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THE EFFECT OF CONJUGATED LINOLEIC ACID ON THE GROWTH OF WEANED PIGLETS

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ABSTRACT

The effect of conjugated linoleic acid (CLA) on growth parameters of sixteen piglets, divided into two groups was studied. The experiment started when the piglets were 29 days old. Prior the age of 39 days animals were fed restrictively on the same amount of feed, independent of the weight of animal. During the next period of the experiment, between ages of 40 and 75 days, the animals were fed individually, with 1.8 times of maintenance energy. Animals were weighed every week. The experimental group was fed extra with supplement of 1.5% of 80% CLA. The same amount of sunflower oil was used in the control group. During the last period of the experiment, between ages of 76 and 123 days, animals were fed *ad libitum* with feed without any CLA or sunflower supplement. CLA decreased average feed consumption and weight of the animals. All observed differences were found in the third or last period of the experiment, after the administration of CLA or sunflower oil was finished.

Key words: pigs / weaned piglets / growth / animal nutrition / feed / feed additives / conjugated linoleic acid / CLA

UČINEK KONJUGIRANE LINOLENSKE KISLINE NA RAST OSTAVLJENIH PUJSKOV

IZVLEČEK

Proučevali smo učinek konjugirane linolenske kisline (CLA) na rast šestnajstih pujskov, razdeljenih v dve skupini. Poskus se je začel pri starosti 29 dni. Do 39. dne starosti so bili pujski krmljeni restriktivno z enako količino krme neodvisno od telesne teže. V naslednjem obdobju poskusa od 40 do 75 dne starosti so pujski dobivali krmo, ki je imela 1,8 kratno individualno določeno vzdrževalno energijo. Težo živali smo ugotavljali vsak teden. Poskusna skupina je dobivala dodatno 1.5 % CLA s 80 % čistostjo. Živali kontrolne skupine so dodatno dobivale enako količino sončničnega olja. V zadnjem ali tretjem obdobju poskusa med 76 in 123 dnevi starosti smo živali krmili po volji s krmo brez dodatka CLA ali sončničnega olja. Dodatek CLA je zmanjšal povprečno težo in porabo krme. Vse razlike med skupinama so nastale šele v tretjem obdobju poskusa, ko živali niso več dobivale CLA ali sončničnega olja.

Ključne besede: prašiči / odstavljeni pujski / rast / prehrana živali / krma / krmni dodatki / konjugirana linolenska kislina / CLA

INTRODUCTON

CLA or conjugated linoleic acid is a mixture of positional and geometric isomers of linoleic acid. It is a product of the fermentation in rumen and known as a rumen acid. Because of moderate or low rate of fermentation in alimentary tract of monogastric animals, low

concentrations or undetectable levels of CLA are found in its products i.e. in meat and milk of monogastric animals. The natural source of CLA in human nutrition is meat (body tissue) and milk of ruminants.

Many different effects of CLA on human or animal organisms were found. CLA caused fat deposition in many experiments. Lower fat deposition was found in groups fed with CLA in pigs (Ostrowska *et al*., 1999, Thiel-Cooper *et al*., 2001), hamsters (Bouthegouard *et al*., 2002), rabbits (Corino *et al*., 2002), mice (Terpstra *et al*., 2002), rats (Azain *et al*. 2002) and in the experiment of Poulos *et al*. (2001) in female but not in male rats.

The effect on body growth is not so clear. Wiegard *et al*. (2002) found higher growth rate and better feed conversion ratio in pigs. The experiment on rats showed no effect on growth rate (Azain *et al*. 2002). Bee (2000) fed pregnant and milking sows and piglets after weaning with supplement of CLA in experimental and linoleic acid in the control group up to the age of 70 days. Piglets, which suckled milk enriched with CLA grew faster in the first period to weaning than the control group. In the period after weaning the supplement of CLA in piglets feed didn't have such a positive effect on daily gain and feed conversion ratio. In long term experiment between 40 kg and 100 kg in the first group and 40 kg and 130 kg in the second group, Lauridsen *et al*. (2005) found tendency for increased daily gain and better feed conversion in two groups, fed with supplement of 0.5% CLA comparing to the control group with supplement of sunflower oil. In the experiment with added CLA and nutritive antibiotic neither CLA alone nor CLA in combination with nutritive antibiotics affected the gain of pigs (Weber *et al*., 2001). In this study, the unclear correlations between CLA supplement in feed and growth performances (daily gain, daily feed consumption and feed conversion ratio) were studied. Due to unclear results and limited number of growth experiments done in pigs and other domestic animals, we decided to investigate the effect of CLA on growth of weaned piglets in our experiment.

MATERIAL AND METHODS

Sixteen piglets of Slovenian Landrace breed from the same litter were introduced in the experiment. Animals were full sibs. Half of them were male castrates and the other half were females. Because of such a large litter, ten animals stayed in mother litter together with other brothers and sisters, but the other six were moved to other litters. They were weaned at the age of nineteen days. On the weaning day they were weighed and housed in individual cages. Animals were divided into experimental and control group. Each group of eight animals consisted of four females and four male castrates. The design of the experiment is shown in Table 1.

Ten days after weaning the animals were fed *ad libitum* on prestarter (feed 1) with 13.5 MJ ME, 18% CP and 12.5 g Lysine per kg of feed. In the next period (age between 28 and 75 days), the animals were fed on the same feed, but on different regimes. At the age of 29 days, animals were weighed and average body weight was calculated. The average maintenance energy for animals according to DLG (Energie- und Nährstoffbedarf …, 1987) was calculated:

$$MaE = \left(754 - 5.9BM + 0.025BM^2\right)BM^{0.75}\left[kJ / day\right]$$

where:

MaE = maintenance energy in kJ/day,
BM = body mass in kg.

Animals were fed on 1.8 times of maintenance energy. The same level of feed for all animals in experiment decreased individual differences in body mass. In the next period of the experiment at the age between 40 and 75 days, animals were fed on 1.8 times of maintenance energy on individual basis. Animals were weighed every week and maintenance energy was

calculated on individual basis. The experimental group of animals was fed with 1.2% supplement of pure CLA on feed basis. Because the purity of CLA was only 80%, the supplement was 1.5% on feed basis. The control group was fed on supplement of 1.5% of sunflower oil. In the last period of experiment at the age between 76 and 123 days animals were kept individually and fed on the same feed (feed 2) *ad libitum* without any supplement. Feed 2 contained 12.8 MJ ME, 16.5% CP and 10.11 g Lysine per kg of feed. Like the previous period, animals were weighed in regular time periods.

Table 1. The design of the experiment
Preglednica 1. Načrt poskusa

Age starost	Age interval starostni interval		Feed krma
0		Birth/rojstvo	
19	age 0 to 19 days/ starost od 0 do 19 dni	weaning to indiv. pen, weighing odstav. individ. boks, tehtanje	
28	age 19 to 28 days/ starost od 19 do 28 dni	weighing / tehtanje	feed 1 *ad libitum* krma 1 po volji
39	age 29 to 39 days/ starost od 12 do 39 dni	weighing / tehtanje	feed 1 group restricted krma 1 skupinsko omejeno
47	age 40 to 75 days/ starost od 40 do 75 dni	weighing / tehtanje	feed 1 individual restricted + supplement krma 1 individualno omejeno + dodatek
54		weighing / tehtanje	
61		weighing / tehtanje	
68		weighing / tehtanje	
75		weighing / tehtanje	
92	age 76 to 123 days/ starost od 76 do 123 dni	individual 2, weighing / tehtanje	feed 2 *ad libitum*/ krma 2 po volji
99		weighing / tehtanje	
106		weighing / tehtanje	
113		weighing / tehtanje	
123		weighing / tehtanje, end of experiment, konec poskusa	

The 1.8 times of maintenance energy was chosen because of experiences from some other experiments. That quantity of feed was eaten without feed waste by all animals in experiments of Rezar *et al*.(2003) and Pajk *et al*. (2006). The same growth rate proportional to body mass is expected at each animal.

The observed data were evaluated with two statistical models:

$$Y_{ijkl} = \mu + T_i + W_{ij} + A_{ik} + e_{ijkl} \qquad \text{model 1}$$

$$Y_{ijkl} = \mu + T_i + W_{ij} + S_k + e_{ijkl} \qquad \text{model 2}$$

where Y_{ijkl} is an observed independent variable, μ is an average value of model, T_i is the treatment group – CLA and control group, W_{ij} is treatment day within treatment, S_k is the sex of animal (female, castrated male), A_{ik} is the effect of animal within group and e_{ijk} is the rest for t-th measurement of k-th sex j-th measurement and i-th treatment. Statistical evaluations were done with SAS/STAT procedure of SAS 8.02.

RESULTS AND DISCUSION

Results of analysis of variance according to the models 1 and 2 are shown in Table 2. All studied traits were statistically significantly explained in both models, but the proportion of explained variance differed depending on the model. The trait weight of animals was explained in both models with very high coefficient of determination (R^2). It was 0.9940 in model 1 and 0.9869 in model 2. The experiment was done in the period of intensive growth and the weight of animals increased ten times. The weight of animals was not influenced only by age. The effect of treatment with CLA / control on body weight was statistically significant in both models. Body weight of animals was influenced also by sex in model 2 and by animal within treatment in model 1.

Comparing the weight of animals, the daily gain was much less explained with the two models. The coefficient of determination was 0.7944 in model 1 and 0.7791 in model 2. It can be concluded that both models explained daily gain with the same power, especially because model 1 used 13 degrees of freedom more for minor increase of coefficient of determination (0.0153). Differences in daily gain in the whole experimental period were not found. The largest part of variance was explained with individual differences inside treatment (model 1) or with age of animals within treatment (model 2).

Both models poorly explained feed conversion ratio. In model 1, the coefficient of determination was 0.4412 and in model 2 it was only 0.3940. The pattern of significance was the same as in the previous trait, but the coefficient of determination in model 1 was much larger than in model 2.

In the Table 3, the LSMs for the effect treatment are presented. Weight of animals was significantly larger in the control group than in the CLA group. Other traits (daily gain and feed conversion ratio) were not significantly different. Some trends for larger daily gain and feed conversion ratio in control group were found. During the whole period, no advantages of CLA supplement in feed were found.

In the Table 4 LSMs for traits weight, daily gain and feed conversion ratio in both models are presented. This effect is significant only in model 2, but the LSMs show the same pattern. At the beginning of the experiment animals of CLA group were larger than the control group, but the difference was not significant. Differences in daily gain were not prior the age of 68 days. In the last or fifth week of experimental period between 68 and 75 days of age, the fastest growth of CLA group was found. At the end of the period the animals from CLA group were heavier than the control group (28.08 vs. 26.29 kg), but the difference was not significant. Animals were fed restrictively and better feed conversion ratio was found in CLA group. The difference was not significant.

In the last period of experiment, after administration of CLA, the control group started to grow faster than CLA group. In that period all animals were fed *ad libitum*. In periods between ages 76 to 92, 73 to 99, 100 to 106, 107 to 113 and 114 to 123 days, the control group ate 0.88, 1.45, 1.64, 1.84, 2.31, 2.49 kg feed daily comparing to the control group, where the daily feed consumption was 0.87, 1.155, 2.13, 2.25, 2.57 and 2.58 kg. Daily feed consumption was, except in the period between 76 and 92 days, much larger in the control group. The consequence of larger feed consumption was faster growth in almost all periods of the last experimental period. At the last weighing at the age of 123 days, the control group was by 3.5 kg heavier. Larger daily gain of the control group decreased feed conversion ratio, but differences between groups were not statistically significant.

Table 2. Results of analysis of variance according to models 1 and 2
Preglednica 2. Rezultati analize variance po modelih 1 in 2

	Model					Treatment Tretman		Age (Treatment) Starost (Tretman)		Animal (treatment) Žival (tretman)	
Model 1	df model df model	df error df ostanek	F ratio F količ.	P	R^2	df	P	df	P	df	P
Weight / teža	37	145	644.98	<.0001	0.9940	1	0.0030	14	<0.0001	22	<0.0001
Daily gain /dnevni prirast	37	145	14.14	<.0001	0.7944	1	0.8367	14	0.6588	22	<0.0001
Feed conversion ratio / konverzija krme	33	116	2.78	<.0001	0.4412	1	0.6885	14	0.7680	18	<0.0001
	Model					Treatment Tretman		Age (Treatment) Starost(Tretman)		Sex Spol	
Model 2	df model df model	df error df ostanek	F ratio F količ.	P	R^2	df	P	df	P	df	P
Weight / teža	24	158	497.71	<0.0001	0.9869	1	0.0060	22	<0.0001	1	0.0110
Daily gain /dnevni prirast	24	158	23.22	<0.0001	0.7791	1	0.7199	22	<0.0001	1	0.4619
Feed conversion ratio / konverzija krme	20	129	4.19	<0.0001	0.3940	1	0.6708	18	<0.0001	1	0.8741

Table 3. LSM values and statistical significance for weight, daily gain and feed conversion ratio for effect treatment according to models 1 and 2
Preglednica 3. LSM vrednosti in statistična verjetnost za težo, dnevni prirast in konverzijo krme za vpliv tretmana po modelih 1 in 2

	CLA	Control Kontrola	P
Model 1			
Weight / teža	31.54	32.29	0.0030
Daily gain /dnevni prirast	0.582	0.587	0.8367
Feed conversion ratio / konverzija krme	2.11	2.16	0.6885
Model 2			
Weight / teža	31.51	32.47	0.0060
Daily gain /dnevni prirast	0.580	0.589	0.7199
Feed conversion ratio / konverzija krme	2.13	2.18	0.6708

Table 4. LSM values and statistical significance for weight, daily gain, and daily feed consumption and feed conversion ratio for effect age within treatment in models 1 and 2 respectively

Preglednica 4. LSM vrednosti in statistična verjetnost za težo, dnevni prirast, dnevno konzumacijo in konverzijo krme za vpliv starost znotraj tretmama po modelih 1 in 2

		Weight / teža			Daily gain Dnevni prirast			Feed conversion ratio Konverzija krme		
	Age starost	CLA CLA	control kontrola	P	CLA CLA	control kontrola	P	CLA CLA	control kontrola	P
Model 1										
3	28	7.77	7.35	0.6091	0.099	0.101	0.9834			
4	39	11.51	11.03	0.5676	0.340	0.335	0.9546			
5	47	14.13	13.13	0.2310	0.328	0.263	0.4140	1.76	2.15	0.3072
6	54	16.77	16.06	0.3900	0.378	0.418	0.6135	1.74	1.50	0.5412
7	61	20.47	19.06	0.0906	0.529	0.429	0.2134	1.38	1.78	0.3097
8	68	23.38	23.00	0.6518	0.415	0.563	0.0650	2.78	1.41	0.0006
9	75	28.08	26.29	0.0329	0.672	0.470	0.0125	1.41	2.08	0.0857
10	92	39.31	41.46	0.0140	0.746	0.973	0.0069	2.05	1.58	0.2410
11	99	44.94	48.67	<0.0001	0.804	1.028	0.0077	2.38	2.12	0.5306
12	106	49.40	53.60	<0.0001	0.692	0.701	0.9140	2.69	2.96	0.5326
13	113	56.90	59.24	0.0097	1.079	0.803	0.0016	2.12	3.37	0.0035
14	123	65.83	68.63	0.0032	0.901	0.957	0.5323	2.80	2.67	0.7641
Model 2										
3	28	7.77	7.35	0.7164	0.099	0.101	0.9832			
4	39	11.51	11.03	0.6848	0.340	0.335	0.9543			
5	47	14.13	13.13	0.3943	0.328	0.263	0.4106	1.76	2.15	0.3009
6	54	16.77	16.06	0.5413	0.378	0.418	0.6109	1.74	1.50	0.5360
7	61	20.47	19.06	0.2283	0.529	0.429	0.2100	1.38	1.78	0.3035
8	68	23.38	23.00	0.7486	0.415	0.563	0.0630	2.78	1.41	0.0005
9	75	28.08	26.29	0.1281	0.672	0.470	0.0118	1.41	2.08	0.0816
10	92	39.31	41.85	0.0375	0.746	0.977	0.0053	2.05	1.61	0.2634
11	99	44.94	49.06	0.0008	0.804	1.032	0.0060	2.38	2.15	0.5743
12	106	49.28	53.99	0.0002	0.685	0.705	0.8098	2.74	2.99	0.5568
13	113	56.78	59.64	0.0234	1.073	0.807	0.0021	2.17	3.40	0.0032
14	123	65.71	69.23	0.0074	0.894	0.961	0.4473	2.85	2.72	0.7517

Faster growth of treated animals as in the last period of second or experimental period between ages 69 and 75 days was found also in experiments of Wiegard *et al*. (2002), Lauridsen *et al*. (2005) and Bee (2000). No effect on growth would not be a surprise, because in experiment on rats (Azain *et al*., 2002) and on pigs (Weber *et al*., 2001) no effect of CLA on growth rate was found. Due to of different periods of treatment and different ages, the exact comparisons are not possible. CLA can influence growth of animals at different ages or in different conditions in different ways. Larger daily feed consumption and consequently faster growth of the control group in "post treatment" period cannot be explained with the results from this experiment.

SUMMARY

The supplement of CLA in feed affected body growth and body composition in many studies. In this study, the effect of CLA on body weight, daily gain and daily feed consumption and feed conversion in three periods was studied. In the first or adapting period animals were fed on regular starter feed. In the second or experimental period a 1.5% of supplement of mixture of fatty acids with 80% of CLA was added to feed (experimental group). The control group was fed on extra dosage of 1.5% sunflower oil added to feed. This part of experiment started at the age of 40 days. The experimental period was 35 days long. In the third experimental period animals were fed on regular feed without any supplement. The period started at the age of 75 days and lasted for 48 days to the age of 123 days. At the beginning of the second period, after administration of CLA started, no effect on studied variables was found. At the age of 75 days, after 5 weeks of supplementation of CLA, a positive effect on growth rate and body weight was found. In the third period of experiment at the age between 75 and 123 days, faster growth of the control group which was never fed on CLA was found. The fast growth of the control group was a consequence of increased daily feed consumption and not a result of better feed utilization. Feed conversion ratio and daily gain were influenced more by individual differences between animals (model 1) or sex of the animals (model 2) than by the treatment with CLA.

SKLEPI

V mnogih raziskavah so ugotovili učinek konjugirane linolenske kisline (CLA) na rast in sestavo telesa. V tej raziskavi smo proučevali učinek CLA na telesno težo, dnevni prirast, dnevno konzumacijo in konverzijo krme v treh obdobjih. V prvem obdobju ali obdobju prilagajanja smo krmili živali z navadnim starterjem. V drugem, poskusnem obdobju so dobivali prašiči poskusne skupine krmo z dodatkom 1,5 % mešanice maščobnih kislin z 80 % CLA. Kontrolna skupina je dobivala 1,5 % sončničnega olja. Ta del poskusa se je začel pri starosti 40 dni. Trajal je 35 dni. Tretje obdobje poskusa se je začelo pri starosti 75 dni in je trajalo 48 dni do starosti 123 dni. Na začetku drugega obdobja poskusa, po začetku dodajanja CLA, nismo odkrili nobenega učinka te snovi. Pri starosti 75 dni po petih tednih dodajanja CLA smo opazili pozitiven učinek na hitrost rasti in težo živali. V tretjem obdobju poskusa, pri starosti od 75 do 123 dni, je rasla hitreje kontrolna skupina. Tej skupini nismo nikoli dodajali CLA. Hitrejša rast te skupine je bila posledica večje konzumacije ne pa boljšega izkoriščanja krme. Na izkoriščanje krme so bolj vplivale individualne razlike med živalmi (model 1) ali spol (model 2) kot pa dodajanje CLA.

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