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REVIEW ARTICLE

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THE ENERGETIC, IMMUNOLOGY AND AMINO ACIDS QUALITY OF SOW'S COLOSTRUM – A REVIEW

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ABSTRACT

Along the increasing number of live born piglets in a litter, which reduce the newborn live weight, plays the colostrum nutritional quality an essential role to the survival of newborn piglets. Concentration of colostrum nutrients is affected with several factors from which the time from the start of parturition has the greatest impact. On the second place is nutrition of pregnant sows. A lot of scientific articles were published with the goal to describe sow's colostrum nutrients. In this review we would bring closer look on the sow's colostrum, where the concentration of energy, immunoglobulins and amino acids are the main determinants for successful survive of piglets first days of life.

Key words: nutrition, sow, colostrum, energy, immunoglobulins, amino acids

Importance of colostrum for newborn piglets

Colostrum of sows is for piglets the only source of water, energy, nutrients, and immunoglobulins, which assure the passive immunisation. Considering that the piglet is born with low energy reserves and an immature immune system, colostrum is the sole source of substances, without intake of which the piglet survives only few hours.

The importance of colostrum intake by newborn piglets immediately after birth confirmed also Kecman and Wähner [2016], they published, that colostrum intake for surviving of newborn piglets within first 24 hours of life must be at least 200 g. As published Devillers et al. [2011] for "trouble-free" surviving of newborn piglets, they must consume colostrum in amount of 300 g.

Piglets with low intake of colostrum typically occurs dehydration, which causes impaired thermoregulation and reduce ability to find place with higher temperature. All these increases the cold stress of newborn piglets and decrease the ability of colostrum intake. Insufficient intake of colostrum affects the viability, health status and live weight of pigs in time of weaning. If the piglet does not intake colostrum, the surviving is impossible.

Energy

At birth, the energy reserves of newborn piglets are extremely low. Therefore, on the first place the newborn piglet must cover the energy requirements for maintenance, thermoregulation, physical activity, and growth. Le Dividich et al. [2005] highlighted, that the requirement of energy (also other nutrients) is the highest in time immediately after birth.

The energy intake by newborn piglet is affected by these factors: viability, ability to gain colostrum from the dam's udder, temperature of environment, but also by the farrowing assistant. Hurley [2015] in a review about gross energy concentration of colostrum listed following values 5.5 to 8.3 MJ · kg^{-1} for samples gained during parturition, 5.2 to 6.7 MJ · kg^{-1} for samples gained at 6th hour after parturition and 4.6 to 6.4 MJ · kg^{-1} for samples gained at 12th hour after parturition. Rolinec et al. [2012a, 2014] demonstrated changes of colostrum gross energy in time interval from birth of first piglet to 18th hour after birth of first piglet. They determined increase of colostrum gross energy from time of birth of first piglet to 3rd hour (5.2 to 5.4 MJ · kg^{-1}). From 4th hour to 12th

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hour varied the colostrum gross energy concentration in interval from 4.9 to 5.2 MJ · kg^{-1}. Between 12th and 18th hour a decrease to 4.5 MJ · kg^{-1} of colostrum gross energy was determined [Rolinec et al. 2012a, Rolinec et al. 2014]. Compared to these results, higher values of colostrum gross energy 5.95 MJ · kg^{-1} was published by Le Dividich et al. [1994].

In colostrum the highest proportion of gross energy cover crude protein, but also colostrum fat content plays especially significant role. Le Dividich et al. [1997] analyzed gross energy of colostrum with different fat concentration. They published gross energy concentration 5.02 MJ · kg^{-1} for colostrum with 5.0% of fat, 5.99 MJ · kg^{-1} for colostrum with 7.5% of fat and 6.78 MJ · kg^{-1} for colostrum with 10.0% of fat. From these information results also the importance to fed pregnant sow before parturition with diet which assure higher concentrations of colostrum fat, which will result to increased energy intake by newborn piglets.

The effects on the energy concentration of colostrum are time and feeding of sows before parturition. Coffey et al. [1982] added animal fat from 109th day of pregnancy to the diet of sows and found higher concentration of gross energy compared to control group (6.48 vs. 6.11 MJ · kg^{-1}), where starch was the source of energy provided in the diet.

Immunoglobulins

In the sow's colostrum, as well as in milk, are presented mainly three classes of immunoglobulins: immunoglobulin G (IgG), immunoglobulin A (IgA) and immunoglobulin M (IgM). The importance of passive immunisation provided by intake of colostrum by newborn piglet is unreplaceable. Reason for this is, that the epitheliochorial type of placenta does not allows transport of antibodies from dam to the offspring during intrauterine growth of pigs [Toman 2000, Kanka et al. 2014).

Immunoglobulins are presented in the blood of newborn piglets, however as published Rolinec [2009] in exceedingly small amounts between 0.03 and 0.06 mg · ml^{-1} of newborn piglet serum. According to Toman [2000], the minimum concentration of immunoglobulins in piglets' blood is 7.5 mg · ml^{-1}. But this concentration protects piglet only within 3 weeks and only against reduced infections load. Nevertheless, 15.0 mg · ml^{-1} of immunoglobulins in piglet blood will protect them within 3 weeks against high infection load and 8 weeks against reduced infections load [Toman 2000]. From this point of view, the transport of immunoglobulin from colostrum to piglet blood during period of colostrum nutrition must be as high as possible.

Kanka et al. [2013, 2014] found out positive correlation between concentration of immunoglobulins in sow's colostrum and presence of immunoglobulins in small intestine of piglets, as well as between presence of immunoglobulins in small intestine of piglets and concentration of immunoglobulins in blood of piglets. Therefore, the concentration of immunoglobulins in colostrum is especially important and must be as high as possible.

The dominant immunoglobulin in colostrum of sows is IgG, followed by IgA and IgM. In time from start of parturition, during next 12 hours decrease concentration of all these three immunoglobulin classes, IgG from 55.12 to 34.20 mg · ml^{-1}; IgA from 8.77 to 7.19 mg · ml^{-1}; and IgM from 1.32 to 1.02 mg · ml^{-1} [Rolinec et al. 2012b). The highest decrease has IgG by 38.0%, then IgM by 22.7% and IgA by 18.0%. Much higher values of colostrum immunoglobulins published Klobasa et al. [1987] IgG 95.6 mg · ml^{-1}, IgA 21.2 mg · ml^{-1} and IgM 9.1 mg · ml^{-1}. Similar high concentrations of immunoglobulins published also Markowska-Daniel and Pomorska-Mól [2010] for colostrum sampled during first hour of lactation, IgG 98.17 mg · ml^{-1}, IgA 23.20 mg · ml^{-1} and IgM 9.07 mg · ml^{-1}.

On the other hand, all articles about sow's colostrum published beside value of immunoglobulin concentration also high value of variation coefficient for this parameter. This may be caused by individuality of sows, which is the reason for high difference between minimal and maximal value of immunoglobulins within the same time point of colostrum sampling. This statement also confirmed Inoue et al. [1980] and Inoue [1981] who determined these minimal and maximal concentration of IgG and IgA in colostrum of sows 11.74 to 101.39 mg · ml^{-1} and 5.63 to 28.14 mg · ml^{-1}, respectively.

The significant effect of colostrum sampling time and individuality of sows is indubitable. Along these, also sows nutrition mainly in last stage of pregnancy plays key role affecting immunoglobulins concentration in colostrum. Mixtajová et al. [2021] researched this problem in recent review study. They concluded that content of immunoglobulins in colostrum can be influenced by feeding pregnant sows. Additions of oils (soy, coconut, and palm oil), conjugated linoleic acids, yeasts, fermented feeds, probiotics increased the content of immunoglobulins in colostrum [Laskowska et al. 2019, Jarosz et al. 2021, Mixtajová et al. 2021].

Amino acids

The concentration of amino acids of sow's colostrum was previously published by several authors [Elliott et al. 1971, Csapó et al. 1996, Dourmand et al. 1998, Daza et al. 2004, Dunshea et al. 2005], but no one of these articles describes the time-depended changes in amino acids concentration in colostrum.

Naturally, the nutrient with highest change in colostrum is crude protein – in which included except

Table 1. Concentration of amino acids (g · kg^{-1} of dry matter) in sow's colostrum during first 12 hours after birth of first piglet

Hour	0*	1	2	3	4	5	6	7	8	9	10	11	12
DM(%)	21.5	22.0	22.5	22.6	21.8	20.6	20.5	22.1	20.0	21.0	19.7	19.7	18.2
Lys	43.3	46.7	45.7	45.4	45.5	44.1	42.3	44.2	38.8	40.4	38.2	36.7	37.7
Thr	33.1	35.8	35.1	34.5	34.5	34.0	32.2	33.1	28.6	29.9	27.6	26.0	26.2
Met+Cys	26.7	27.7	27.2	27.5	26.8	26.8	25.2	25.2	22.6	23.6	22.1	21.3	21.7
Arg	32.3	35.1	34.5	33.9	34.0	33.2	31.3	32.8	28.8	29.5	28.4	26.5	28.0
Phe+Tyr	51.0	53.9	52.6	52.2	52.1	51.7	49.5	50.8	44.2	46.5	41.1	40.6	40.7
His	15.5	16.4	16.0	16.0	15.9	15.8	15.2	15.5	13.6	14.3	13.3	12.4	12.3
Ile	19.3	21.3	20.8	20.5	20.7	20.6	19.4	20.1	17.9	18.6	17.5	17.0	17.0
Leu	55.0	58.9	57.8	57.6	57.3	57.1	54.5	55.4	49.0	51.2	48.0	46.0	46.2
Val	33.8	37.3	36.4	35.6	36.0	35.8	33.7	34.8	30.3	31.5	29.6	27.9	27.6
Ala	25.2	26.6	26.0	25.9	25.8	25.4	24.3	25.0	21.8	22.7	21.2	19.9	20.1
Gly	19.3	20.5	20.1	19.8	19.9	19.6	18.8	19.4	17.0	17.3	16.5	15.5	15.8
Asn	48.1	50.8	50.2	49.8	49.7	49.6	47.3	48.2	42.9	44.8	40.9	39.3	40.0
Glu	85.8	92.1	91.0	91.2	91.3	90.5	86.9	87.2	79.0	82.0	76.7	75.6	75.8
Pro	57.6	61.0	60.6	60.5	60.9	60.4	57.5	59.9	54.5	56.0	53.4	50.5	51.0
Ser	37.5	39.8	39.2	38.9	38.6	38.1	36.4	37.1	32.4	34.0	31.3	29.6	29.6

* – birth time of the first piglet in a litter; DM – colostrum dry matter; Lys – lysine; Thr – threonine; Met – methionine; Cys – Cysteine; Arg – Arginine; Phe – phenylalanine; Tyr – tyrosine; His – histidine; Ile – isoleucine, Leu – leucine; Val – valine; Ala – alanine; Gly, glycine; Asn – Asparagine; Glu – glutamic acid; Pro – proline; Ser – serine. Source: Rolinec et al. [2016].

proteins and immunoglobulins also amino acids. Rolinec et al. [2016] determined concentration of colostrum amino acids on the hour basis within first 12 hours from the birth of first piglet. Results of this study are presented in Table 1. As shown Table 1. the essential amino acid with the highest concentration (at all sampling times) was leucine.

Results of experiment published by Rolinec et al. [2016] confirmed decrease of amino acids concentration with time after start of parturition. They detected,that at 6th hour after birth of first piglet all amino acids of sow's colostrum had lower concentration than they had at time of birth of first piglet (except isoleucine and glutamic acid). Such that, together with the decrease of colostrum immunoglobulins, simultaneously decreased also amino acids concentration. Moreover, with the time from start of parturition also changed the proportion of amino acids to the lysine.

Study published by Rolinec et al. [2018] aimed to calculation of essential amino acid index (EAAI) of sow's colostrum. EAAI determined the quality of protein in a sample, as a reference protein the egg protein is considered. No one of the sow's colostrum samples gained during first 12 hours after birth of first piglet achieve the protein quality of egg. Colostrum sampled at 4th and 7th hour after birth of first piglet have the highest protein quality with EAAI value 97.1 and 96.8, respectively [Rolinec et al. 2018].

Concentration of total protein in sow's colostrum is the highest at the start of parturition and decreased with the time. This corresponds also to the amino acids concentration of sow's colostrum. In general, the concentration of amino acids is not affected by the nutrition of pregnant sows. Slight differences can be detected between breeds or sow's hybrids [Chanhmany and Korawan 2017]. But the main factor affecting the concentration of proteins and thus also the amino acids of colostrum is the lactation period.

CONCLUSIONS

This article reviewed energy, immunoglobulins, and amino acids concentration of sow's colostrum. Colostrum energy and immunoglobulins concentration can be affected by nutrition of pregnant sow, during last stage of pregnancy. On the other hand, colostrum amino acids concentration not. For all three reviewed colostrum components is typical, that the highest concentration is detectable in samples gained during first few hours after start of parturition. With the time from start of parturition the concentration of colostrum energy, immunoglobulins as well as amino acids decreased. Therefore, the newborn piglet must ingest as soon as possible colostrum in adequate amount. For surviving is this crucial. No significant differences are observed in immunoglobulin G and energy components (net energy, fat, protein and lactose) in

colostrum of primiparous and multiparous sows [Craig et al. 2019].

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REFERENCES

Chanhmany, S., Korawan, S. (2017). Comparison of quality and immunity between Thai native and crossbred pigs in colostrum and milk. J. Agric., 32(2), 245–256.

Coffey, M.T., Seerley, R.W., Marby, J.W. (1982). The effect of source of supplemental dietary energy on sow milk yield, milk composition and litter performance. J. Animal Sci., 55, 1388–1394. DOI: 10.2527/jas1982.5561388x.

Craig, J.R., Dunshea, F.R., Cottrell, J.J., Wijesiriwardana, U.A., Pluske, J.R. (2019). Primiparous and multiparous sows have largely similar colostrum and milk composition profiles throughout lactation. Animals, 9, 2, article 35. DOI: 10.3390/ani9020035.

Csapó, J., Martin, T.G., Csapó-Kiss, Z.S., Hazas, Z. (1996). Protein, fats, vitamin and mineral concentration in porcine colostrum and milk from parturition to 60 days. International Dairy Journal, 6, 881–902. DOI: 10.1016/0958-6946(95)00072-0.

Daza, A., Riopérez, J., Centeno, C. (2004). Changes in the composition of sows milk between days 5 to 26 of lactation. Span. J. Agric. Res., 2, 333–336. DOI: 10.5424/sjar/2004023-102.

Devillers, N., Le Dividich, J., Prunier, A. (2011). Influence of colostrum intake on piglet survival and immunity. Animal, 5, 1605–1612. DOI: 10.1017/S175173111100067X.

Dourmand, J.Y., Noblet, J., Étienne, M. (1998). Effect of protein and lysine supply on performance, nitrogen balance, and body composition changes of sows during lactation. J. Animal Sci., 76, 542–550. DOI: 10.2527/1998.762542x.

Dunshea, F.R., Bauman, D.E., Nuget, E.A., Kerton, D.J., King, R.H. McCauley, I. (2005). Hyperisulinaemia supplemental protein and branched-chain amino acid when combined can increase milk protein yield in lactating sows. Brit, J. Nutr,, 93, 325–332. DOI: 10.1079/BJN20041366.

Elliott, R.F., Van Der Noot, G.W., Gilbreath, R.L., Fisher, H. (1971). Effect of dietary protein level on composition changes in sow colostrum and milk. J. Animal Sci., 32, 1128–1137. DOI: 10.2527/jas1971.3261128x.

Hurley, W.L. (2015). Composition of sow colostrum and milk. In Farmer C. et al. 2015. The gestating and lactating sow. 1. ed. Wageningen: Wageningen Academic Publishers. 452 p. DOI: 10.3920/978-90-8686-803-2_9.

Inoue, T. (1981). Possible factors influencing immunoglobulin A concentration in swine colostrum. Am. J. Vet. Res., 42, 533–536.

Inoue, T., Kitano, K., Inoue, K. (1980). Possible factors influencing the immunoglobulin G concentration in swine colostrum. Am. J. Vet. Res., 41, 1134–1136.

Jarosz, Ł., Ciszewski, A., Marek, A., Grądzik, Z., Kaczmarek, B., Rysiak, A. (2021). The effect of feed supplementation with EM Bokashi® multimicrobial probiotic preparation on selected parameters of sow colostrum and milk as indicators of the specific and nonspecific immune response. Probiotics and Antimicrobial Proteins. DOI: 10.1007/ s12602-021-09850-z.

Kanka, T., Rolinec, M., Šťastná, D., Imrich, I., Bíro, D., Gálik, B. (2013). Structural changes of mucous membrane and the presence of immunoglobulins in small intestine of neonatal pigs. Acta Veter. Brno, 82, 317–322. DOI: 10.2754/avb201382030317.

Kanka, T., Rolinec, M., Bíro, D., Šťastný, P. (2014). Analýza pasívnej imunizácie prasiatok v postnatálnom období. 1. ed., Nitra: Slovak University of Agriculture in Nitra, 146 p. [in Slovak].

Kecman, J., Wähner, M. (2016). Management of large litters in piglet production. Tierärz. Praxis, 44, 318–325. DOI: 10.15653/TPG-160625.

Klobasa, F., Werhahn, E., Butler, J.E. (1987). Composition of sow milk during lactation. J. Animal Sci., 64, 1458–1466. DOI: 10.2527/jas1987.6451458x.

Laskowska, E., Jarosz, Ł., Grądzik, Z. (2019). Effect of multimicrobial probiotic formulation bokashi on pro- and anti-inflammatory cytokines profile in the serum, colostrum and milk of sows, and in a culture of polymorphonuclear cells isolated from colostrum. Probiot. Antimicrob. Prot., 11, 220–232. DOI: 10.1007/s12602-017-9380-9.

Le Dividich, J., Herpin, P., Paul, E., Strullu, F. (1997). Effect of fat content of colostrum on voluntary colostrum intake and fat utilization in newborn pigs. J. Animal Sci., 75, 707–713. DOI: 10.2527/1997.753707x.

Le Dividich, J., Rooke, J.A., Herpin, P. (2005). Nutritional and immunological importance of colostrum for the new-born pig. J. Agri. Sci., 143, 469–485. DOI: 10.1017/ S002185-9605005642.

Le Dividich, J., Herpin, P., Rosario-Ludovino, R.M. (1994). Utilization of colostral metabolites in the newborn pig. J. Animal Sci., 72, 2082–2089. DOI: 10.2527/1994.728-2082x.

Markowska-Daniel, I., Pomorska-Mól, M. (2010). Shift in immunoglobulins levels in the porcine mammary secretions during whole lactation period. Bull. Vet. Inst. Pulawy, 54, 345–349.

Mixtajová, E., Rolinec, M., Bíro, D., Gálik, B., Juráček, M., Šimko, M., Hanušovský, O., Kalúzová, M. (2021). The impact of nutrition on the content of immunoglobulins in colostrum and milk of sows – a review. Nutrinet 2021, Košice: University of Veterinary Medicine and Pharmacy in Košice, 78–87, ISBN 978-80-8077-713-5.

Rolinec, M. (2009). Postnatálna tvorba imunoglobulínov prasiat. Disertation thesis, Nitra: Slovak University of Agriculture in Nitra, 93 p. [in Slovak].

Rolinec, M., Bíro, D., Gálik, B., Šimko, M., Juráček, M. (2012a). Analysis of the energy value of sow colostrum. Acta Fytotech. Zootech., 15, 100–103.

Rolinec, M., Bíro, D., Gálik, B., Šimko, M., Juráček, M., Hanušovský, O. (2018). Essential amino acid index of sows colostrum. J. Centr. Europ. Agri., 19, 95–101. DOI: 10.5513/JCEA01/19.1.2028.

Rolinec, M., Bíro, D., Gálik, B., Šimko, M., Juráček, M., Kanka, T., Hanušovský, O. (2014). Development of the energy content of sow colostrum. Res. Pig Breeding, 8, 36–38.

Rolinec, M., Bíro, D., Gálik, B., Šimko, M., Juráček, M., Kanka, T., Imrich, I., Bučko, O. (2016). Changes in the average concentration of amino acids in sows colostrum. Res. Pig Breeding, 10, 25–28. DOI: 10.15414/afz.2016.19.01.25-28.

Rolinec, M., Bíro, D., Šťastný, P., Gálik, B., Šimko, M., Juráček, M. (2012b). Immunoglobulins in colostrum of sows with porcine reproductive and respiratory syndrome – – PRRS. J. Centr. Europ. Agri., 13, 303–311. DOI: 10.5513/JCEA01/13.2.1049.

Toman, M. (2000). Veterinární imunologie. 1. ed. Prague: Grada Publishing, 416 p. [in Czech].

Rolinec, M., Gálik, B., Bíro, D., Šimko, M., Juráček, M., Hanušovský, O., Kalúzová, M., Mixtajová, E. (2021). The energetic, immunology and amino acids quality of sow's colostrum – a review. Acta Sci. Pol. Zootechnica, 20(3), 65–70. DOI: 10.21005/asp.2021.20.3.09

JAKOŚĆ ENERGETYCZNA, IMMUNOLOGICZNA I AMINOKWASOWA SIARY MACIORY – PRZEGLĄD

STRESZCZENIE

Wraz ze wzrostem liczby żywych prosiąt w miocie, co zmniejsza żywą wagę noworodków, jakość odżywcza siary odgrywa kluczową rolę w przeżyciu nowonarodzonych prosiąt. Na stężenie składników odżywczych siary wpływa kilka czynników, z których najważniejszy jest czas od rozpoczęcia porodu. Na drugim miejscu jest żywienie loch prośnych. Opublikowano wiele artykułów naukowych, których celem było opisanie składników odżywczych siary u loch. W tym przeglądzie przyjrzymy się bliżej siarze lochy, w której zawartość energii, immunoglobuliny i aminokwasy są głównymi wyznacznikami przeżycia prosiąt w pierwszych dniach po urodzeniu.

Słowa kluczowe: żywienie, locha, siara, energia, immunoglobuliny, aminokwasy

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