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THE EFFECT OF FEED WITH THE ADDITION OF CONJUGATED LINOLEIC ACID OR SUNFLOWER OIL ON FATTY ACID PROFILE OF CROSSBRED PIGS MEAT

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Abstract

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The aim of the paper was to investigate the impact of feeding pigs with 2 % addition of sunflower oil (SFO) or conjugated linoleic acid (CLA) on fatty acid profile of *Longissimus dorsi* muscle. The subjects of research were 116 crossbred gilts divided into 3 groups (SFO, CLA and control). The addition of sunflower oil or conjugated linoleic acid started at the time when the weight of the pigs ranged 82 kg, averagely. Conditions for the maintenance, care and nutrition of all experimental fatteners were standardized. Diet was available *semi ad libitum*. Animals were slaughtered at c.a. 120 kg of body weight. Fatty acid profile was determined in samples of *Longissimus dorsi* muscle from each animal. Gas chromatography was used (in the research). The significance of differences between groups was verified by Duncan's test. In the present study pigs from experimental groups getting the addition of sunflower oil or conjugated linoleic acid had higher amount of polyunsaturated fatty acids (PUFA) and essential fatty acids (EFA) as compared to the animals from the control group what was proved by statistical differences.

Key words: conjugated linoleic acid, sunflower oil, pigs, fatty acid profile, *Longissimus dorsi*

Introduction

In a modern breeding and production of pigs, the aim is to obtain animals of high fattening efficiency, high meat content and a slightly fat content, while maintaining normal quality of meat, including the optimal fatty acid profile. The quality of pork is influenced by many factors - genetic and environmental, including nutrition. It is difficult to get pork of good technological properties while retaining its good taste. Pork meat has an unfavorable fatty acid profile. Polyunsaturated fatty acids cannot be synthesized in the body of pigs and must be delivered in animal feed, mostly in the form of linoleic and linolenic acids (Więcek et al., 2010).

Preferences of the consumers interested in a pro-health food significantly affect the work on the best composition and properties of meat (Dransfield, 2001). The fatty acid composition in a meat fat is very important for the health of humans. Healthy food is also called a functional food, or one that in addition to nutrition components supply has a positive effect on in-

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hibiting the development of various diseases (Jiménez-Colmenero et al., 2001). Variability of quantitative and qualitative composition of fatty acids in meat and fat depends on genetics and breed, age, gender and type of diet (Sawosz, 1999; Rosenvolt and Andersen, 2003). With the breeding work carried out to improve meat content and reduce fat content the share of polyunsaturated fatty acids in the tissues of modern pigs is high (Raj et al., 2010).

The aim of this study was to determine the effect of feeding pigs the feed with the addition of conjugated linoleic acid or sunflower oil on fatty acid profile of *Longissimus dorsi* muscle.

Material and Methods

The study was conducted in Bonagro a.s. agricultural company, Czech Republic. In the experiment, 116 crossbred pigs were used (PLEBO hybrids Brno), which were divided into three groups: two experimental (n = 40) and control (n = 36).

Varied diets were used according to the following scheme:

Group:

1 – Diet of 2.0% amount of sunflower oil (SFO)

2 – Diet of 2.0% amount of conjugated linoleic acid (CLA)

3 – Control diet (C)

At the beginning of the experiment, the pigs were individually weighted numbered and grouped by gender. The addition of sunflower oil or conjugated linoleic acid started at the time when the weight of the pigs ranged 82 kg, averagely. The slaughter was carried out when the weight ranged 120 kg, averagely. Conditions for the maintenance, care and nutrition of all experimental fatteners were standardized. Diet was available *semi ad libitum*. Feed composition is shown in Table 1. It was prepared in Bonagro a.s.

The source of conjugated linoleic acid was Luta-CLA® 60 preparation made by BASF of CLA (C 18:2) containing min. 56%, including c9 t11 isomer min. 28% and t10 c12 isomer min. 28%.

Fatty acid profile was determined in the samples of *Longissimus dorsi* muscle from each animal. Gas chromathography was used – Varian 3400 Gas Chromatograph, equipped with DB-23 capillary column.

The results were statistically processed – mean ($\bar{x}$) and standard deviation (s) were calculated. The significance of differences between tested groups was verified by Duncan's test. A computer program Statistica 8.0 PL (2008) was used.

Results

The fatty acid profile in the fat of *Longissimus dorsi* muscle of pigs fed the diet supplemented with conjugated linoleic acid, sunflower oil and in a control groups is shown in a Table 2.

The lowest concentration of C10: 0 acid (decanoic acid) appeared in a control animals (0.09%), the highest in the case of individuals from experimental groups (0.11%). There were a statistically high significant differences between group 1 and 2, 3 and also between 2 and 3.

The highest amount of C12: 0 acid (lauric acid) was observed in the individuals treated with 2% conjugated

Table 1
Content of the fodder, %

Components	Group		
	1 (SFO)	2 (CLA)	3 (C)
Wheat	10.0	10.0	10.0
Wheat bran	10.0	10.0	10.0
Soybean meal	10.0	10.0	10.0
Mikrop A1-CDP-19	2.6	2.6	2.6
Corn	65.4	65.4	67.4
Sunflower oil	2.0	-	-
Conjugated linoleic acid	-	2.0	-
Total	100	100	100

linoleic acid added into the fodder (0.11%), while the lowest (0.08%) was in a control group. Statistically high significant differences were observed between group 1 and 2, 3 and also between 2 and 3 group.

The lowest content of C14: 0 acid (myristic acid) was characterized by a control group of animals (1.39%), while the highest occurred in the case of individuals from the group receiving conjugated linoleic acid (1.71%). There were a statistically high significant differences between group 1 and 2, 3 and also between 2 and 3 group.

The highest concentration of C15: 0 IS acid (0.07%) occurred in animals treated with 2% conjugated linoleic acid supplement into the fodder, while the lowest (0.05%) in the control group. It has been proven statistically high significant differences between group 3 and 1, 2.

The lowest amount of C16: 0 acid (palmitic acid) appeared in the control group of animals (25.52%), the highest in the case of individuals from the group receiving conjugated linoleic acid (27.32%). There were a statistically high significant differences between group 1 and 2, 3 and also between 2 and 3 group.

The highest content of C16: 1n7c acid (palmitoleic acid) was observed in animals treated with 2% conjugated linoleic acid added into the fodder (3.51%), while the lowest (3.21%) was in individuals from the control group. It has been proven statistically significant difference between group 2 and 3.

The lowest concentration of C18: 0 acid (stearic acid) was characterized by a group of animals treated with sunflower oil into the fodder (13.66%), while the high-

Table 2
Fatty acid profile in Longissimus dorsi muscle (%)

Fatty acids	Statistical measure	Group			Total	Significance of differences	
		1 (SFO)	2 (CLA)	3 (C)		P≤0.05	P≤0.01
Number	n	40	40	36	116	-	-
C10 : 0	$\bar{x}$	0.11	0.11	0.09	0.11	-	1-2.3; 2-3
	s	0.01	0.01	0.01	0.01		
C12 : 0	$\bar{x}$	0.10	0.11	0.08	0.10	-	1-2.3; 2-3
	s	0.09	0.01	0.01	0.01		
C14 : 0	$\bar{x}$	1.54	1.71	1.39	1.55	-	1-2.3; 2-3
	s	0.13	0.12	0.10	0.18		
C15 : 0 IS	$\bar{x}$	0.06	0.07	0.05	0.06	-	3-1.2
	s	0.02	0.02	0.01	0.02		
C16 : 0	$\bar{x}$	26.10	27.32	25.52	26.34	-	1-2.3; 2-3
	s	0.95	1.02	0.69	1.17		
C16 : 1n7c	$\bar{x}$	3.40	3.51	3.21	3.38	2-3	-
	s	0.42	0.58	0.46	0.50		
C18 : 0	$\bar{x}$	13.66	14.44	14.35	14.14	1-3	1-2
	s	1.00	1.00	1.47	1.21		
C18 : 1n9c	$\bar{x}$	40.62	38.52	43.21	40.70	-	1-2.3; 2-3
	s	1.74	1.96	1.50	2.57		
C18 : 1n7c	$\bar{x}$	4.02	3.88	4.11	4.00	-	2-3
	s	0.34	0.36	0.42	0.38		
C18 : 2n6c	$\bar{x}$	8.82	8.81	6.41	8.07	-	3-1.2
	s	1.42	2.05	1.56	2.02		
C18 : 3n3c	$\bar{x}$	0.28	0.28	0.32	0.29	-	-
	s	0.05	0.07	0.12	0.08		
C20 : 0	$\bar{x}$	0.25	0.25	0.24	0.24	-	-
	s	0.03	0.03	0.02	0.03		
C20 : 1n9c	$\bar{x}$	0.73	0.71	0.80	0.75	-	3-1.2
	s	0.07	0.08	0.10	0.09		
C20 : 2n6c	$\bar{x}$	0.31	0.30	0.23	0.28	-	3-1.2
	s	0.05	0.06	0.05	0.06		

est occurred in the case of individuals from the group receiving conjugated linoleic acid (14.44%). There was a statistically high significant difference between group 1 and 2 and statistically significant difference between group 1 and 3.

The highest amount of C18: 1n9c (oleic acid) was observed in control subjects (43.21%), while the lowest (38.52%) in subjects who receive conjugated linoleic acid. It has been proven a statistically high significant difference between group 1 and 2, 3 and also 2 and 3.

The lowest content of C18: 1n7c (vaccenic acid) was recorded in animals receiving the supplement of conjugated linoleic acid into the fodder (3.88%), while the highest was found in the control group (4.11%). There was a statistically high significant difference between group 2 and 3.

The highest concentration of C18: 2n6c (linoleic acid) occurred in individuals from a experimental groups given sunflower oil into the fodder (8.82%) and addition of conjugated linoleic acid (8,81%), while the lowest (6.41%) in individuals from the control group. Between experimental groups and control group were verified statistically high significant differences.

The lowest amount of C18: 3n3c (linolenic acid) appeared in the experimental groups (0.28%), the highest in the case of individuals from the control group (0.32%). The content of C20: 0 acid (arachidic acid) in tested groups was similar.

The lowest concentration of C20: 1n9 acid (eicosenoic acid) was detected in the group of animals receiving the supplement of conjugated linoleic acid into the fodder (0.71%), then in a group of pigs fed the fodder with addition of sunflower oil (0.73%). The highest amount of this acid occurred in case of individuals from the control group (0.80%). There were statistically high significant differences between control and experimental groups.

The lowest amount of C20: 2n6c acid (ecosadienoic acid) was characterized by a control group of animals (0.23%), while the highest occurred in the case of individuals from the groups receiving sunflower oil as an additive (0.31%) and conjugated linoleic acid (0,30%). The differences between control group and the experimental groups were confirmed as statistically high significant.

Table 3 summarizes the content of saturated and unsaturated (mono – and polyunsaturated) fatty acids and their ratio in the *Longissimus dorsi* muscle. The amount of saturated fatty acids (SFA) in the *Longissimus dorsi* muscle ranged from 41.71 (control group) to 44.00% (group with the addition of CLA). Between group 2 and 1, 3 there were statistically high significant differences. The concentration of unsaturated fatty acids (UFA) contained in the range from 56.00% (a group with addition of CLA) to 58.29% (control group). Between group 2 and 1, 3 were proved a statistically high significant differences, too.

Statistically high significant differences were also observed in the case of monounsaturated fatty acids (MUFA). The lowest concentration of 46.62% occurred in the group of animals receiving CLA as a feed additive. The highest - 51.32% was in the control group. Statistically high significant differences were confirmed between group 3 and 1, 2. Statistically significant differences ($P \leq 0.01$) between experimental groups were also observed.

The highest content of polyunsaturated fatty acids (PUFA) occurred in the group of pigs getting the fodder with addition of sunflower oil (9.41%), then in a group of fatteners receiving conjugated linoleic acid (9.38%) and the lowest in animals from the control group (6,96%). Between group 3 and two experimental groups the statistical differences ($P \leq 0.01$) were confirmed.

High content of essential fatty acids (EFA) had animals from experimental groups, i.e. 1 and 2 (9.10 and 9.08%, respectively) compared with control group (6.73%). These differences between group 1, 2 and 3 were confirmed as statistically high significant. Hypercholesterolemic acids (OFA), the highest concentration (29.02%) occurred in the group of pigs fed the feed supplemented with conjugated linoleic acid and then the group of animals treated with sunflower oil (27.64%). The lowest concentration was found in the control group (26.91%). Statistically high significant differences occurred between group 1 and 2, 3 and also between 2 and 3.

Statistically highly significant differences were observed also in the case of hipocholesterolemic acid (DFA) between the same groups as in the case of OFA acids. However, the highest DFA acid content had a

Table 3
Amount of fatty acids in muscle Longissimus dorsi (%)

Fatty acids	Statistical measure	Group			Total	Significance of differences	
		1 (SFO)	2 (CLA)	3 (C)		P≤0.05	P≤0.01
Number	n	40	40	36	116	-	-
SFA	$\bar{x}$ s	41.81 1.85	44.00 1.71	41.71 1.65	42.54 2.03	-	2-1.3
UFA	$\bar{x}$ s	58.19 1.85	56.00 1.71	58.29 1.65	57.46 2.03	-	2-1.3
MUFA	$\bar{x}$ s	48.78 2.29	46.62 2.53	51.32 1.89	48.82 2.95	-	1-2.3; 2-3
PUFA	$\bar{x}$ s	9.41 1.50	9.38 2.16	6.96 1.62	8.64 2.10	-	3-1.2
EFA	$\bar{x}$ s	9.10 1.46	9.08 2.11	6.73 1.57	8.36 2.05	-	3-1.2
OFA	$\bar{x}$ s	27.64 1.06	29.02 1.11	26.91 0.75	27.89 1.32	-	1-2.3; 2-3
DFA	$\bar{x}$ s	71.85 1.08	70.44 1.13	72.63 0.75	71.61 1.35	-	1-2.3; 2-3
DFA : OFA	$\bar{x}$ s	2.60 0.14	2.43 0.13	2.70 0.10	2.58 0.17	-	1-2.3; 2-3
MUFA : SFA	$\bar{x}$ s	1.17 0.10	1.06 0.08	1.23 0.09	1.15 0.11	-	1-2.3; 2-3
UFA : SFA	$\bar{x}$ s	1.40 0.10	1.28 0.09	1.40 0.10	1.36 0.11	-	2-1.3
PUFA : MUFA	$\bar{x}$ s	0.19 0.04	0.20 0.06	0.14 0.03	0.18 0.05	-	3-1.2
PUFA : SFA	$\bar{x}$ s	0.23 0.04	0.21 0.05	0.17 0.04	0.20 0.05	-	3-1.2
n 6 : n 3	$\bar{x}$ s	32.40 2.90	32.86 2.95	23.42 8.15	29.77 6.66	-	3-1.2

control group (72.63%), the lowest (70.44%) group of animals receiving conjugated linoleic acid. Between the control group and experimental groups, statistically high significant differences were confirmed. Statistically significant differences ($P \leq 0.01$) between experimental groups were also observed.

The most narrow ratio of DFA: OFA (2.43) acids and MUFA: SFA (1.06) acids had the groups of pigs getting addition of CLA into the fodder. The highest was in a control group (2.70 and 1.23, respectively). The differences between group 2 and the remaining groups were confirmed as statistically high significant.

The most narrow ratio of UFA: SFA (1.28) acids had the group of pigs getting addition of conjugated linoleic acid as the fodder supplement. Between this group of pigs and the individuals from the group getting addition of sunflower oil and a control group statistically high significant difference occurred.

Statistically high significant differences were proved between control group and experimental groups in case of acids: PUFA: MUFA, PUFA: SFA and n6: n3. The control group in these three cases had the lowest amount.

Discussion

The saturated fatty acids - SFA in high concentrations (especially C12: 0, C14: 0 and C16: 0), are responsible for increases in total cholesterol in serum. It has been proven that the acid C16: 0 has atherogenic activity (Bolton-Smith et al., 1991; Sawosz, 1999). The risk of heart disease and a circulatory system reduces the C18: 1 acid (Hoffman et al., 2007). Polyunsaturated fatty acids (C18: 2 and C18: 3) are responsible for prohealth and nutritional value of meat (Xiccato and Trocino, 2003). It is also important to determine the content

of linoleic acid (C18: 3n3) and arachidonic acid (C20: 4n6). The ratio of polyunsaturated fatty acids (PUFA) to saturated fatty acids (SFA) should be greater than 0.4 (Wood et al., 2003).

In a study of Huang et al. (2008) the concentration of C18: 3n-3 and n-3 PUFA fatty acid family in the *Longissimus dorsi* muscle increased in pigs fed diet supplemented with flaxseed. Romans et al. (1995 a, b) and Nuernberg et al. (2005) also obtained similar results. In previous own studies (Wasilewski et al., 2011) the impact of conjugated linoleic acid or sunflower oil was not proved on modifying the fatty acid profile of *Longissimus dorsi* muscle. Jiang et al. (2010) observed that the addition of CLA to the feed for pigs has increased the content of lean meat (from 3.5 to 4.7%) and intramuscular fat and reduced fat thickness (from 12.9 to 16.6 %).

Eggert et al. (2001), obtained in the *Longissimus dorsi* muscle of gilts fed the fodder with addition of conjugated linoleic acid more saturated fatty acids ($P \leq 0.001$) and less unsaturated fatty acids ($P \leq 0.001$). Similarly, Bee (2001) and Corino et al. (2003) found that pigs receiving CLA had altered fatty acid profile in ham - more SFA and less MUFA. Barowicz and Kędzior (2000), in their study also showed a significant increase of polyunsaturated fatty acids (PUFA) in lipids of *Longissimus dorsi* muscle. Significantly high increase of acids from the PUFA family and a small decrease of SFA and MUFA were proved in their research Koczanowski et al. (2002). Walkiewicz et al. (2001) reported that the relationship between the major fatty acids in intramuscular lipids of crossbred pigs that are the offspring of sows of Siamese and PLW breed and fathers of PL breed in different periods of growth and development (body weight 10 - 50 kg) were as follows: the level of PUFA increased by 7%, EFA monoenic acids showed decreasing trend (49.4 - 44.9%), whereas increased levels of polyenic fatty acids n-6 (11.6 - 13.5%), and decreased the share: n-3 (0.9 - 0.6%). Schone et al. (2003) and Martin et al. (2008) observed that the addition of CLA to the feed resulted in higher content of CLA in muscle fat.

Summarizing obtained results it should be stated that the pigs from experimental groups getting the addition of sunflower oil or conjugated linoleic acid had higher amount of polyunsaturated fatty acids (PUFA) and essential fatty acids (EFA) as compared to the animals from the control group what was proved by statistical differences.

Conclusions

The aim of the paper was to investigate the impact of feeding pigs with 2 % addition of sunflower oil (SFO) or conjugated linoleic acid (CLA) on fatty acid profile of *Longissimus dorsi* muscle. In the present study pigs from experimental groups, getting the addition of sunflower oil or conjugated linoleic acid had higher amount of polyunsaturated fatty acids (PUFA) and essential fatty acids (EFA) as compared to the animals from the control group what was proved by statistical differences.

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