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RELATIONSHIPS BETWEEN CHEMICAL COMPOSITION OF COLOSTRUM AND MILK AND REARING PERFORMANCE OF PIGLETS DURING A 21-DAY LACTATION*

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Abstract

Normal development of piglets is determined principally by the milking ability of the sows. This study attempted to determine the relationships between sow's milk quality and rearing performance of the piglets. The experiment was carried out under uniform conditions, with standard feeding of the sows and a similar number of piglets per litter. The study accounted for 109 lactations of second- and third-parity Polish Large White (PLW) sows and 123 lactations of second- and third-parity Polish Landrace (PL) sows. Colostrum and milk were collected from the sows at 1, 7, 14 and 21 days of lactation and analysed for solids, crude protein, fat, lactose and somatic cell count (SCC). Rearing performance of second- and third-litter piglets was determined based on the number and weight of piglets at birth and at 7, 14 and 21 days of age. The coefficients of correlation, estimated between basic composition of milk and rearing performance of the piglets over subsequent weeks of lactation were low and exceeded r = 0.200 only for some traits. The experiment showed that a higher content of basic milk components, in particular protein, may be one of the factors contributing to an increase in weight gain of piglets during a 21-day lactation. Milk fat content may be of significance for rearing performance of piglets only during their first week of life. Rearing performance of the piglets is unrelated to udder health expressed as milk SCC.

Key words: sows, milk, rearing of piglets, coefficients of correlation

One of the factors influencing the profitability of pork production is the normal development of piglets, which is determined principally by the milking ability of the sows because milk is the main food for piglets during the first three weeks of life. Therefore, many studies were performed to determine the effect of various factors on the quality of sow's milk as reflected in the content of protein, fat or other components. The genetic value of sows may also exert some effect on the chemical

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composition of milk. However, this issue was mainly narrowed down to the differences between breeds (Boruta et al., 2009; Buczyński et al., 2006) or even to the differences between the wild boar and the pigs of different breeds (Walkiewicz et al., 1999) while neglecting the effect of genes (genetic markers) on milk chemical composition. The differences between the breeds in the composition of milk are related to their different resistance to environmental conditions (Gourdine et al., 2006), which has a direct effect on the course of lactation. Under conditions of high ambient temperature and high humidity, not only the quantity but also the quality of milk produced deteriorates. Many authors report that nutrition is the most important factor affecting the quality of milk (Beyer et al., 2007; McNamara and Pettigrew, 2002). In this connection attempts were made not only to modify the ration composition of lactating sows for energy and protein content, but also to use additives that might change the chemical composition of colostrum or milk (Ariza-Nieto et al., 2011).

The association of milk quality with piglet rearing traits was also analysed in terms of the effect of somatic cell count (Rekiel and Więcek, 2002; Babicz et al., 2011; Skrzypczak et al., 2012).

Regardless of the above research on milk composition, studies were also conducted on the mechanism of milk ejection, namely milking speed, milk yield of individual teats, etc. (Špinka et al., 2011). To date, no conclusive answer as to what measures should be taken to improve rearing performance in piglets has been found.

The present study is another attempt to determine the relationship between sow's milk quality and rearing performance in piglets. It should be noted that the experiment was conducted under uniform housing conditions and using standard feeding, with a similar number of piglets per litter.

Material and methods

Subjects were Polish Large White (PLW) and Polish Landrace (PL) sows of second and third parity (58 and 51 PLW sows and 65 and 56 PL sows, respectively). They were kept at the Experimental Station of the National Research Institute of Animal Production Żerniki Wielkie Ltd. During their productive life, sows were maintained under the same conditions and received the same complete feeds. Feeding system conformed to the farm standards and was adapted for lactating sows. The food ration contained 12.94 MJ metabolizable energy, 15% crude protein and 6.2% crude fat.

The study accounted for 109 lactations of second- and third-parity PLW sows and 121 lactations of second- and third-parity PL sows, and comprised all seasons of the year. Colostrum was collected from the sows up to six hours after birth (day 1). Milk was collected at 7, 14 and 21 days of lactation. Colostrum and milk were collected from the first, third and sixth teats in the amount of 50 ml (one milk sample). A total of 851 good milk samples was collected. The samples were later chilled to 4ºC and stored at this temperature until analysis. The samples of fresh milk were transported to the Laboratory for Milk Assessment and Analysis at the Wrocław University of

Environmental and Life Sciences to determine basic composition of the milk. Colostrum and milk were analysed for solids, crude protein, fat, lactose and somatic cell count (SCC).

To determine the relationships between colostrum and milk composition and rearing parameters of the piglets, only the litters with no deaths between 1 and 21 days of age and with birth litter size of 11 and 12 piglets were considered.

Rearing performance of second- and third-litter piglets was determined based on the following traits:

– number of piglets born alive,
– number of piglets at 7, 14 and 21 days of age,
– individual body weight of piglets at birth,
– individual body weight of piglets at 7, 14 and 21 days of age.

The data obtained were analysed statistically using the procedures of SAS (1998). The material was characterized for each breed separately. Three-way analysis of variance was performed for traits describing changes in chemical and cytological composition of milk according to the following model.

$$Y = a_i + b_j + c_k + e_{ijk}$$

where:

a_i – breed (1 = 1,2),
b_j – lactation (j = 1,2),
c_k – day of lactation (k = 1–4),
e_{ijk} – interaction variable error.

Two-way analysis was used for piglet rearing traits according to the following model:

$$Y= a_i +b_j +e_{ij}$$

where:

a_i – breed (1=1,2),
b_j – day of lactation (k=1-4),
e_{ij} – interaction variable error.

Next, Pearson correlations were determined between individual components of colostrum and milk, and between milk composition and piglet rearing parameters. These were computed from within-group variation (error) for both breeds together.

Results

Analysis of the chemical composition of colostrum and milk from PLW and PL sows, presented in Table 1, shows that compared to colostrum, sow's milk is characterized on each subsequent day of lactation by significantly higher ($P \leq 0.01$) fat and lactose content and somatic cell count, as well as lower protein and solids content. The content of milk components on subsequent days of lactation does not differ significantly in any of the breeds. When analysing differences in the chemical com-

position of colostrum between the breeds, it was found that compared to PLW sows, PL sows were characterized by significantly higher content of fat (by 1.32%, P≤0.01), protein (by 2.40%, P≤0.01) and solids (by 2.81%, P≤0.01). Colostrum from PL sows contained significantly less lactose (by 0.77%, P≤0.05) than colostrum from PLW sows. For individual chemical components of milk on subsequent days of lactation, no statistically significant differences were found between the breeds except for lactose content on day 21 (P≤0.05). Somatic cell count (SCC) was higher for both colostrum and milk from PL sows, but differences between the breeds were not significant.

Table 2 presents data on rearing performance of second- and third-litter piglets from PLW and PL sows. Analysis of these data indicates that compared to PL sows, PLW sows gave birth to significantly more piglets per litter, by 0.4 animal on average (P≤0.05). The body weight of these piglets was slightly smaller than that of PL sows, with a non-significant difference. However, the larger number of piglets born in this breed did not translate into better rearing performance on subsequent days of lactation, because better rearing parameters were obtained for litters of PL sows. It was found that compared to the PLW breed, PL sows were characterized by significantly higher weight gains to 7 days of age (in relation to day of birth), by 0.114 kg on average (P≤0.01) and had significantly higher body weight at 7 and also 14 days of age, by 0.15 kg on average (P≤0.01 and P≤0.05, respectively). Compared to PLW sows, a higher percentage of piglets reared was observed in each lactation period for the litters of PL sows. At 14 and 21 days of lactation, this parameter was significantly higher by 3.27% (P≤0.01) and 3.26% (P≤0.05), respectively.

Subsequent tables contain data on the coefficients of simple correlation between the content of basic components of colostrum (Table 3) and milk (Table 4) from sows of both breeds analysed. For colostrum (Table 3), statistically significant (P≤0.001) relationships were only found between solids content and amount of fat, protein and lactose, and between protein and lactose content. These correlation coefficients exceeded r=0.600. For milk (Table 4), the estimated correlations were mostly significant (P≤0.05; P≤0.01) except for the correlation between milk lactose and solids content, and between somatic cell count and other milk components. The highest relationships were determined between protein and lactose content (P≤0.01), between fat and solids content (P≤0.01), and between fat and protein content (P≤0.01).

Table 5 presents the coefficients of correlation between basic composition of milk and rearing performance of the piglets over subsequent weeks of lactation. In general, these relationships were low and not significant. Only for some traits at 7, 14 and 21 days of lactation did the coefficients of correlation exceed r=0.200. This especially concerns the relationship between weight gain of piglets to 7 days of lactation and the content of fat, protein and lactose in milk, as well as the relationships between weight gain of piglets to 14 days of lactation and protein content, and between weight gain of piglets to 21 days of lactation and solids content. A similar value of these coefficients was found for litter weight gain over subsequent weeks of lactation. In the case of piglet weight and litter weight, higher correlations occurred only on day 21 of lactation with solids content. No significant relationships were also found between the analysed rearing traits and somatic cell count except between piglet weight on day 21 of lactation and somatic cell count (P≤0.05).

Table 1. Basic chemical composition of milk from second- and third-lactation PLW and PL sows

		Day of lactation											
		1 (colostrum)			7			14			21		
		x	σ	significance between breeds	x	σ	significance between breeds	x	σ	significance between breeds	x	σ	significance between breeds
PLW 109 lactations	Fat %	4.02 ABC	2.33	**	7.55 A	1.52	ns	6.98 B	1.57	ns	6.83 C	1.82	ns
	Protein %	13.26 ABC	2.85	**	4.76 A	1.05	ns	4.70 B	1.38	ns	5.67 C	2.76	ns
	Lactose %	2.58 ABC	0.85	**	5.41 A	0.58	ns	5.60 B	0.59	ns	5.17 C	1.12	*
	Solids %	20.54 ABC	2.97	**	17.95 A	1.77	ns	17.64 B	1.08	ns	18.09 C	2.15	ns
	SCC (10^6)	0.897 ABC	0.87	ns	1.703 A	1.83	ns	1.801 B	1.680	ns	2.315 C	2.503	ns
PL 121 lactations	Fat %	5.34 ABC	2.42	**	7.68 A	1.75	ns	7.38 B	1.58	ns	7.20 C	1.85	ns
	Protein %	15.66 ABC	3.37	**	4.88 A	1.49	ns	4.86 B	1.76	ns	4.99 C	1.69	ns
	Lactose %	1.81 ABC	0.86	**	5.46 A	0.61	ns	5.53 B	0.72	ns	5.73 C	0.71	*
	Solids %	23.35 ABC	3.44	**	18.35 A	1.82	ns	18.21 B	1.51	ns	18.33 C	1.94	ns
	SCC (10^6)	1.272 AB	2.33	ns	1.615	2.13	ns	2.365 A	2.21	ns	2.451 B	2.42	ns

Means in rows with the same capital letters (ABC) – significant differences ($P \leq 0.01$) between colostrum and milk composition over subsequent days of lactation within analysed breeds.

* in columns – significant differences ($P<0.05$) between PLW and PL breeds for the analysed milk quality trait on day of lactation.

** in columns – significant differences ($P<0.01$) between PLW and PL breeds for the analysed milk quality trait on day of lactation.

ns – non-significant differences.

Table 2. Mean rearing performance of second- and third-litter PLW and PL piglets

		Day of age											
		1		significance between breeds	7		significance between breeds	14		significance between breeds	21		significance between breeds
		x	σ		x	σ		x	σ		x	σ	
PLW 109 lactations	No. of piglets	11.76	0.98	*	11.02	1.14	ns	10.54	1.46	ns	10.19	1.51	ns
	Piglet weight (kg)	1.46	0.15	ns	2.64	0.31	**	4.03	0.47	*	5.67	0.58	ns
	Litter weight (kg)	17.17	2.31	ns	29.11	4.51	ns	42.45	7.45	ns	57.34	11.76	ns
	Piglet weight gain (kg)	-	-		1.181	0.29	**	2.568	0.46	ns	4.214	0.56	ns
	Litter weight gain (kg)	-	-		13.014	3.40	*	27.051	5.93	ns	42.148	8.47	ns
	No. of piglets reared (%)	-	-		93.82	7.37	ns	89.70	10.77	**	86.85	11.83	*
PL 121 lactations	No. of piglets	11.35	1.39	*	10.82	1.44	ns	10.52	1.43	ns	10.19	1.55	ns
	Piglet weight (kg)	1.49	0.15	ns	2.79	0.35	**	4.18	0.52	*	5.74	0.61	ns
	Litter weight (kg)	16.88	2.54	ns	30.15	5.42	ns	43.97	7.75	ns	58.44	10.28	ns
	Piglet weight gain (kg)	-	-		1.295	0.33	**	2.691	0.50	ns	4.247	0.59	ns
	Litter weight gain (kg)	-	-		14.055	3.99	*	28.326	6.33	ns	43.275	8.49	ns
	No. of piglets reared (%)	-	-		95.54	7.26	ns	92.97	8.08	**	90.11	10.15	*

* in columns – significant differences (P<0.05) between PLW and PL breeds for the analysed piglet rearing trait on day of age.
** in columns – significant differences (P<0.01) between PLW and PL breeds for the analysed piglet rearing trait on day of age.
ns – non-significant differences.

Table 3. Coefficients of correlation between chemical and cytological composition of colostrum from PLW and PL sows

	Fat content	Protein content	Lactose content	Solids content	SCC
Fat content	–	0.022	–0.073	0.601**	–0.066
Protein content		–	–0.874**	0.775**	0.127
Lactose content			-	–0.707**	0.047
Solids content				-	0.020

**coefficient of correlation significant at P≤0.01.

Table 4. Coefficients of correlation between composition of milk from PLW and PL sows

	Fat content	Protein content	Lactose content	Solids content	SCC
Fat content	–	–0.442**	0.332*	0.650**	0.161
Protein content		–	–0.816**	0.301*	–0.202
Lactose content			–	–0.198	–0.048
Solids content				–	–0.177

* coefficient of correlation significant at P≤0.05.
** coefficient of correlation significant at P≤0.01.

Table 5. Coefficients of correlation between milk composition and rearing performance of piglets at 7, 14 and 21 days of lactation

Number of litters		Day of lactation		
		7	14	21
		96	68	48
		piglet weight		
PLW and PL	Milk fat content	–0.008	–0.043	0.148
	Milk protein content	0.112	0.194	0.081
	Milk lactose content	–0.180	–0.068	0.109
	Milk solids content	0.123	0.165	0.233
	SCC	0.144	0.084	0.309*
		piglet weight gain from birth		
	Milk fat content	–0.249	–0.121	0.132
	Milk protein content	0.262	0.278	0.121
	Milk lactose content	–0.218	–0.170	0.082
	Milk solids content	0.052	0.073	0.272
	SCC	–0.094	–0.018	0.252
		litter weight		
	Milk fat content	–0.168	–0.068	0.144
	Milk protein content	0.079	0.146	0.097
	Milk lactose content	–0.038	-0.024	0.085
	Milk solids content	–0.046	0.104	0.257
	SCC	–0.199	0.113	–0.193
		litter weight gain from birth		
	Milk fat content	–0.227	–0.115	0.137
	Milk protein content	0.222	0.225	0.112
	Milk lactose content	–0.145	–0.098	0.091
	Milk solids content	–0.033	0.069	0.269
	SCC	–0.133	0.024	0.206

* coefficient of correlation significant at P≤0.05.

Discussion

Milk composition is a variable trait that is largely dependent on nutrition, breed and lactation period. In this study, the possible effect of these factors was eliminated by investigating a group of animals kept in the same pig house and under the same conditions, and receiving the same feeds. The analysis was made for the two breeds separately, taking account of the successive days of lactation. The results obtained for chemical composition of sow's milk depending on breed and stage of lactation show that compared to PLW sows, better colostrum parameters and higher milk fat content were found in the colostrum of PL sows. Similar findings were reported by Boruta et al. (2009), who demonstrated higher fat content and significantly higher protein and solids content in the milk of PL compared to PLW sows. The concentration of components found in our study in the milk of PLW sows is similar to the values reported by Walkiewicz et al. (1999), where the content of fat in all of the milk collected from the sows was 7.89%, with protein content of 5.60% and solids content of 18.08%. In the same study, the milk of PL sows was characterized by a slightly higher average value of individual components (fat – 7.66%; protein – 6.73%; solids – 19.05%) compared to the milk of PL sows studied. In a study investigating the chemical composition of colostrum and milk of PL sows, Migdał and Kaczmarczyk (1986) found the fat content of colostrum from these sows to be 5.88%, which is similar to the value obtained in our study. When investigating the milk of crossbred sows at 21 days of lactation, Rząsa et al. (2004) found fat and protein content to be 7.17% and 4.7%, which is consistent with our results concerning the composition of milk from PL sows on the same 21st day of lactation.

The present study showed that the rate and direction of change in individual components of colostrum and milk with successive weeks of lactation were similar for both breeds. The observed direction of change is consistent with the findings of Migdał and Kaczmarczyk (1986), Paściak et al. (2003), Walkiewicz et al. (2004). When comparing the composition of colostrum and milk, these authors showed that colostrum contains much more solids and protein, and less fat and lactose than milk on subsequent days of lactation. Buczyński et al. (2006) and Babicz et al. (2011), who analysed changes in the composition of milk from sows of different breeds during lactation, found fat, protein and solids content to decrease, and lactose content of milk to increase on subsequent days of lactation, which agrees with our results.

The lower colostrum SCC and the increasing SCC in milk on subsequent days of lactation are consistent with the results of other authors (Garst et al., 1999; Babicz et al., 2011), who found SCC to be higher towards the end of lactation compared to the period immediately after parturition. At the same time, the maximum SCC value on day 21 of lactation in PLW sows and on days 14 and 21 of lactation in PL sows was only slightly above the accepted norms for sows, which Rekiel et al. (2004) reported to range between 1.7×106/ml and 2.0×106/ml. This SCC level is evidence of very good udder condition and good condition of the sows of both breeds. Skrzypczak et al. (2012), who analysed SCC content of milk from Złotnicka White sows, found a higher value of this parameter without observing clinical mastitis in these animals.

The results obtained for rearing performance of the piglets of both breeds indicate that PL sows, despite giving birth to significantly fewer piglets per litter compared to PLW sows, raised their piglets more successfully. The better rearing performance of the piglets was due primarily to their higher weight gains, especially to 7 days of age, which resulted in their higher body weight at 7 as well as 14 days of age. As a consequence, PL sows weaned significantly more piglets and the difference between the breeds was particularly evident at 14 and 21 days of lactation. The differences in rearing performance of the piglets between the analysed breeds are confirmed by Boruta et al. (2009), who also reported smaller litter size in PL compared to PLW sows (11.8 and 12.3 piglets, respectively). They also found that PL sows weaned the heaviest piglets, the average weight of which reached 5.3 kg at 21 days of age.

The high coefficients of correlation estimated in our study between individual chemical components of colostrum and milk show that solids content is significantly related to the fat and protein content of colostrum and milk. These results are supported by Boruta et al. (2009), who analysed the relationships between chemical composition of milk collected from PLW and PL sows at 10 days of lactation and found that the highest coefficient of correlation was between milk fat and solids content ($r = 0.9$). They also observed highly significant relationships between milk protein and lactose content ($r = –0.65$) and between milk protein and solids content ($r = 0.28$). Unlike our results, these authors concluded that fat content is positively correlated to milk protein content ($r = 0.21$).

The primary purpose of this study was to determine the degree to which the observed differences in milk composition are related to the rearing of piglets over subsequent days of lactation. The low and non-significant coefficients of correlation obtained between milk composition and rearing performance suggest that piglet rearing parameters are influenced by more than one of the milk components under analysis. The slightly higher correlation values between weight gain of piglets and the content of fat, protein, lactose and solids are indicative that these components matter when considered in conjunction with one another. The negative coefficient of correlation between fat content and piglet weight gain to 7 days of age may suggest that milk that is lower in fat contributed to better weight gain of the piglets during this period. This statement is supported by Babicz et al. (2011) who studied PLW and PL crossbred sows and showed that daily weight gains from 1 to 7 days of age in piglets sucking milk with less than 6.0% fat were higher than in piglets sucking milk containing more fat (above 6.1%). The daily weight gains of these piglets were 271.7 g and 196.7 g, respectively. Over subsequent weeks of lactation, this study revealed no differences between the weight gain of piglets from these groups. Meanwhile, in a study analysing the effect of milk composition on rearing performance of Złotnicka White piglets, Buczyński et al. (2008) reported that daily gains during a 21-day lactation were higher in piglets derived from the group of sows yielding milk with more fat (above 7%). They also found that the body weight of piglets aged 7 days is significantly affected by the higher milk protein content.

In our study, we generally observed no relationship between SCC and rearing performance of the piglets except the relationship between SCC and weight of piglets at 21 days of lactation. In the study by Babicz et al. (2011), the low SCC was found to

be more conducive to obtaining litters with a greater number of piglets characterized by higher body weight and daily weight gains during the rearing period.

In summary, the PL sows, compared to PLW sows, were characterized by a higher content of fat, protein and solids, but only in the colostrum. The PL sows gave birth to fewer piglets than PLW sows, but during 21 days of lactation PL pigs reared statistically more piglets. The solids content of colostrum and milk is significantly related to the fat and protein content, and fat content of milk is negatively related to the protein content. Generally, the higher content of basic milk components, in particular protein, may be one of the factors contributing to an increase in weight gain and body weight of piglets during a lactation. Milk fat content may be of significance for rearing performance of piglets only during their first week of life. Rearing performance of the piglets is not dependent on SCC in milk.

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Zależności pomiędzy składem chemicznym siary i mleka a wynikami odchowu prosiąt w czasie 21-dniowej laktacji

STRESZCZENIE

Prawidłowy rozwój prosiąt determinowany jest głównie przez mleczność odchowujących je macior. Podjęte badania stanowią próbę określenia zależności pomiędzy jakością mleka loch a wynikami odchowu prosiąt. Przeprowadzono je w ujednoliconych warunkach, standardowym żywieniu loch, jak również przy wyrównanej liczbie prosiąt w miotach. W badaniach uwzględniono 109 laktacji loch rasy wielkiej białej polskiej (wbp) oraz 121 laktacji loch rasy polskiej białej zwisłouchej (pbz). Były to laktacje po urodzeniu drugich i trzecich miotów tych loch. Od zwierząt zdajano siarę i mleko w 1., 7., 14. i 21. dniu laktacji. W siarze i mleku oznaczano: suchą masę, białko ogólne, tłuszcz, laktozę oraz komórki somatyczne (LKS). Wyniki odchowu prosiąt z drugiego i trzeciego miotu określone były na podstawie: liczby prosiąt oraz ich masy w dniu urodzenia oraz w 7., 14. i 21. dniu ich życia. Oszacowane współczynniki korelacji pomiędzy podstawowym składem mleka a wynikami odchowu prosiąt w kolejnych tygodniach laktacji były niskie i przewyższały wartość r = 0,200 jedynie dla niektórych cech. Badania wskazują, że większa zawartość podstawowych składników mleka, w szczególności białka i suchej masy, może być jednym z czynników wpływających na zwiększenie przyrostów prosiąt w czasie 21-dniowej laktacji. Zawartość tłuszczu w mleku może mieć znaczenie na odchów prosiąt tylko w pierwszym tygodniu ich życia. Wyniki odchowu prosiąt nie są zależne od liczby LKS w mleku.