African Journal of Biotechnology Vol. 11(64), pp. 12781-12786, 9 August, 2012
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB11.3685
ISSN 1684–5315 ©2012 Academic Journals

Full Length Research Paper

The influence of the different content of protein fractions in sows' milk in piglet rearing

Ewa Skrzypczak[1]*, Karolina Szulc[1], Monika Demkowicz[2], Damian Knecht[3], Anna Jankowska-Mąkosa[3], Janusz T. Buczyński[1] and Marek Babicz[4]

[1]Department of Pig Breeding and Production, Poznań University of Life Sciences, ul. Wołyńska 33, 60-637 Poznań, Poland.
[2]Department of Cattle Breeding and Milk Production, The Institute of Animal Breeding, Wrocław University of Environmental and Life Sciences, ul. J. Chełmońskiego 38C, 51-630 Wrocław, Poland.
[3]Department of Pig Breeding, The Institute of Animal Breeding, Wrocław University of Environmental and Life Sciences, ul. J. Chełmońskiego 38C, 51-630 Wrocław, Poland.
[4]Department of Breeding and Technology of Pig Production, University of Life Sciences in Lublin, ul. Akademicka 13, 20-950 Lublin, Poland.

Accepted 15 June, 2012

The aim of this study was to investigate the influence of the percentage content of protein fractions in total protein of sow`s colostrums and milk and their influence on the traits related with piglet rearing. The animal specimens were 20 sows of the native Złotnicka White breed. Złotnicka pigs were subjected to the National Genetic Resources Conservation Programme. Colostrum and milk were collected between the 20th and 24th h after parturition and on the 2nd, 3rd, 7th, 14th and 21st day of lactation. A total of 120 samples (60 colostrum samples and 60 milk samples) were collected from all active mammary glands. Individual fractions of total protein were separated by means of electrophoresis on polyacrylamide gel in the presence of sodium dodecyl sulphate (SDS). The piglets' body weights average daily gains and mortality were checked consecutively after 24 hours after parturition and on the day 7th, 14th, and 21st of lactation. 207 piglets were examined. A highly significant correlation between the number of piglets, daily growths and protein fractions was observed. The most favourable rearing results were obtained at the highest level (III) of individual fractions. The study also proved most of the piglets are lost from the litters when the level of fractions is the lowest (I).

Key words: Sows, milk, protein fractions, Złotnicka White, piglet rearing.

INTRODUCTION

Sows' colostrum and milk are the main sources of necessary nutrients during the first days of piglets' lives (Devillers et al., 2004; Skrzypczak et al., 2012a). Milk proteins are particularly significant due to the fact that they participate in all life processes (Wheeler et al., 2007; Stelwagen et al., 2009), they are an important building block and play an enormous role in the development of the immune system (Bernatowicz and Reklewska, 2003; Sangild, 2003; Lipiński, 2007; Płusa, 2009). The proteins whose role has only partly been recognised deserve attention. Lactoferrin and β-lactoglobulin exhibit the antineoplastic effect (McIntosch et al., 1998; Szulc, 2010), β-lactoglobulin and immunoglobulins G also exhibit the supportive effect in viral and bacterial infections (Pan et al., 2006, 2007; Płusa, 2009), α-lactalbumin is a Ca^{2+} carrier and it is an anti-carcinogenic, antibacterial, immunological and supportive factor. In stressful situations, it may lower the blood pressure (Meisel, 1997; Zimecki and Arytm, 2005).

*Corresponding author. E-mail: ewa.skrzypczak@op.pl.

Abbreviations: SDS, Sodium dodecyl sulphate; LSM, least square means; **SE,** standard errors.

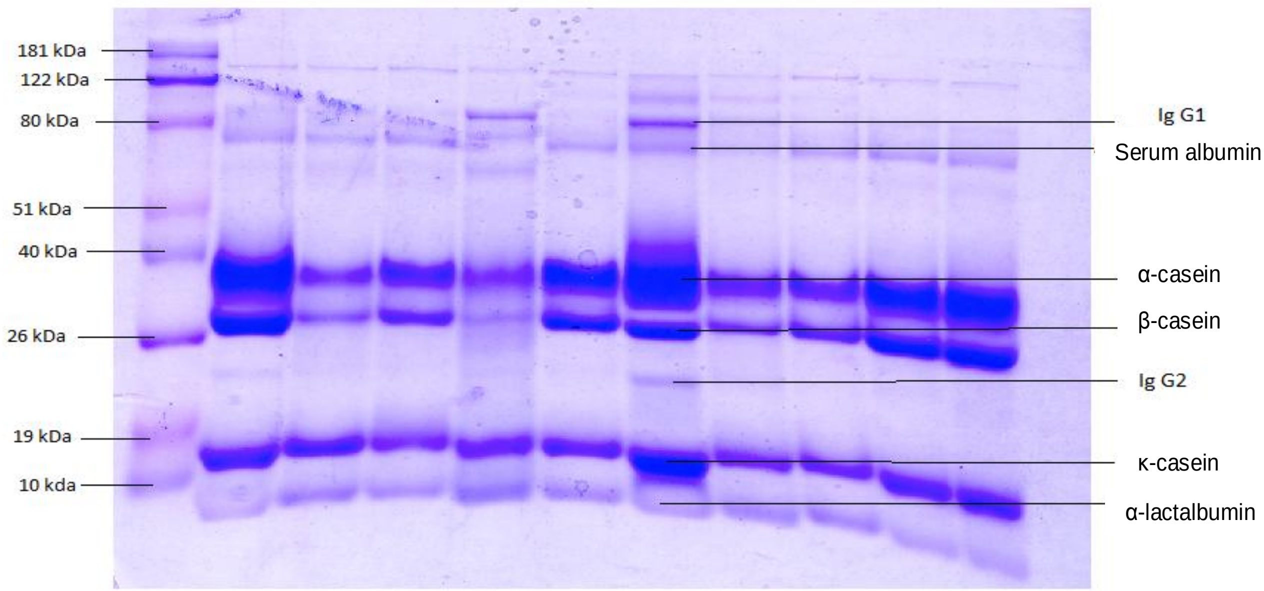

Figure 1. Polyacrylamide gel with milk protein fractions.

Casein has above all anticoagulant properties and it inhibits thrombocyte aggregation and serotonin liberation (Kuczyńska, 2008; Płusa, 2009). Therefore, investigation of the correlation between sows' milk protein fractions and results of piglet rearing is justified.

MATERIALS AND METHODS

Animals

The animal materials were 20 sows of the native Złotnicka White breed, which were subject to the National Genetic Resources Conservation Programme (Szulc et. al., 2012).

The research was carried out from October, 2009 to September, 2010. All experimental sows were housed in identical conditions meeting all welfare requirements. The sows were housed in single farrowing crates from about the 10th day before parturition to the 4th week of lactation. They were fed individually with standard total mixed rations according to polish Nutrient Requirements for Pigs (1993). Feed in the amount of 2 kg in one dose was supplied twice a day with *ad libitum* access to water.

The sows in the experiment were naturally mated according to the mating plan approved on the farm and the offspring came from one boar. Each farrowing it was supervised by personnel. The piglets' body weight was checked consecutively after 24 h, on the 7th, 14th, and 21st day of lactation. Altogether 207 piglets from 20 sows were examined.

Collection of materials for analysis and analytical methods

Colostrum and milk were collected after earlier intramuscular injection of 2 to 4 ml of oxytocin. The amount of oxytocin administered depended on the day of lactation. Colostrum and milk were manually collected from all active mammary glands to test tubes with a preservative (MILKOSTAT). The samples were collected between the 20th and 24th h after parturition and on the 2nd, 3rd, 7th, 14th and 21st day of lactation. Then the samples were cooled down to the temperature of -20°C. Altogether 120 samples were collected (60 colostrum samples and 60 milk samples).

The electrophoretic separation of individual fractions of total protein, that is, serum albumin, α- casein, β- casein, κ- casein, immunoglobulins G and α- lactalbumin and other protein structures were carried out according to Laemmli's method (1970) on polyacrylamide gel in the presence of sodium dodecyl sulphate (SDS). The qualitative and quantitative analysis was carried out according to the electrophoretic separations developed by Kim and Jimenez-Flores (1994). The percentage share of individual fractions of total protein was calculated by defining their sum as 100%. The electrophoretic separations were compared by means of a protein marker. The separations were archived by means of an optical scanner. Bio Rad 6 program was used for qualitative and quantitative analysis. Figure 1 shows the vertical electrophoresis of colostrum and milk proteins on polyacrylamide gel.

Statistical analysis

The obtained data was statistically processed with SAS (2007) ver. 8.11. Package with the use of the following methods:

1. Normality test (UNIVARIATE).
2. Multivariate analysis of variance with PROC GLM LSM.
3. The results were presented as least square means (LSM) and standard errors (SE).
4. For discrete random variables (the number of piglets aged 24 h, 7, 14 and 21 days) probit transformation described by Żuk (1989) and Lynch and Welsh, (1998) was applied, which enables transformation from discrete random variables to continuous random variables.
5. The protein fractions were divided according to their levels in total protein (Table 1).

In the statistical models applied for the analysis apart from the

Table 1. Protein fractions and their various medium levels.

Protein fraction	Protein Levels (%)		
	I (low) N = 40	II (medium) N = 40	III (high) N = 40
Serum albumin	≤ 0.645	0.646 - 0.963	≥0.964
α- casein	≤ 0.673	0.674 - 0.858	≥0.859
β- casein	≤ 0.665	0.666 - 0.884	≥0.885
κ- casein	≤ 0.722	0.723 - 0.989	≥ 0.990
α- lactalbumin	≤ 0.651	0.652 - 0.881	≥0.882
Immunoglobulins G	≤ 0.879	0.880 - 1.212	≥1.213
Other fractions	≤ 0.860	0.861 - 1.407	≥1.408

Table 2. The influence of protein fractions on the average number of piglets

Protein fraction		Number of piglets (head)		
		I	II	III
Serum albumin	LSM	10.31	9.00[a]	10.54[b]
	SE	0.68	0.48	0.42
α – casein	LSM	10.21	9.00[a]	10.64[b]
	SE	0.66	0.47	0.43
β – casein	LSM	9.53	9.36	10.66
	SE	0.60	0.50	0.44
κ – casein	LSM	10.25	9.06[a]	10.56[b]
	SE	0.71	0.48	0.42
α - lactalbumin	LSM	10.36	9.07[a]	10.54[b]
	SE	0.74	0.47	0.42
Immunoglobulins G	LSM	9.48	9.68	10.57
	SE	0.55	0.50	0.48
Other protein structures	LSM	9.92	10.59	10.47
	SE	0.59	0.52	0.49

Means designated with small letters (a, b) statistically differ significantly at P ≤ 0.05.

main effects under investigation, other effects were also taken into consideration:

(i) Season of sample collection (autumn, winter, spring, summer).
(ii) Sows' lactation (according to the sow parity number)
(iii) Colostrum and milk collection (time specified).
(iv) Piglet's sex (male, female).

RESULTS

Tables 2 and 3 show characteristics of the level-dependent influence of individual protein fractions on the number and growth of piglets in the litter. The average number of piglets and their growth rate was proved to be the most favourable when the level of fractions in total protein was the highest. Those differences were confirmed at the level P ≤ 0.01 and P ≤ 0.05.

The lowest level of protein fractions (I) was also found to be decisive for the highest piglet mortality (Table 4) and it was proved to affect the piglet's mean body weight (Table 5). The trait was proved to have statistically significant differences.

DISCUSSION

In contrast to many other species of animals and

Table 3. The influence of protein fractions on the growth of piglets

Protein fraction		Week's growth of piglets (kg)		
		I	II	III
Serum albumin	LSM	0.36[a]	0.52[a]	0.81[b]
	SE	0.14	0.10	0.09
α – casein	LSM	0.44[a]	0.51[a]	0.80[b]
	SE	0.14	0.10	0.09
β – casein	LSM	0.43[a]	0.53[a]	0.81[b]
	SE	0.13	0.10	0.09
κ – casein	LSM	0.37[a]	0.51[a]	0.80[b]
	SE	0.15	0.09	0.08
α - lactalbumin	LSM	0.38[a]	0.50[a]	0.82[b]
	SE	0.16	0.10	0.09
Immunoglobulins G	LSM	0.47[a]	0.52[a]	0.84[b]
	SE	0.11	0.10	0.10
Other protein structures	LSM	0.51[A]	0.53[A]	1.03[B]
	SE	0.15	0.13	0.12

Means designated with capital letters (A, B) differ statistically significantly at $P \leq 0.01$. Means designated with small letters (a, b) statistically differ significantly at $P \leq 0.05$.

Table 4. The influence of protein fractions on the piglets mortality.

Protein fraction		Mortality of piglets (%)		
		I	II	III
Serum albumin	LSM	21.00[a]	9.00[b]	11.75
	SE	3.69	2.61	1.85
α – casein	LSM	21.00[a]	9.00[b]	11.75
	SE	3.69	2.61	1.85
β – casein	LSM	21.00[a]	9.00[b]	11.75
	SE	3.69	2.61	1.85
κ – casein	LSM	21.00[a]	9.00[b]	11.75
	SE	3.69	2.61	1.85
α - lactalbumin	LSM	21.00[a]	9.00[b]	11.75
	SE	3.69	2.61	1.85
Immunoglobulins G	LSM	21.00[a]	9.00[b]	11.75
	SE	3.69	2.61	1.85
Other protein structures	LSM	9.0	10.0	12.33
	SE	2.90	4.11	2.37

Means designated with small letters (a, b) statistically differ significantly at $P \leq 0.05$.

Table 5. The influence of protein fractions on the piglet`s body weight

Protein fraction		Average body weight of piglet (kg)		
		I	II	III
Serum albumin	LSM	5.13^{Aa}	3.81^{b}	2.83^{Ba}
	SE	0.45	0.32	0.27
α – casein	LSM	4.86^{Aa}	3.83^{a}	2.83^{Bb}
	SE	0.44	0.32	0.29
β – casein	LSM	4.86^{Aa}	3.65^{b}	2.84^{Bb}
	SE	0.40	0.33	0.29
κ – casein	LSM	5.19^{Aa}	3.84^{ab}	2.83^{Bb}
	SE	0.47	0.31	0.26
α - lactalbumin	LSM	5.26^{Aa}	3.85^{ab}	2.80^{Bb}
	SE	0.49	0.31	0.27
Immunoglobulins G	LSM	4.62^{Aa}	3.62^{b}	2.76^{Bb}
	SE	0.36	0.33	0.32
Other protein structures	LSM	3.44^{a}	3.82^{Aa}	2.17^{Bb}
	SE	0.41	0.36	0.34

Means designated with capital letters (A, B) differ statistically significantly at $P \leq 0.01$.
Means designated with small letters (a, b) statistically differ significantly at $P \leq 0.05$.

humans, pigs are in practice born without any immunological preparation for life in outer environment due to their placenta, which is impermeable to immune bodies. Therefore, colostrum is the only possibility to obtain immunoglobulins from the mother (Butler and Kehrli, 2005; Hurle and Theil, 2011). Later, when the level of immunoglobulins decreases and they can no longer be passively absorbed, the essential role of milk proteins is to provide the necessary amino acids for the needs of existence, growth and development of newly born animals (Patureau-Mirandi et al., 1990; Xu, 1996; Blättler et al., 2001; Sauter et al., 2004; Senda et al., 2011). Therefore, obtaining appropriate growths has a considerable influence on piglets' balanced weight when weaned and thus produces the best results of pig fattening.

The authors' own research proved a statistically significant correlation between individual protein fractions of colostrum and milk, and the number of piglets and their daily gains. The results are also confirmed by experiments on other species of animals. Wroński and Sosnowska (2008) proved that bulls fed with colostrum with higher specific weight and higher content of whey proteins and immunoglobulins gained higher body dimensions than those fed with colostrum with a lower content of those proteins.

The experiment on deer calves made by Landete-Castillejos et al. (2001) confirms the fact that the body weight is strongly correlated with the content of protein in the milk ($P \leq 0.05$). The authors also noted a high correlation between the protein and fat ratio and calf growth.

Buczyński et al. (2008) proved that the mean weight of the piglet (2.82 kg) and growths were higher in the group of sows whose milk had the highest content of protein. Boruta et al. (2009) also arrived at similar conclusions in their studies on Polish Large White and Polish Landrace breeds and their crossbreeds. The authors proved that the piglets from the sows with the highest share of protein in their milk achieved better rearing results. They also noticed a correlation between piglet mortality and the share of whey proteins. A higher content of whey proteins increased piglets' survival rate.

The authors' own studies confirm the fact that the highest mortality of piglets (up to 21%) was according to the lowest content of all protein fractions in their mothers milk (level I). The results were statistically confirmed.

Those results were not confirmed in an analogical experiment made by Walkiewicz et al. (2004). They noted that crossbreeds piglets (Puławska x Duroc) from the sows with a higher level of protein grew worse than the piglets from the sows with a lower content of total protein.

To sum up the importance of milk proteins in the processes of growth and development, it is necessary to add that they are not only decisive in piglets' acquisition of immunity but they are also significant in piglet rearing. In view of those facts, it is particularly important to ensure the piglet's access to its mother and feeding on colostrum as soon as possible after birth. This will guarantee minimisation of losses and achievement of high growths of piglets.

REFERENCES

Bernatowicz E, Reklewska B (2003). The bioactive components of milk protein fraction. (in Polish) Prze. Hod. 3:1-9.

Blättler U, Hammon HM, Morel C, Philipona C, Rauprich A, Romé V, Le Huërou-Luron I, Guilloteau P, Blum JW (2001). Feeding colostrum, its composition and feeding duration variably modify proliferation and morphology of the intestine and digestive enzyme activities of neonatal calves. J. Nutr. 131:1256-1263.

Boruta O, Pecka E, Jasek S, Zachwieja A (2009). The share of protein fractions in the whey of sows' colostrum and milk depending on the breed and stage of lactation. (in Polish) Zesz. Nauk. Uniwer. Przyrod. we Wrocławiu. 575:65-75.

Buczyński JT, Skrzypczak E, Panek A, Szulc K, Niedzielska M (2008). The influence of the chemical composition of sows' milk on the rearing of Złotnicka White piglets. (in Polish) Rocz. Nauk. Zoot. 35:11-17.

Butler JE, Kehrli Jr. ME (2005). Immunoglobulin's and immunocytes in the mammary gland and its secretions. Mucosal. Immunol. 2:1764-1793.

Devillers N, Van Milgen J, Prunier A, Le Dividich J (2004). Estimation of colostrums intake in the neonatal pig. J. Anim. Sci. 78:305-313.

Hurle WL, Theil PK (2011). Perspectives on Immunoglobulin's in Colostrum and Milk. Nutrients 3:442-474.

Kim HHY, Jimenez-Flores R (1994). Comparison of milk proteins using preparative is electric focusing followed by polyacrylamide gel electrophoresis. J. Dairy Sci. 8:2177-2190.

Kuczyńska B (2008). The healthy properties of components of milk protein fraction. (in Polish) Prze. Hod. 11:8-12.

Laemmli UK (1970). Cleavage of structural proteins during the assembly of the head of bacteriophage. Nature, 227:680-685.

Landete-Castillejos T, Garcia A, Gallego L (2001). Calf growth in captive Iberian red deer (*Cervus elaphus* hispanicus): effects of birth date and hind milk production and composition. J. Anim. Sci. 79:1085-1092.

Lipiński K (2007). The importance of colostrum in piglet rearing (in Polish) Trz. Chle. 5:70-74.

Lynch M, Welsh B (1998). Genetics and analysis of quantitative triads. Sinauer Associates Inc. Tabilisches Puschers Sunderland Massachuset (USA).

McIntosch GH, Royle PI, Le Leu RK, Regester GO, Johnson MA, Grinsted RL, Kenward RS, Smithers GW (1998). Whey proteins as functional food ingredients. Int. Dairy J. 8:425-434.

Meisel H (1997). Biochemical properties of bioactive peptides derived from milk proteins: potential nutracenticals for food and pharmacentical applications. Livest. Prod. Sci. 50:125-138.

Pig Feeding Standards (in Polish) (1993). Wydawnictwo Instytutu Fizjologii i Żywienia Zwierząt PAN.

Pan Y, Lee A, Wan J, Coventry MJ, Michalski WP, Shiell B, Roginski H (2006). Antiviral properties of milk proteins and peptides. Int. Dairy J. 16: 1252-1261.

Pan Y, Shiell B, Wan J, Coventry MJ, Michalski WP, Lee A, Roginski H (2007). The molecular characterization and antimicrobial properties of amidated bovine β-lactoglobulin. Int. Dairy J. 17:1450-1459.

Patureau-Mirand P, Mosoni L, Levieux D, Attaix D, Bayle G, Bonnet Y (1990). Effect of colostrum feeding on protein metabolism in the small intestine of newborn lambs. Biol. Neonate 57:30-36.

Płusa T (2009). The immunomodulatory proteins contained in the colostrum. (in Polish) Pol. Merkuriusz Lek. 25:234-238.

Sangild PT (2003). Uptake of Colostral Immunoglobulins by the Compromised Newborn Farm Animal. Acta Vet. Scand. 98:105-122.

SAS (2007). Users Guid Statistical Analysis System Institute. Inc. Cary North California.

Sauter SN, Roffler B, Philipona C, Morel C, Romé V, Guilloteau P, Blum JW, Hammon HM (2004). Intestinal development in neonatal calves: effects of glucocorticoids and dependence of colostrum feeding. Biol. Neonate 85:94-104.

Senda A, Fukuda K, Ishii T, Urashima T (2011). Changes in the bovine whey proteome during the elary lactation period. Anim. Sci. J. 82:698-706.

Skrzypczak E, Babicz M, Szulc K, Marcisz M, Buczyński JT (2012a). The analysis of variability of pH level and somatic cell count (SCC) in the colostrum and milk of Złotnicka White sows. Afr. J. Biotechnol. 11(20):4687-4692.

Stelwagen K, Carpenter E, Haigh B, Hodgkinson A, Wheeler TT (2009). Immune components of bovine colostrum and milk. J. Anim. Sci. 87:3-9.

Szulc K, Skrzypczak E, Buczyński JT, Stanisławski D, Jankowska A, Knecht D (2012). Evaluation of fattening and slaughter performance and determination of meat quality in Zlotnicka Spotted pigs and their crosses with the Duroc breed. Czech J. Anim. Sci. 57:95-107.

Walkiewicz A , Stasiak A , Dziura J, Kamyk P, Babicz M (2004). The variability of the chemical composition and concentration of fatty acids in the colostrum and milk of hybrid sows. (in Polish) Zesz. Nauk. Przeg. Hod. 72:49-54.

Wheeler TT, Hodgkinson AJ, Prosser CG, Davis SR (2007). Immune components of colostrum and milk – a historical perspective. J. Mammary Gland. Biol. 12:237-247.

Wroński M, Sosnowska W (2008). Relationships between the density and composition of colostrums and the performance of calves. Pol. J. Nat. Sci. 23(3):573-582.

Xu RJ (1996). Development of the newborn GI tract and its relation to colostrum/milk intake: a review. Reprod. Fertil. Dev. 8:35-48.

Zimecki M, Arytm J (2005). The therapeutic properties of proteins and peptides from colostrum and milk. (in Polish) Postep. Hig. Med. Dosw. 59:309-323.

Żuk B (1989). Applied biometry. (in Polish) PWRiL. Państwowe Wydawnictwo Rolne i Leśne Warszawa.