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Chemical Composition of Colostrum and Sow's Milk Depending on the Day of Lactation

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Colostrum and later sow's milk is indispensable food for piglets in the first period of their life (Barowicz and Kwolek, 2001, Skrzypczak et al., 2015). Despite the early start of feeding of the piglets with full-blend food, it is colostrum and milk that are the basic food types they ingest. It provides all the necessary nutrients for the regular growth and breeding of young animals (Edwards, 2002, Rząsa et al., 2004, Le Dividich et al., 2005, Rząsa, 2007, Quesnel et al., 2012). Many authors particularly emphasise the immunological (Pastoret, 2007, Pejsak, 2006, Pejsak and Truszczyński, 2007, Pomorska-Mól and Markowska-Daniel, 2009) and the energy supply role of colostrum (Pejsak, 2006, Devillers et al., 2007; Theil et al., 2014) as the factors directly affecting the survival of suckling pigs (Quesnel et al., 2012, Theil et al., 2014). It is estimated that 200 g of colostrum taken during the first day of life is the minimum intake reducing piglets mortality before the shunt, providing passive immunity and minimal body weight gains (Quesnel et al., 2012). Sows' lactation and the ability to feed the litter are among the most important factors affecting the reproductive capacity of sows and their usefulness for further raising (Skrzypczak et al., 2013). The production of milk by sows in the last decades has significantly increased and now amounts to about 9.5 kg of milk/day (Babicz et al., 2016), which, however, still does not allow to maximise the growth rate of piglets. A factor limiting the growth rate of pigs is not only the amount of produced milk but also its quality (Revell et al., 1998; Migdał et al., 2004, Koska and Eckert, 2016; Declerck, 2017). The results of the sow milk tests indicate a large variation in the content of primary chemical components, not always easy to justify and often resulting from the impact of unidentified factors (Rząsa, 2007).

The purpose of the research was to determine the effect of the day of lactation on the content of selected chemical components and the profiles of fatty acids for colostrum and sow's milk.

Materials and methods

The composition of colostrum and milk of 30 PIC hybrid sows was assessed. In the determination of the content of selected components of colostrum and milk, the impact of the day of lactation was taken into account.

During the research, the content of dry matter, ash, crude protein, whey protein, colostrum fat and sow milk as well as the profiles of fat acids were determined. During the research, the sows were fed with cereal-soybean complete mixes, balanced in accordance with the valid national standards (Nutritional recommenda-tions..., 2015). The samples of colostrum were collected one hour after delivery, milk in 2-3 hours and on the 28th day of lactation. Colostrum and milk were collected by hand. Before the milk was taken, the intramuscular injection of 2 ml of synthetic oxytocin was necessary (about 15 minutes earlier).

Chemical analyses of milk were carried out in the laboratory of the Department of Animal Nutrition and Feed Management of the Warmian-Mazurian University in Olsztyn. Crude protein and whey protein content was determined according to the methods presented by Żegarska et al. (1991). The content of crude protein was determined by the Kjeldahl method. Casein proteins were isolated by precipitation of a clot using the solution of acetic acid and sodium acetate. The resulting casein clot was collected on a hard, nitrogen-free filter. The filtrate obtained by the isolation of casein proteins was used to determine whey protein content. In the alkaline environment, whey proteins were precipitated at the boiling temperature conditions and then isolated on the filter. The nitrogen content of whey proteins was determined by the Kjeldahl method. The obtained results of the total nitrogen concentration of individual protein fractions were converted into the total protein content and serum proteins of the analysed samples of colostrum and sow milk.

The concentration of fat in milk was determined using the Roese-Gottlieb extraction method. In order to release fat from protein combinations, the milk was treated with ammonium base, then ethyl alcohol was added and fat was extracted with a mixture of ethers (ethyl and petrol ether). The fat content was determined by evaporation of the solvent.

The amount of dry matter in the samples of colostrum and milk was determined with the use of the weight-drying technique according to AOAC (2005), and then the obtained samples were subjected to total mineralisation and the crude ash content was determined by weight.

The content of fatty acids in colostrum fat and milk fat was determined by gas chromatography by means of using fat obtained from samples of colostrum and milk with the Roese-Gottlieb method. The fatty acid methyl esters necessary for the analysis were prepared according to the modified Peisker method (Żegarska et al., 1991). The separation and determination of individual fatty acids was carried out using a Varian CP-3800 gas chromatograph (carrier gas - helium) using the flame ionisation detector (FID; detector temperature of 250°C) and a capillary column (200°C) and a dosing unit (split 50: 1, 225°C). The size of the applied sample was equal to 1 µl. For the purpose of identifying fatty acids the retention time of the maximal peaks of single methyl esters of fatty acid standards (Sigma - Aldrich) was compared to the maximum peaks of the methyl esters of fatty acids of the analysed sample. The relative amount of the specified fatty acids was expressed as a percentage content of the total fatty acid in a given sample (Żegarska et al., 1991, AOAC, 2005).

The differences between the means and the relevance levels were determined using the analysis of variance and Duncan's test. The obtained results were analysed statistically (STATISTICA VERSION 12.0). The significance of differences between the mean values of the analysed features in groups was verified by a one-factor analysis of variance with the Duncan's test.

The results and their discussion

During the experiment colostrum collected one hour after delivery and milk taken in 2-3 hours and on the 28th day of lactation were analysed. The assessment of the chemical composition of milk indicated high significant differences ($P \leq 0.01$) in the content of dry matter, crude ash, crude protein and whey protein and fat between colostrum (on the 1st day of lactation) and sow milk (days 2-3, day 28 of lactation) (Tab. 1).

Colostrum was characterised by a higher content of crude protein (by 41%), while milk had a higher concentration of crude ash and fat (by 30 and 53%, respectively). Statistically significant and highly significant differences were also confirmed in the concentration of dry matter and whey protein between milk taken on day 2 or 3 of lactation and milk collected after the 28th day of lactation (by 8 and 54%, spectively, $P \leq 0.01$ and $P \leq 0.05$). There was also an increase in fat concentration and a gradual reduction in the content of dry matter, crude protein and whey protein, which was not confirmed statistically (Tab. 1).

The results of our own research were confirmed in the data presented by Barowicz et al. (2002), Migdał et al. (2003), Fuchs et al. (2007) and Koska and Eckert (2016), who point out to higher content of dry matter and protein in colostrum, and in milk to higher content of fat. The research by Migdał et al. (2003), Mazur and Stasiak (2006), Fuchs et al. (2007), in turn, confirm the increase in fat concentration and the reduction of protein content along with subsequent lactation days and the results obtained by Barowicz et al. (2002) and Migdał et al. (2003) also confirm tendencies for gradual decrease in dry matter content. Research carried out by Yun et al. (2014) indicates a similar concentration of total protein and whey proteins in sow's milk. On the 7th day of lactation, the authors recorded 4.32% of crude protein and 3.42% of whey protein, and on the 12th day of lactation, respectively, the values were 3.17% and 3.94%. Klobasa et al. (1987) showed higher whey protein content than in our own studies on the 1st day of lactation - 14.3% (immediately after delivery) and on the 28th day of lactation - 2.8%, and on days 2-3 of lactation the results were similar to those found during own research - approx. 3.8 %. Both own research and the results obtained by the above mentioned authors confirm the finding by Klobasa et al. (1987) and Csapo et al. (1996) of the gradual reduction of concentration of whey protein in milk along with subsequent lactation days. These authors indicate that the total amount of whey protein in colostrum can be as high as 90%, and then gradually decreases - 70% (24 hours after delivery). According to Theil and Hurley (2016), in mature milk, the content of whey protein is about 50%.

Table 1. The content (%) of selected chemical components in the colostrum and milk of sows depending on the day of lactation

Item	*Day of lactation*			SEM
	1	2-3	28	
Dry matter	23.28 A	20,34 Ba	18,69 Cb	0.40
Crude ash	0.62 A	0.88 B	0.88 B	0.04
Crude protein	14.06 A	6.11 B	5.36 B	0.57
Whey protein	7.18 A	3,52 Ba	1,62 Cb	0.05
Fat	2.79 A	6.17 B	5.69 B	0.28

* A,B – P≤0,01, ** a, b – P≤0,05.

Table 2. Fatty acid composition (% of total acids) of sow's colostrum and milk

Item	*Day of lactation*			SEM
	1	2–3	28	
SFA	48.24	42.78	42.55	2.49
MUFA	33.73 a	42.18..	43.38..	1.59
PUFA	18.03	15.08	14.07	1.44
UFA	51.76	57.22	57.45	2.49
OFA	39.75	38.10	37.83	2.08
DFA	60.25	61.90	62.17	2.08
N-3	1.95	1.53	1.378	0.14
N-6	15.97	13.47	12.62	1.32

* a, b – P≤0,05

In the conducted research, the profile of fatty acids (percentage of total fatty acids) of milk from subsequent lactation days was also analysed (day 1 of lactation, days 2-3 of lactation, day 28 of lactation). The analysis shows that the share of mono-unsaturated fatty acids (MUFA) in total fatty acids was comparable in sow's milk on the 2nd or 3rd and on the 28th day of lactation, but higher than in colostrum (P≤0.05) (Table 2), which was confirmed by data provided by Migdał et al. (2003). In turn, Barowicz et al. (2002) recorded the highest concentrations of mono-unsaturated fatty acids (MUFA) on day 1 (46.38%), and the lowest on day 5 of lactation (45.75%). The results of our own research indicated the tendency of the increase in the level of unsaturated fatty acids (UFA), hypocholesterolemic fatty acids (DFA) and reducing the level of polyunsaturated fatty acids (PUFA), hypercholesterolemic fatty acids (OFA) and polyunsaturated fatty acids - omega 3 and 6 (n-3 and n-6), which was not confirmed statistically (Table 2). The decreasing concentration of poly-unsaturated fatty acids (PUFA) was also reported by Barowicz et al. (2002) and Migdał et al. (2003), whereas the results obtained by Mazur and Stasiak (2006) did not confirm the indicated dependence. Barowicz et al. (2002) also showed the increase in the concentration of fatty acids with hypocholesterolemic effect (DFA) along with subsequent lactation days, while the concentration of omega-3 acids remained at a similar level on all the lactation days (the first day of lactation approx. 2.0%, the 5th day – c. (1.8%), and the 22nd day – 2.1%). The research by Skrzypczak et al. (2015) indicated the higher level of unsaturated fatty acids (UFA), including omega 3 and 6 in colostrum (the first day of lactation) than in milk (day 14 of lactation). According to our own research, colostrum was characterised by a higher level of saturated fatty acids (SFA) in comparison with milk on days 2-3 and on the 28th day of lactation (Table 2).

Wielbo (1995), Etienne et al. (1999), Barowicz et al. (2002), Migdał et.al. (2003) and Skrzypczak et al. (2015) showed in their research higher concentrations of saturated fatty acids in milk than in colostrum. Skrzypczak et al. (2015) showed in their research a strong correlation of linoleic acid (n-6) with the weight of piglets (r = 0.456) and a negative correlation with piglet mortality (r = -0.312). These authors also emphasised the correlation between UFA in colostrum and milk with the body mass, growth rate and lower mortality. In turn, Migdał et al. (2003) indicated the possibility of changing the chemical composition of colostrum and sow's milk with the help of fat additives in the feeding of high-breeding sows. These authors, as a result of the use of the addition of linoleic isomers, observed the presence of these isomers in the colostrum of sows (the first day of lactation) and trace amounts in milk (day 8 and day 21 of lactation).

Summary

On the basis of the obtained results, it was found that colostrum collected an hour after delivery contained more protein (crude and whey) and dry matter while milk was characterised by a higher fat content. The analysis of the results of studies presented by other authors allows us to conclude that the recorded changes in the composition of milk are consistent with the genetic conditions of sows and do not differ from the data presented by other authors.

The profile of fatty acids changed depending on the day of lactation, which only in the case of mono-unsaturated fatty acids (MUFA) was confirmed statistically. Colostrum collected on the first day of lactation was characterised by a statistically significantly higher content. The differences in the concentration of other fatty acids have not been confirmed statistically.

Bibliography

AOAC (2005). Association of Official Analytical Chemists. Official Methods of Analysis. 18th ed. Gaitherburg, Maryland, AOAC International.

Babicz M., Kropiwiec K., Hałabis M. (2016). Wpływ systemu utrzymania i żywienia loch prośnych na ich behawior okołoporodowy, skład siary i mleka oraz wyniki użytkowości rozpłodowej. Ann. UMCS, Sect. EE, 34: 45–51.

Barowicz T., Kwolek M. (2001). Czynniki warunkujące mleczność lochy. Trzoda Chlew., 2: 28–30.

Barowicz T., Migdał W., Pieszka M. (2002). Skład chemiczny siary i mleka loch żywionych w trakcie ciąży oraz laktacji dawkami z udziałem oleju lnianego. Rośl. Oleiste, XXIII: 495–500.

Csapo J., Martin T.G., Csapo-Kiss Z.S., Hazas Z. (1996). Protein, fats, vitamin and mineral concentrations in porcine colostrum and milk from parturition to 60 days. Int. Dairy J., 6 (8–9): 881–902.

Declerck I. (2017). Sows' colostrum yield and piglets' colostrum intake: a challenge in high-prolific pig production (Doctoral dissertation, Ghent University); 222 pp.

Devillers N., Farmer C., Le Dividich J., Prunier A. (2007). Variability of colostrum yield and colostrum intake in pigs. Animal, 1 (7): 1033–1041.

Edwards S.A. (2002). Perinatal mortality in the pig: environmental or physiological solutions? Livest. Prod. Sci., 78 (1): 3–12.

Etienne M., Noblet J., Dourmad J.Y., Castaing J. (1999). Association of cell wall constituents and fat in the lactation diet of sows. Effects on digestive utilization and on milk and piglet composition. J. Rech. Porc. Franc., 31: 199–205.

Fuchs B., Rząsa A., Szuba-Trznadel A., Haremza D. (2007). Preparat drożdży piwnych podawany lochom prośnym i karmiącym jako czynnik stymulujący produkcyjność i zdrowotność prosiąt. Acta Sci. Pol., Zoot., 6 (4): 17–27.

Klobasa F., Werhahn E., Butler J.E. (1987). Composition of sow milk during lactation. J. Anim. Sci., 64 (5): 1458–1466.

Koska M., Eckert R. (2016). Wpływ otłuszczenia loch na skład chemiczny siary i mleka oraz ich użytkowość rozpłodową. Rocz. Nauk. Zoot., 43 (2): 147–162.

Le Dividich J., Rooke J.A., Herpin P. (2005). Nutritional and immunological importance of colostrum for the newborn pig. J. Agr. Sci., 143 (6): 469–485.

Mazur A., Stasiak A. (2006). Wpływ zawartości tłuszczu surowego w mieszance na skład chemiczny i profil kwasów tłuszczowych w mleku loch ras pbz i puławskiej. Ann. UMCS, Sect. EE, 21: 147–154.

Migdał W., Pieszka M., Barowicz T., Pietras M. (2003). Skład chemiczny siary i mleka loch otrzymujących sprzężony kwas linolowy w paszy. Med. Weter., 59 (4): 327–330.

Migdał W., Barowicz T., Pieszka M. (2004). Sprzężony kwas linolowy [CLA] w żywieniu loch – wpływ na odchów prosiąt. Prz. Hod., 72 (10): 17–20.

Pastoret P.P. (2007). Challenges and issues of early life vaccination in animals and humans. J. Comp. Path., 137: 1–2.

Pejsak Z. (2006). Siara – źródło energii i odporności biernej dla ssących prosiąt. Życie Wet., 81 (9): 588–591.

Pejsak Z., Truszczyński M. (2007). Uodparnianie noworodków i młodych zwierząt. Życie Wet., 82 (3): 183–186.

Pomorska-Mól M., Markowska-Daniel I. (2009). Siara jako źródło odporności humoralnej oraz komórkowej dla prosiąt osesków. Med. Weter., 65 (4): 237–240.

Quesnel H., Farmer C., Devillers N. (2012). Colostrum intake: influence on piglet performance and factors of variation. Livest. Sci., 146: 105–114.

Revell D.K., Williams I.H., Mullan B.P., Ranford J.L., Smits R.J. (1998). Body composition at farrowing and nutrition during lactation affect the performance of primiparous sows: II. Milk composition, milk yield, and pig growth. J. Anim. Sci., 76: 1738–1743.

Rząsa A. (2007). Wpływ budowy anatomicznej gruczołu sutkowego loch lub zastosowania surowicy anty-H. somnus na wyniki odchowu prosiąt. Zesz. Nauk. UP we Wrocławiu, Rozpr., 244: 1–80.

Rząsa A., Poznański W., Procak A., Akińcza J. (2004). Anatomical structure of the sow's udder and composition of milk. Ann. Anim. Sci., 2: 95–99.

Skrzypczak E., Szulc K., Babicz M., Buczyński J.T. (2013). Effect of teat order on piglet rearing results of native Złotnicka White breed. Arch. Tierz., 56 (62): 617–627.

Skrzypczak E., Waśkiewicz A., Beszterda M., Goliński P., Szulc K., Buczyński J.T., Babicz M. (2015). Impact of fat and selected profiles of fatty acids contained in the colostrum and milk of sows of native breeds on piglet rearing. Anim. Sci. J., 86 (1): 83–91.

StatSoft Inc. (2014). STATISTICA (data analysis software system), version 12; www.statsoft.com
Theil P.K., Hurley W.L. (2016). The protein component of sow colostrum and milk. In: Milk proteins – from structure to biological properties and health aspects. InTech, Rijeka, Croatia: 183–198.
Theil P.K., Lauridsen C., Quesnel H. (2014). Neonatal piglet survival: impact of sow nutrition around parturition on fetal glycogen deposition and production and composition of colostrum and transient milk. Animal, 8 (7): 1021–1030.
Wielbo E. (1995). Określenie biologicznej i gospodarczej efektywności stosowania dodatków tłuszczów naturalnych w żywieniu loch użytkowanych rozpłodowo. Rozpr. hab. Rozpr. Nauk. AR Lublin, 180: 1–48.
Yun J., Swan K.M., Vienola K., Kim Y.Y., Oliviero C., Peltoniemi O.A.T., Valros A. (2014). Farrowing environment has an impact on sow metabolic status and piglet colostrum intake in early lactation. Livest. Sci., 163: 120–150.
Zalecenia żywieniowe i wartość pokarmowa pasz dla świń (2015). Praca zbiorowa Grela E.R., Skomiał J. (red.). Instytut Fizjologii i Żywienia Zwierząt PAN, ss. 56–62.
Żegarska Z., Jaworski J., Borejszo Z. (1991). Ocena zmodyfikowanej metody Peiskera otrzymywania estrów metylowych kwasów tłuszczowych. Acta Acad. Agricult. Tech. Olst., 24: 25–33.

CHEMICAL COMPOSITION OF COLOSTRUM AND SOW'S MILK DEPENDING ON THE DAY OF LACTATION

Summary

The article presents the results of research on chemical composition of sow's colostrum and milk depending on the day of lactation. The research was carried out in 2016–2017 on a farm in the Warmian-Masurian voivodeship.

The day of lactation influences differences in the content of all analysed chemical components of sow's colostrum and milk. Sow's colostrum was characterized by higher content of proteins (crude and whey protein) and dry matter compared to sow's milk but ash and fat showed a higher content in milk. Day of lactation was the factor that also differentiated the fatty acid composition. Colostrum was characterized by higher content of monounsaturated fatty acids (MUFA) compared to milk collected on subsequent days of lactation.

Key words: sows, colostrum, milk, chemical composition, day of lactation

Photo1. Piglets suckling sow's milk on the 28th day of lactation