press, pp. 143–158.

BAIDOO S.K., AHERNE F.X., KIRKWOOD R.N., FOXCROFT G.R. 1992. *Effect of feed intake during lactation and after weaning on sows reproductive performance.* Can. J Anim. Sci., 72: 799–807.

BAROWICZ T., PIESZKA M., PIETRAS M. 2003. *Wpływ zastąpienia soli wapniowych tłuszczu utylizacyjnego przez sole wapniowe oleju lnianego w dawkach pokarmowych loch na wyniki reprodukcji oraz odchowu prosiąt.* Rośliny Oleiste, 24(1): 289–295.

BELSTRA B.A., DIEKMAN M.A., SINGLETON W.L., RICHERT B.T. 1999. *Effect of lactation length and steroid hormone treatment on embryonic survival and peripheral steroid concentrations in multiparous sows.* Purdue University Swine Day Reports – Anim. Sci., 7–9.

BLAND I.M., ROOKED J.A., BLAND V.C., SINCLAIR A.G., EDWARDS S.A. 2003. *Appearance of immunoglobulin G in the plasma of piglets following intake of colostrum, with or without a delay in suckling.* Anim. Sci., 77: 277–286.

BLECHA F. 1998. *Immunological aspects: comparison with other species*. In: *The lactating sow*. Eds. M.W.A. Verstegen, P.J. Moughan, J.W. Schrama. Wageningen Press, pp. 4–21.

BOYD R.D., MOSER B.O., LEWIS A.J., PEO E.R. JR., NIZINO R.D. 1979. *Effect of energy source administrated to sows perior parturition on energy pattern of plasma metabolities associated with glucose homeostatis on neonatal pigs*. J. Anim. Sci. 49, Suppl., 1: 78.

BUCZYŃSKI J., SKRZYPCZAK E., SZULC K. 2003. *Skład mleka loch*. Prace z Zakresu Nauk Rol., WPTP Poznań, Suppl., pp. 125–131.

COFFEY M.T., DIGGS B.G., HANDLIN D.L., KNABE D.A., MAXWELL C.V., JR., NOLAND P.R., PRINCE T.J., GROMWELL G.L. 1994. *Effects of dietary energy during gestation and lactation on reproductive performance of sows: a cooperative study*. J. Anim. Sci., 72: 4–9.

COFFEY M.T., SEERLEY R.W., MABRY J.W. 1982. *The effect of source of supplemental dietary energy on sow milk yield, milk composition and litter performance*. J. Anim. Sci., 55(6): 1388–1394.

CSAPO J., MARTIN T.G., CSAPO-KISS Z.S., HAZAS Z. 1996. *Proteins, fats vitamin and mineral concentrations in porcine colostrum and milk from parturition to 60 day*. Int. Dairy J., 6: 881–902.

CZUBASZEK A. 2003. *Wybrane cechy fizyczne i skład chemiczny ziarna kilku odmian owsa*. Biul. IHAR, 229: 307–316.

DARRAGH A.J., MOUGHAN P.J. 1998. *The composition of colostrum and milk*. In: *The lactating sow*. Eds. M.W.A. Verstegen, P.J. Moughan, J.W. Schrama. Wageningen Press.

DUBIS B., BUDZYŃSKI W. 2003. *Reakcja owsa nagoziarnistego i oplewionego na termin i gęstość siewu*. Biul. IHAR, 229: 139–146.

FISKE C.H., SUBBAROW Y. 1925. *The colorimetric determination of phosphorus*. J. Biol. Chem., 66(2): 375–400.

HODBOD P., ZEMAN L. 2001. *Changes in milk composition of sows during 28 days of lactation*. Czech J. Anim. Sci., 46(12): 509–513.

KIM S.W., EASTER R.A. 2001. *Nutrient mobilization from body tissues as influenced by litter size in lactating sows*. J. Anim. Sci., 79(8): 2179–2186.

KOKETSU Y., DIAL G.D., PETTIGREW J.E., MARSH W.E., KING V.L. 1996a. *Influence of imposed feed intake patterns during lactation on reproductive performance and on circulating levels of glucose, insulin, and luteinizing hormone in primiparous sows*. J. Anim. Sci., 74: 1036–1046.

KOKETSU Y., DIAL G.D., PETTIGREW J.E., MARSH W.E., KING V.L. 1996b. *Characterization of feed intake patterns during lactationin commercial swine herds*. J. Anim. Sci., 74: 1202–1210.

KRAKOWSKI L., KRZYŻANOWSKI J., WRONA Z., SIWICKI A.K., KRAKOWSKI M. 1999. *Wpływ podawania ciężarnym lochom wybranych immunostymulatorów na parametry immunologiczne siary*. Med. Wet., 55(9): 608–610.

MAZUR A., STASIAK A. 2006. *Analiza wyników użytkowości rozpłodowej oraz zmiany masy ciała loch w pierwszym cyklu rozrodczym żywionych mieszankami z udziałem owsa nagoziarnistego*. Annales UMCS, sect. EE, 24(19): 133–139.

MIGDAŁ W. 1996. *Tłuszcze i glukoza w żywieniu loch*. Zeszyty Naukowe AR Kraków, Rozprawa habilitacyjna nr 213.

MIGDAŁ W., KACZMARCZYK J. 1990. *Skład chemiczny siary i mleka loch*. Post. Nauk Roln., 1(2): 63–72.

MOSER B.D., LEWIS A.J. 1981. *Fat additions to sows – a review*. Pig News and Information, 2: 265–269.

Nutient requirements of pigs. Nutritive value of feedstuffs. 1993. PAN, Warszawa. The Kielanowski Institute of Animal Physiology and Nutrition (Editor), Jabłonna (Poland).

PELTONEN-SAINIO P. 1997. *Groat yield and plant stand structure of naked and hulled oat under different nitrogen fertilizer and seeding rates*. Agron. J., 89: 140–147.

PETERSON D.M. 2001. *Oats antioxidants*. J. Cereal Sci., 2: 115–129.

PETKOV K., PIECH M., LUBOWICKI R., ŁUKASZEWSKI Z., JASKOWSKA I., BIEL W. 2001. *Ocena wartości pokarmowej ziarna owsa nieoplewionego i oplewionego w żywieniu świń*. Rocz. Nauk. Zoot., 28(2): 151–157.

PETTIGREW J.E. Jr. 1981. *Supplemental dietary fat for peripartal sows. A review*. J. Anim. Sci., 53: 107–117.

PIECH M., MACIOROWSKI R., PETKOV K. 2003. *Plon ziarna i składników pokarmowych owsa nieoplewionego i oplewionego uprawianego przy dwóch poziomach nawożenia azotem*. Biul IHAR, 229: 103–113.

PIETRAS M., BAROWICZ T. 2002. *Wpływ tłuszczu pokarmowego na skład chemiczny oraz profil kwasów tłuszczowych w siarze i mleku loch*. Med. Wet., 58: 134–137.

PISULEWSKA E., TOBIASZ-SALACH R., WITKOWICZ R., CIEŚLIK E., BOBRECKA-JAMRO D. 2011. *Wpływ warunków siedliska na ilość i jakość lipidów w wybranych formach owsa.* Żywn. Nauka Technol. Jakość, 3(76): 66–77.

PISULEWSKA E., WITKOWICZ R., BOROWIEC F. 1999. *Wpływ sposobu uprawy na plon oraz zawartość i skład kwasów tłuszczowych ziarna owsa nagoziarnistego*. Żywn. Nauka Technol. Jakość (Suppl.), 6: 240–245.

REKIEL A. 2003. *Wybrane aspekty fizjologiczne i produkcyjne laktacji loch.* Acta Sci. Pol., Zootechnica, 2(2): 101–112.

RZĄSA A. 2007. *Wpływ budowy anatomicznej gruczołu sutkowego loch lub zastosowania Anty-H Somnus na wyniki odchowu prosiąt.* Zesz. Nauk. UP Wrocław, Rozprawy 549.

STASIAK A., WALKIEWICZ A., KAMYK P., DZIURA J. 2000. *Charakterystyka rozwoju narządów rozrodczych i płodności potencjalnej loszek żywionych dawkami z udziałem owsa nagoziarnistego.* Roczn. Nauk. PTZ, 48: 283–289.

STEFANIAK T. 2006. *Control of intestinal diseases by dietary supplementation with antibodies.* Biol. Nutr. Grow. Anim., 4(8): 285–309.

VAN DEN BRAND H., HEETKAMP M. J., SOEDE N.M., SCHRAMA J.W., KEMP B. 2000. *Energy balance of lactating primiparous sows as affected by feeding level and dietary energy source.* J. Anim. Sci., 78(6): 1520–1528.

WALKIEWICZ A., WIELBO E., MATYKA S., BURDZANOWSKI J., BABICZ M. 2000. *Skład chemiczny mleka loch i wyniki odchowu prosiąt mieszańców z różnym udziałem krwi świni syjamskiej.* Biul. Nauk., 7: 299–305.

WIELBO E. 1995. *Określenie biologicznej i gospodarczej efektywności stosowania dodatków tłuszczów naturalnych w żywieniu loch użytkowanych rozpłodowo.* Rozpr. Nauk. 180, AR Lublin.

WOLTER B.F., ELLIS M., CORRIGAN B.P., DEDECKER J.M. 2002. *The effect of birth weight and feeding of supplemental milk replacer to piglets during lactation on preweaning and postweaning growth performance and carcass characteristics.* J. Anim. Sci., 80(2): 301–308.