ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume LX 10 Number 6, 2012

EFFECT OF FEEDING SOWS ON RATIONS ENRICHED WITH CONJUGATED LINOLEIC ACID (CLA) AND THE GROWTH CAPACITY AND SURVIVAL OF THEIR PIGLETS

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Received: July 3, 2012

Abstract

HADAŠ, Z., ČECHOVÁ, M., NEVRKLA, P.: *Effect of feeding sows on rations enriched with conjugated linoleic acid (CLA) and the growth capacity and survival of their piglets.* Acta univ. agric. et silvic. Mendel. Brun., 2012, LX, No. 6, pp. 81–88

The evaluation of the effect of supplements of conjugated linoleic acid (CLA) given to pregnant and lactating sows on the phenotypic manifestation of their reproductive performance and on the birth and weaning weight of piglets was performed under conditions of a commercial herd of pigs. The experiment involved altogether 40 hybrid sows divided into two equal groups, i.e. Controls with 20 sows and Experimental Group with also 20 sows. Experimental Group received within the time interval from the 108th day of pregnancy to the 28th day after the parturition a supplement of 2 % of CLA. In individual litters the following performance parameters were recorded: number of all newborn piglets, number of piglets born alive, number of stillbirths, number of weaned piglets and individual weights of newborn piglets and weaned piglets. Obtained results concerning numbers of all newborn piglets in Controls and Experimental Group (i.e. 12.20 ± 2.09 and 11.85 ± 2.58, respectively) indicate that supplementing of the feeding ration with CLA in the last stage of pregnancy does not influence the size of litter. In Controls, numbers of piglets born alive were higher by 0.4 animals per litter; this difference, however, was statistically insignificant. Also the weights of newborn and weaned piglets were not influenced by the supplement of CLA. Statistically significant differences ($P \leq 0.01$) were found out between Controls and Experimental Group in numbers of weaned piglets, viz. 9.75 ± 1.68 *vs.* 8.35 ± 1.39, respectively, and between corresponding losses until weaning, viz. 0.95 ± 1.39 *vs.* 2.60 ± 1.93 in Controls and Experimental Group, respectively ($P \leq 0.01$).

reproduction, sow, piglet, fatty acids, conjugated linoleic acid, losses, body weight

The level of reproductive capacity of sows is generally accepted as a key factor that influences efficiency and economic profitability of pig farming. Regarding the current trends of reduction in sow numbers, it is very important to improve their reproductive parameters. To preserve the competitiveness of the pig industry, it is necessary not only to increase numbers of newborn piglets but also numbers of weaned piglets per sow per year because also these are economically very important. The nutritional and physiological condition of pregnant and lactating sows directly influences not only the development of foetuses but also growth and health condition of newborn piglets. Genotypes of modern types of sows enable to reach a high level of fertility and their progeny shows a great growth potential (Ji *et al*., 2005). The level of reproduction is influenced by a number of factors and these can be divided into two basic groups, viz. internal and external effects. Environmental and living conditions of animals play an important role in launching the process of control of sexual activity and the nutrition is one of the most important among them (Říha *et al*., 2003). The nutrition of sows is a complex and dynamic process that involves a regulated transfer of nutrients from the feeding

ration into embryonic tissues, foetuses and milk (Easterl and Kim, 1998). Kim *et al.* (2007) mentioned that a restricted nutrition within the period of pregnancy and lactation resulted in the occurrence of catabolic processes so that the supply and availability of nutrients for foetuses was reduced (especially in the second half of the pregnancy period). As mentioned by Zijlstra *et al.* (1996) and Bressner *et al.* (2000), catabolic processes could not only inhibit the growth of foetuses and of newborn piglets but also increased their mortality and morbidity. Although the basic mechanisms have not been fully explained yet, they can involve a reduced availability of functional amino acids and fatty acids. These compounds are not only indispensable for growth of animals but also for the synthesis of many biologically active substances (Uauy and Castillo, 2003). A supplementation of amino and fatty acids showing specific functions can increase performance of sows through their effects on key metabolic pathways. These substances may increase conception rate, embryogenesis, antioxidant activities, immune system, and development of intestinal walls (Kim *et al.*, 2007). Fatty acids are the most important of them and, from the viewpoint of nutrition, they are also the major constituents of lipids (Velíšek, 1999). A great importance is accredited above all to omega-3 fatty acids. These are essential polyunsaturated fatty acids (PUFAs), which must be supplied to pigs via the feeding rations. They play a key role in growth and development of all body organs and determine some of their properties. Essential PUFAs are also precursors of eicosanoids, prostaglandins and leucotriens (Kojima *et al.*, 1997). Recently, also CLA is in focus of interest, viz. due to its physiological effects, not only in the sphere of human medicine and physiology but also in that of animal nutrition. Its effects were studied by many authors, e.g. by Belury (2002) who investigated its role in lipodystrophy, Kim *et al.* (2002) who paid attention to its anticancerogenous effects, Bhattacharya *et al.* (2006) who analysed its effects on the immune system, Thiel-Coooper *et al.* (2001) who studied its effect on the growth capacity, and Harrell *et al.* (2002) who paid attention to the role of CLA in reproduction. CLA represents a group of positional and geometric isomers of linoleic acid (C18:2). These isomers have conjugated double bonds; this means that they are not separated by a methyl group as other fatty acids with two and more double bonds. CLA is an intermediate product of transformation of linoleic acid to oleic acid by rumen bacteria of the species *Butyirivibrio fibrisolvens* (Kepler *et al.*, 1966). In animal nutrition, we use synthetic CLA, which can be produced by means of a non-destructive alkaline isomeration from linoleic acid, a common component of plant oils (Marounek, 2007). The aim of this study was to verify the effect of CLA on reproductive parameters of sows as well as on basic parameters of the growth capacity of piglets within the period from birth till weaning.

MATERIALS AND METHODS

The evaluation of the effect of CLA on reproductive parameters of sows and on birth weight and growth capacity of piglets within the period from birth to weaning was performed on a commercial pig farm of the agricultural company Bonagro a. s. with the seat in Šlapanice, Czech Republic. Experiments involved altogether 40 pregnant hybrid sows, which were divided into two groups: Controls (C) with 20 sows received a standard feed mixture and the Experimental Group of another 20 sows received the same feed mixture with a supplement of 2% of CLA. Experiments began on the day of arrival of pregnant sows (i.e. on the 108th day of pregnancy) to the farrowing house. Pregnant and lactating sows were housed in individual farrowing pens. Both groups of sows were fed individually on a standard feed mixture for lactating sows (sold under the commercial name KPK) three times a day; water was available *ad libitum*. Experimental feed mixture with the supplement of 2% CLA was offered from the 108th day of pregnancy (i.e. 7 days prior to parturition) till the weaning of piglets. On this farm, piglets were weaned early, i.e. in the age of 28 days. This means that the experimental feed mixture was offered to sows for a period of 35 days. CAL was supplied in the form of the BASF preparation Lutalin (C 18:2 trans-10 cis-12). The agricultural enterprise Bonagro has a feed mill of its own where a standard feed mixture was enriched with 2% CLA. Numbers of newborn piglets (all, born alive, and stillbirths) were recorded in all litters. Recorded were also weights at birth and on the day of weaning. Birth weights of piglets born alive were recorded individually within the first 24 hours of life. Piglets that died in the course of parturition (i.e. at birth) were not involved in this study. For the period of following 28 days, all piglets were with their mothers so that they passed through an identical period of milk nutrition. On the day of weaning, i.e. in the age of 28 days, the weight of each individual was recorded as well. This means that for the statistical analysis the following data were used: number of all piglets, number of piglets born alive, their weight at birth, and their weight on the day of weaning. These data were statistically processed and analysed using the package STATISTICA, version 8.0.

RESULTS AND DISCUSSION

Results of evaluation of effects of CLA supplements on the phenotypic level of reproduction traits of sows are presented in Tab. I.

It results from data presented in Tab. I that the phenotypic level of reproduction traits of sows was not significantly influenced by supplements of 2% CLA given to sows after the 108th day of pregnancy. Recorded numbers of all newborn piglets (12.20 ± 2.09 *vs,* 11.85 ± 2.58 in Controls and in Experimental Group, respectively) obviously indicated that CLA supplements offered in the last stage of pregnancy did not influence the number of piglets per litre.

I: *Effect of dietary CLA on the litter size*

	Group		Statistical significance
	Control	CLA	
Total born Piglets/litter	12.20 ± 2.09	11.85 ± 2.58	NS
Born alive Piglets/litter	10.95 ± 2.26	10.55 ± 1.88	NS
Still born Piglets/litter	1.25 ± 1.52	1.35 ± 2.11	NS
Litter weight (kg)	19.37 ± 7.42	19.65 ± 5.10	NS

NS = statistically non-significant (P ≥ 0.05)

II: *Effect of CLA supplement on parameters under study in piglets*

Parameter	Group		Statistical significance
	Control	CLA	
Born alive piglets/litter	10.95 ± 2.26	10.55 ± 1.88	NS
Piglets weight at birth (kg)	1.45 ± 0.25	1.46 ± 0.26	NS
Weaned piglets/litter	8.35 ± 1.39	9.75 ± 1.68	S**
Loss of piglets piglets/litter	2.60 ± 1.93	0.95 ± 1.39	S**
Piglets weight at weaning (kg)	6.98 ± 0.84	6.97 ± 0.95	NS
Average daily gain (g/day)	205.1 ± 27.1	204.1 ± 31.8	NS

NS = statistically non-significant (P ≥ 0.05), S** = statistically highly significant (P ≤ 0.01)

Similar results obtained also Harrell *et al.* (2002) who reported that the supplement of 1% CLA showed no effect on the number of newborn piglets. Also Park *et al.* (2005) published similar results; in their experiments, sows received a supplement of 3% CLA since the 74th day of pregnancy but the effect of this dose on the size of litter was not significant. However, other studies indicated that a supplement of CLA given in different stages of the reproductive cycle could influence either the number of ovulated follicles or the embryonic mortality. Urbánková and Václavková (2010) mentioned in their study that the supplement of 1% CLA before mating increased both the number of corpora lutea and of embryos. Although their results were not significant, this trend indicated the possibility of improvement of reproductive parameters in animals fed on feed mixtures with a supplement of CLA. Similar conclusions (although also insignificant) were published also by Hadaš and Čechová (2011) who offered gilts prior to AI a supplement of 2% CLA and recorded a subsequent increase in the number of all newborn piglets by 0.72. As mentioned by Mattos *et al.* (2000), CLA participates in and contributes to the inhibition of prostaglandin F_{2alfa} synthesis taking place in the uterus endometrium; this prostaglandin is an antagonist of progesterone secreted by the corpus luteum. CLA also reduces the sensitivity of corpus luteum to PGF_{2alfa}. In this way, the persistence of corpus luteum can be increased and the maintenance of early pregnancy improved so that the probability of the occurrence of and early embryonic mortality is markedly reduced. When evaluating numbers of piglets born alive, it was found out that in Controls their number was higher by 0.4 piglet per litter; however, this result was statistically insignificant. When comparing numbers of stillbirths, the obtained results were practically the same in both groups. This corresponded with data published by Poulos *et al.* (2004) and Bontempo *et al.* (2004) who also mentioned that the supplementation of feed rations with CLA in the course of pregnancy did not influence numbers of piglets born alive and/or of stillbirths. On the other hand, however, Barowicz *et al.* (2002) concluded that the supplements of 2% CLA after the 90th day of pregnancy showed a positive effect on the number of piglets born alive. Similarly also Smits *et al.* (2011) reported an increase in the number of piglets born alive after the enrichment of feed rations with CLA.

In the other part of this study it was assessed if a supplement of 2% CLA to pregnant sows shortly before the parturition influenced the birth weight of piglets and if the enrichment of feed doses for lactating sows with this compound could influence weight of weaned piglets and their losses within the period from birth till weaning. The basic statistical parameters are presented in Tab. II.

In the course of pregnancy, the composition of individual foetal tissues passes through dynamic changes. According to McPherson *et al.* (2004) amount of proteins and fat were accelerated and increased after the 69th day of pregnancy. Noblet *et al.* (1985) mentioned that a significant effect of sow on the weight of progeny was manifested as late as after the 80th day of pregnancy. When trying to assess if CLA supplements in nutrition of sows can influence the birth weight of piglets, it is important to know if supplied fatty acids can pass through placenta in the course of intrauterine development

of piglets. As far as this problem is concerned, different authors had different opinions. Elphick *et al.* (1980) mentioned that in their experiments concentrations of fatty acids in foetuses were very low and that they were independent on those estimated in sows. Quite opposite were conclusions of other authors (Brazle *et al.*, 2009) who reported an increase in PUFAs concentrations in foetuses of sows given a supplement of fatty acids. Similar findings were published also by Rooke *et al.* (2000) who demonstrated a placental transfer of omega-3 fatty acids during the final stages of pregnancy. Also Park *et al.* (2005), who analysed newborn piglets, observed changes in the composition of *musculi femoris* and in the percentage of the adipose tissue in their body. Basing on these observations they draw a conclusion that CLA was efficiently transported via placenta in the course of prenatal development of piglets. In our study, however, when evaluating the effect of CLA supplements given in the final stage of pregnancy, no differences were found out between Controls and Experimental Group in the weight of newborn piglets (1.45 ± 0.25 kg *vs.* 1.46 ± 0.26 kg, respectively). Similar conclusions were drawn also by Smits *et al.* (2011) who mentioned that, in general, supplements of PUFAs into the feed of pregnant sows did not influence the weight of piglets at birth. Conclusions of studies on effects of CLA on the birth weight of piglets corresponded also with our results. Harrell *et al.* (2002) mentioned that the one-percent supplement of CLA did not influence the birth weight of piglets. Poulos *et al.* (2004) in their study analysed bodies of newborn piglets and reported that even a long-term offering of CLA influenced neither the size of litter nor the weight of newborn piglets. However, quite opposite conclusions were published by Park *et al.* (2005) who wrote that although a high level of CLA did not influence the size of litters, it significantly decreased the body weight of newborns. Rooke *et al.* (2001) mentioned that although CLA did not decrease the birth weight of piglets, their survival till weaning was better.

The number of weaned piglets was another parameter under study. In the course of lactation, sows received the same dose of CLA till the moment of weaning of their piglets. To evaluate this parameter, it is necessary to know how CLA penetrates into colostrum and, later on, milk of sows (including all possible physiological processes taking place within the organism of sows and piglets). Bee (2000) reported that CLA isomers were present both in colostrum and milk. Also Park *et al.* (2005) wrote about an efficient transfer of CLA into milk of sows. CLA also influences the immune system of sows and of suckling piglets. As reported by Bontempo *et al.* (2004), a supplementation of feed rations with CLA in the last stage of pregnancy and during lactation increased concentration of IgG in colostrum. Regarding results of Huang *et al.* (1992) it is obvious that all IgG present in sow's colostrum are derived from their serum concentrations and their transfer into the udder is mediated by a specific function of epithelial cells. It was found out that the concentrations of IgG in serum of sows receiving a supplement of CLA was significantly increased and an increase in the level of IgG was observed also in their piglets. As mentioned by Blecha *et al.* (1983), a passive immunity resulting from the resorption of IgG originating from colostrum and milk in early stages of life is quite indispensable because it is practically the only possibility of protection progeny against eventual infections. An increase in the level of lysozyme in sows and piglets receiving CLA was another observed physiological effect of this fatty acid. Lysozyme, which is present in secretions and leucocytes, is very efficient against gram-positive bacteria (Corino *et al.*, 2002). Weber *et al.* (2001) reported that a supplement of CLA increased the level of serum antibodies against bacteria of the species *Mycoplasma hyopnemoniae*. Piezska *et al.* (2007) wrote that it showed a positive effect on values of haemoglobin and hematocrit. Patterson *et al.* (2008) observed a decrease in cases of enteritides in piglets. Our results indicated better values of the parameter "number of weaned piglets", viz. 9.75 ± 1.68 *vs.* 8.35 ± 1.39 piglets per litter in Experimental Group and Controls, respectively. The difference between both groups in the number of weaned piglets was 1.40 per litter. This was related also to a decrease in losses of piglets till weaning in litters of sows receiving CLA (0.95 ± 1.39 *vs.* 2.60 ± 1.93 piglets per litter in Experimental Group and Controls, respectively). A supplement of CLA to lactating sows decreased losses by 1.65 piglet per litter. Similar results were mentioned also by Barowicz *et al.* (2002) who offered their sows feed rations with a supplement of 2 % of CLA within the period starting on the 90th day of pregnancy. Our obtained results therefore indicate that supplements of CLA can accelerate the development of active immunity in piglets and, thus, increase the survival of piglets till weaning. On the other hand, however, Corino *et al.* (2009) and Harrell *et al.* (2002) did not observed any significant effect of CLA supplements of losses of piglets till weaning. A part of this study involved also an assessment and evaluation of the effect of CLA given to lactating sows on the growth capacity of piglets and/or their weight at weaning. In Experimental Group and Controls, the weaning weight of piglets was 6.97 ± 0.95 kg *vs.* 6.98 ± 0.84 kg, respectively. The obtained results indicate that the effect of CLA on the growth capacity of piglets within the period from birth to weaning was not demonstrated. Harrell *et al.* (2002) analysed both colostrum and milk of sows and referred that the supplementation of feed rations resulted in a significant decrease in levels of dry matter and fat in milk but that the content of proteins was not different. Nevertheless, these changes did not resulted in differences in the growth capacity of piglets born to sows receiving a CLA supplement. Bontempo *et al.* (2004), as well, performed analyses of colostrum and milk of sows and mentioned that the content of milk fat in colostrum was decreased

by 7%. These changes had subsequently a dynamic character because in milk the contents of milk fat decreased by 17% and 36% after supplements of 0.5% and 1% of CLA, respectively. Ostrowska *et al.* (1999) demonstrated that a decrease in the level of milk fat was not associated with changes in the growth of muscular tissue. Kim *et al.* (2007), as well, mentioned that they did not observed any differences in weight gains of piglets. However, data published by Patterson *et al.* (2008), are at variance with our results because they reported a decrease in body weight of piglets originating from sows receiving a supplement of CLA. Similarly, also Park *et al.* (2005) reported that a long-term feeding on a mixture containing CLA caused a decrease in the body weight of weaned piglets.

SUMMARY

The aim of this study was to evaluate effects of CLA supplements offered to pregnant and lactating sows on the phenotypic level of reproduction and growth capacity of piglets till weaning (including their eventual losses). The evaluation was performed under conditions of a commercial pig farm. The experiment involved altogether 40 pregnant hybrid sows that were divided into two groups, viz. 20 control pregnant hybrid sows and 20 experimental animals receiving a supplement of 2% of CLA. Both groups received a standard feed mixture for lactating sows (KPK) three times a day within the period starting on the 108th day of pregnancy and finishing on the day of weaning; drinking water was offered *ad libitum*. Experimental Group received within the aforementioned period a feed ration with the supplement of 2% CLA. On this farm, piglets were weaned early, i.e. in the age of 28 days. The experimental feed mixture was therefore given within the time interval of 35 days. In individual litters, the following parameters were recorded: number of newborn piglets (all, born alive, and stillbirths), weight at birth and on the day of weaning, and losses till weaning. When evaluating the effect of CLA given to sows in the last stage of pregnancy on their reproductive parameters, no statistically significant differences between both groups under study were observed. The effect of CLA on birth weight of piglets was also not significant. However, a statistically significant difference ($P \leq 0.01$) existed in numbers of weaned piglets between Experimental Group and Controls (i.e. 9.75 ± 1.68 *vs.* 8.35 ± 1.39 piglets, respectively). This observation was associated also with a statistically significant difference in losses of piglets till weaning, viz. 0.95 ± 1.39 *vs.* 2.60 ± 1.93 in Experimental Group and in Controls, respectively. The effect of CLA on weight gain of piglets within the period from birth till waning was not demonstrated and for that reason there were no differences in the weight of weaned piglets. It can be therefore concluded that the supplement of CLA to lactating sows can reduce losses of piglets till weaning.

Acknowledgement

This study was supported by project No. QH71284 and No. QI111A166, which are financed by the Ministry of Agriculture of the Czech Republic.

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