Improving the fatty acid composition of animal originated food by nutrition

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Abstract – Feeding of 1 and 2% CLA-product (53.5% CLA content) resulted 1.84 and 3.49% c9t11 C18:2 in broiler thigh meat compared to the control of 0.111% value. It was observed that frying the meat in lard or in sunflower oil altered c9t11C18:2 content, but the absolute CLA content of meat did not decrease significantly compared to raw meat. The c9t11 CLA content of egg can also be enhanced: 1% CLA-product in the diet increased the c9t11 C18:2 proportion of egg fat from 0.06% to 1.2%. In another experiment the n-3 content and n-6/n-3 ratio was improved in lamb meat by feeding 3% calcium soap of linseed oil. As expected, the linolenic acid (C18:3n3) and thus the n-3 content in the *biceps semimembranosus* muscles was improved significantly ($P<0.05$) (C18:3n3: 0.80 vs. 0.51; n-3: 1.15 vs. 0.85, respectively). The n-6/n-3 ratio was narrower in the experimental group than in the control samples (5.82:1 vs. 8.43:1, respectively).

Keywords: calcium soap of linseed oil / CLA / lamb / n-3 fatty acid / poultry

1. INTRODUCTION

In recent years several works were focused on possible changing the composition of animal products (meat, milk and egg) in order to better meet human demands. Fat content and fatty acid composition of foods of animal origin have great importance in terms of human nutrition. A great number of studies proved that different fatty acids have number of effects on human health, depending on their different physiological roles. Researchers targeted in several works to decrease the proportion of saturated fatty acids (SFA) in favour of the polyunsaturated fatty acids (PUFA) - especially the n-3 fatty acid - to achieve or at least approach the optimal n-6/n-3 ratio.

Special attention has been paid to conjugated linoleic acids (CLA), because of their anticarcinogenic effect, proved in severel experiments in animals. It was reported that CLA can inhibit the development of tumours (skin, breast or gastrointestinal cancer) caused by chemicals. Furthermore, it has been confirmed, that CLA has remarkable antioxidant property. Significant quantities of CLA are only in ruminant products (milk, meat), therefore several experiments have been carried out recently to increase the CLA content of meat in monogastric animals, too.

In one part of our experiments the effect of the by us produced CLA supplement on the fatty acid composition of broiler meat and egg yolk was investigated. In other experiments with lambs the aim was to increase the n-3 fatty acid content of lamb meat by feeding bypass linseed oil (calcium soap of linseed oil).

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2. MATERIALS AND METHODS

2.1. Experiment with broilers

In this experiment our aim was to determine the effect of dietary CLA-supplement on the fatty acid profile of the meat. The CLA-supplement used was produced by alkaline isomerisation of sunflower oil in our department. This product contained 53.5% CLA and the c9t11 C18:2 isomer having beneficial physiological properties, has represented 26.3% proportion in it.

The fattening experiment was carried out with 150 Ross 308 genotype broiler roosters (50 animals/group). Chickens consumed 21days of age starter feed; between 22-35 days of age grower feed; and until the end of the experiment – that is the 42 days of age – finishing feed. Diets were of the same energy and protein content. The treatments differed only in the oil sources fed. The control diet (C) contained 4% sunflower oil. The experimental group CLA1 received 1% CLA-product+3% sunflower oil and the diet of the group CLA2 was supplemented with 2% CLA-product+2% sunflower oil.

The body weight of the broilers was measured individually at the 21st and 42nd fattening days and the feed intake of groups was determined as well. All birds were slaughtered at the end of the experiment and meat samples (breast and thigh) were collected from 5 animals of each treatment for laboratory analysis.

The changes in the c9t11 C18:2 content of the broiler meat (thigh) was also tested, when frying without fat or in different cooking fats (such as sunflower oil and lard) compared to raw meat. In the course of the frying test 3-3 legs were fried of the treatments C and CLA1. The legs with skin were placed one by one into aluminum trays, then without or with 50 g of added fat were fried for 90 minutes in 180 ^{o}C oven. Fat content and fatty acid profile was determined in a same manner as in the case of raw meat.

2.2. Experiment with laying hens

The experiment with laying hens aimed to study how alters the fatty acid composition of egg yolk if 1% CLA-product + 2% sunflower oil is added into the diet (experimental group E) of the laying hens compared to the control group (C) having 3% sunflower oil in the diet. Forty caged Shaver-576 laying hybrids were involved in both treatments. The CLA-product was the same as in the broiler trial.

2.3. Experiment with lambs

Merino lambs were used to assess the effect of the dietary linseed oil on the fatty acid profile of lamb meat. Each diet was fed to 5-5 lambs during the 60 days experimental period, which was preceded by a 10-days adaptation period. The diet of the expremintal group (S) contained 3% calcium soap of linseed oil, while that of the control 1% sunflower oil. Diets were the same energy content.

At the end of the experiment all lambs were slaughtered and *biceps semimembranosus* muscle samples were collected from the right side of each carcass in both groups to determine the fatty acid profile of meat.

2.4. Fatty acid analysis

The fatty acid composition of the fed oil supplements, the fats used for frying, the slaughtered product and of the fried meat was determined with an HP Agilent Technologies 6890N gas chromatograph (Agilent Technologies, Inc. Headquarters Santa Clara, US). The standard was the SupelcoTM 37 Component FAME Mix Catalog No. 47885-U.

2.5. Statistical analysis

The effect of diet on fatty acid composition was analyzed using SPSS 15.0 for Windows program package (SPSS Inc., Chicago, USA). After studying the data distribution (Kolmogorov-Smirnov test) in case of parameters showing normal distribution we initiated one factor analysis of variance (Levene's test, one-way ANOVA, Bonferoni test, Games-Howell test) while in the opposite cases we used non-parametric trials (Kruskal-Wallis test, Mann-Whitney test). Statistical significance was considered at $P<0.05$.

3. RESULTS AND DISCUSSION

3.1. Experiment with broilers

As *Table 1.* shows the highest daily weigh gain was found in CLA1 treatment (fed 1% CLA-supplement) both at the end of the starter period (21st day) and on the 42nd day. However, live weights did not differ significantly from the weights of the group fed 2% CLA-supplement (CLA2). Feed conversion ratio of the group CLA1 was also the most favourable.

Table 1. The effect of CLA-supplement on the body weight and feed conversion ratio

		C	***CLA1***	***CLA2***
Body weight	*21. day*	760 ± 161^{a}	835 ± 159^{b}	802 ± 159^{ab}
	42. day	2550 ± 331^{a}	2739 ± 359^{b}	2713 ± 327^{b}
Feed conversion ratio (kg/kg)	*21. day*	1.97	1.74	1.93
	42. day	2.20	2.04	2.09

a,b: different superscripts within a row indicate significant differences ($P<0.05$)

The fatty acid analysis results of breast and thigh meat have shown that increasing dosage of CLA resulted in significant ($P<0.05$) increase of CLA-content in the meat. The amount of linolenic acid (C18:3 n3), which is essential in human nutrition, has also been increased significantly ($P<0.05$) (*Table 2.*). The proportion of c9t11 CLA isomer, which has beneficial physiological properites in human body, was raised from 0.01% to 1.84% and 3.49% of the total fatty acids in thigh meat by adding 1% and 2% CLA-product. The tendency was similar in the case of breast meat, too.

Table 2. The effect of CLA-supplement on the fatty acid composition of thigh meat (% of total fatty acids)

Parameters	**C**	**CLA1**	**CLA2**
CLA in the diet (%)	0	1	2
Sunflower oil in the diet (%)	4	3	2
SFA	26.13 ± 1.42^{c}	37.70 ± 1.37^{b}	41.78 ± 1.45^{a}
MUFA	38.58 ± 2.27^{a}	30.47 ± 1.29^{b}	26.65 ± 1.15^{c}
C18:2 n6	32.52 ± 2.94^{a}	26.43 ± 1.19^{b}	22.83 ± 1.58^{c}
c9,t11-C18:2 n6	0.01 ± 0.01^{c}	1.84 ± 0.11^{b}	3.49 ± 0.30^{a}
t10,c12-C18:2 n6	0.05 ± 0.01^{c}	1.15 ± 0.09^{b}	2.34 ± 0.29^{a}
C18:3 n3	0.48 ± 0.05^{b}	0.74 ± 0.04^{a}	0.72 ± 0.05^{a}
PUFA	34.81 ± 3.26^{a}	31.44 ± 1.41^{b}	30.67 ± 2.01^{b}

SFA=saturated fatty acids, MUFA=monounsaturated fatty acids, PUFA=polyunsaturated fatty acids

Although, the CLA-product contained a similar amount of t10c12 as the isomer c9t11, it was recovered in lower proportion in the meat (*Table 2.*). BADINGA et al. (2003) reported also an increased c9t11 content.

In contrast, the increasing ratio of saturated and paralell with it the significantly reducing amount of mono- and polyunsaturated fatty acids were undesirable changes induced by dietary CLA in meat. These changes primarily due to the lower oleic (C18:1) and linoleic (C18:2 n6) acid content in the experimental groups. The PUFA ratio was found lower in the study of JAVADI et al. (2003), too.

The effect of frying and the source of fat used for frying on the fatty acid profile of the meat compared to raw meat rich in CLA was studied. It was established that the fat source (lard or sunflower oil) altered the fatty acid profile of the meat according to the characteristic of their own fatty acid composition. However, this effect is lower than it was expected, because approximatly 18-21% of the frying fat was absorped into the meat. The *Figuere 1.* indicates that CLA-content of fried meat was as high as that in raw meat samples of the CLA1 group. CLA was approximatly 0.19 g/100g meat.

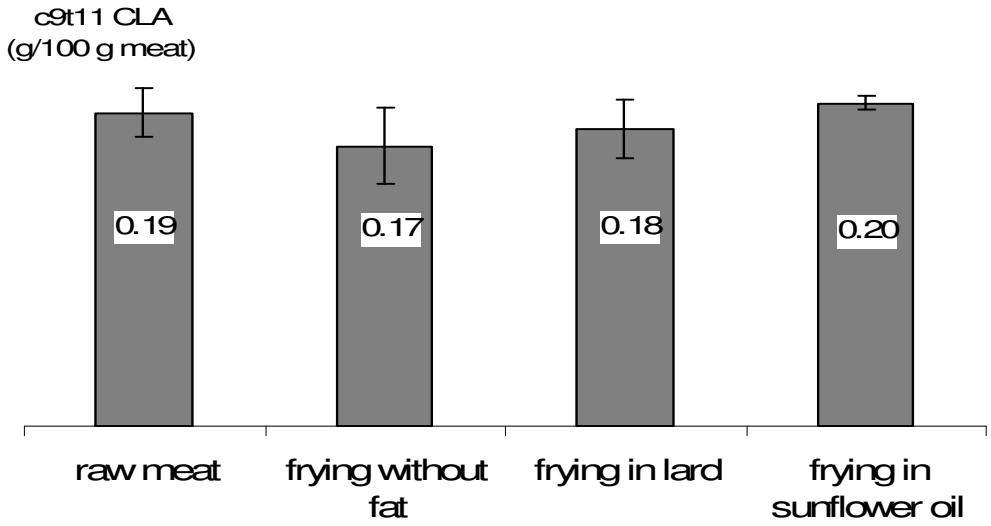

Figure 1. The c9t11 CLA content in the thigh meat of broilers fed 1% CLA-supplement

3.2. Experiment with laying hens

The dietary CLA-supplement, similarly to broiler meat, resulted in higher CLA content in eggs (*Table 3.*). Dietary CLA-product increased the quantity of c9t11 isomer from 0.06% (C) to 1.20% (E) of total fatty acids in the egg yolk. In spite of the fact that c9t11 and t10c12 isomers were involved in similar amount in the CLA-product, almost four-times more c9t11 isomer was recovered in the egg than the other isomer.

Increasing SFA and decreasing MUFA are considered as undesirable changes from the point of view of human nutrition. HUSVÉTH et al. (2005) had similar results, when supplemented laying hen's diet with CLA.

Dietary CLA increased significantly PUFA proportion ($P<0.05$) compared to control, despite the fact, that the n-6/n-3 ratio was wider in this group. Other authors reported also that PUFA content increased by feeding dietary CLA (BÖLÜKBASI et al., 2005; SHANGER et al, 2005), but there are opposite findings, too (SUKSOMBAT et al., 2006; HUR et al., 2007). Further investigation is needed to find an optimal fat source, which can moderate these unfavourable changes.

Table 3. The effect of CLA-supplement on the fatty acid profile of egg
(% of total fatty acids)*

Parameters	C	E
CLA in the diet (%)	0	1
Sunflower oil in the diet (%)	3	2
SFA*	32.1±0.92[a]	43.8±2.28[b]
MUFA*	42.0±1.96[b]	28.3 ±1.58[a]
c9,t11-C18:2 n-6*	0.06±0.02[a]	1.20±0.11[b]
t10,c12-C18:2 n-6*	0.01±0.01[a]	0.32±0.06[b]
PUFA*	24.2± 212[a]	26.7±1.64[b]
n-6/n-3	29.5	36.6

SFA=saturated fatty acids, MUFA=monounsaturated fatty acids, PUFA=polyunsaturated fatty acids

3.3. Experiment with lambs

Bypass fat (calcium soap of linseed oil) was applied in the lamb fattening experiment. It lasted 60 days long, which resulted charecteristic alteration in the meat of experimental group (*Table 4.*).

Table 4. The effect of calcium soap of linseed oil feeding on the fatty acid profile of lamb meat
(% of total fatty acids)

	C	S
C16:0	25.24±0.85[a]	24.51±0.85[a]
C18:0	11.31±0.80[a]	12.15±0.53[a]
SFA	**44.39±1.81[a]**	**44.49±0.90[a]**
C18:1 n9	30.24±1.30[a]	26.69±2.57[b]
MUFA	**43.00±1.95[a]**	**40,18±1,48[b]**
C18:2 n6	5.53±0.52[a]	5.02±0.86[a]
C18:3 n3	0.51±0.04[b]	0.80±0.15[a]
PUFA	**7.99±0.53[a]**	**7.79±0.75[a]**
n-6	7.14±0.48[a]	6.65±0.66[a]
n-3	0.85±0.07[b]	1.15±0.14[a]
n6/n3	8.43:1	5.82:1

SFA=saturated fatty acids, MUFA=monounsaturated fatty acids, PUFA=polyunsaturated fatty acids

Dose of 3% calcium soap did not alter the SFA and PUFA proportion in the meat of the group S, at the same time MUFA was significantly lower ($P<0.05$), which is primarily due to the significant decrease of palmitoleic (C16:1) and oleic acid (C18:1).

As it was expected, the calcium soap containing 52% linolenic acid (C18:3 n-3) increased with 57% the linolenic acid proportion in the meat. As a consequence, higher n-3 content was found in the meat of treatment S. As the n-6 fatty acid content was not affected by dietary manipulation, the n-6/n-3 ratio became narrower in group S than in group C, which can meet the 4-5:1 human demand (WAHRBURG et al., 2004).

Any publications were not found which have used calcium soap of linseed oil but only linseed oil to improve n-3 content of lamb meat (BAS et al., 2007; ELMORE et al., 2005). Further work is needed to determine the maximum amount of calcium soap of linseed oil, which still in the diet does not impair the sensory properties of the meat.

4. CONCLUSION

Our results presented that the addition of 1% CLA-product to the diet is an efficient way to improve significantly the CLA content in broiler meat and in eggs, which is favorable in terms of human nutrition. Frying does not alter the increased CLA content of the raw meat, if the frying is done in lard or in sunflower oil. Further studies are needed to eliminate some adverse effects of CLA supplementation on the fatty acid profile.
Feeding of calcium soap of linseed oil is an appropriate method to improve the n-3 fatty acid content in lamb, too.

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