Animal Science Papers and Reports vol. 31 (2013) no. 2, 147-158
Institute of Genetics and Animal Breeding, Jastrzębiec, Poland

Modification of fatty acids composition of lambs' fat by supplementing their diet with isomerised grapeseed oil*

Robert Bodkowski, Bożena Patkowska-Sokoła**

Institute of Animal Breeding, Wroclaw University of Environmental and Life Sciences, Chełmońskiego 38C, 51-630 Wrocław, Poland

(Received September 18, 2012; accepted March 8, 2013)

The alkaline isomerisation of grapeseed oil changed the position of double bonds in the chains of unsaturated fatty acids (positional) and altered the arrangement of radicals in relation to the double bond axis (geometric). Most of saturated fatty acids were removed as a result of crystallization with urea. These two processes produced oil preparation in the form of isomerised grapeseed oil (IGO) containing conjugated dienes of linoleic acid in amounts of 38.3% (*cis*-9,*trans*-11), 35.6% (*trans*-10,*cis*-12) and 3.7% (*cis*-11,*trans*-13) of FFA. The supplementation of lambs' diet with IGO had favourable effects on the fatty acid content of lambs' adipose tissue causing an increase in biologically active components with health-promoting effects such as *c*9,*t*11 (from 59 to 75 percentage points) and *t*10,*c*12 isomers of linoleic acid (from 67 to 129 percentage points) and vaccenic acid (from 78 to 173 percentage points), and a decrease in saturated fatty acids and the atherogenic index.

KEY WORDS: Atherogenic index / CLA / fatty acids/ grapeseed oil / lambs

Conjugated linoleic acid (CLA) is a collective term describing a mixture of positional (8 and 10, 9 and 11, 10 and 12 or 11 and 13) and geometric (*cis* and *trans*) isomers of octadecadienoic acid (C18:2) in which, unlike in linoleic acid *cis*-9,*cis*-12 C18:2, double bonds are separated by only one single bond, *i.e.* are conjugated

*Carried out as a part of Research Project 3 T09B 130 29 financed by the Polish Ministry of Science and Higher Education.
**Corresponding author: robert.bodkowski@up.wroc.pl

[Eulitz *et al*. 1999]. In natural products, isomers of *cis*-9,*trans*-11 and *trans*-10,*cis*-12 configuration predominate and these dienes have been attributed with special biological activity [Pariza *et al*. 2001].

Experimental evidence has demonstrated that dietary CLA can protect against cancer [Palombo *et al*. 2002] and atherosclerosis [Kritchevsky *et al*. 2002], stimulate the immune system [Chew *et al*.1997], normalize impaired glucose tolerance [Nikel and Belury 1998], and enhance bone formation and resorption [Brownbill *et al*. 2005].

In the past decade the aspect of CLA that has drawn much attention is its ability to enhance lipid metabolism [Pariza *et al.* 1997, Akahoshi *et al*. 2002, Baumgard *et al*. 2002, Evans *et al*. 2002, Wynn *et al*. 2006].

Natural CLA is produced in the rumen through an enzymatic conversion mechanism during the biohydrogenation of linoleic and linolenic acids [Harfoot and Hazelewood 1988]. Some bacterial species in the large intestine of monogastric animals also possess this capacity, but CLA would not be subsequently absorbed. Another source of CLA is synthesis *via* Δ^9-desaturase of *trans*-11 octadecanoid acid in mammalian tissue [Corl *et al*. 2001]. Conjugated dienes of linoleic acid may also be formed during thermal processing of food and as a result of chemical synthesis (dehydration of hydroxyl fatty acids, bromianation/dehydrobromination, isomerisation, reduction of olefinic or acetylenic bonds) or biochemical methods (extraction from seed oil samples, enzymatic methods) – Adolf [2000].

The aim of this study was to synthesize the conjugated dienes of CLA from linoleic acid contained in grapeseed oil (by alkaline isomerisation and crystallization with urea process) and an application of this supplement in lambs' feeding in order to modify fatty acids composition of their adipose tissues.

Material and methods

CLA synthesis

CLA isomers were synthesized at the Industrial Chemistry Research Institute, Warsaw, Poland.

Commercially purchased food grade grapeseed oil was used as raw material. Used were also ethylene glycol, potassium hydroxide, concentrated hydrochloric acid, ethanol, methanol and urea. Hexane was used as a solvent.

Grapeseed oil was enriched with CLA using alkaline isomerisation and crystallisation with urea. The conditions and the course of that process are presented on Figure 1.

Animals, diets and sampling

Forty randomly chosen Polish Merino ram lambs aged about 8 weeks and weighing 22±1.2 kg were divided into two groups (control and experimental, I and II respectively) with 20 animals per group (kept two per pen). All lambs were fed indoors. The ration was formulated according to the INRA system [IZ-PIB-INRA 2009]. The standard

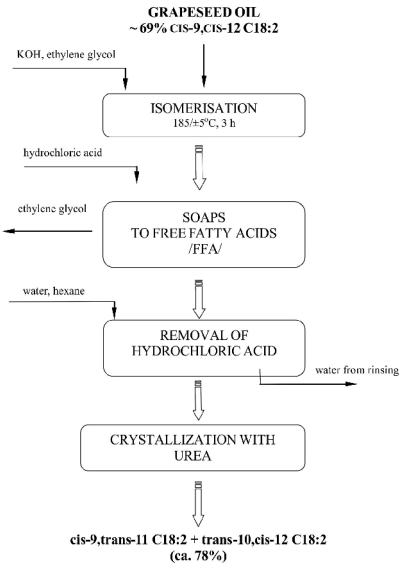

Fig. 1. Scheme for obtaining linoleic acid isomers (*c*9,*t*11 and *t*10,*c*12C18:2) during isomerisation and crystallisation with urea of linoleic acid from grapeseed oil [Walisiewicz-Niedbalska *et al*. 2009].

Table 1. Composition of concentrate mix (g/100 g) and daily consumption (g/lamb)

Specification	Groups	
	control	experimental
Content of concentrate mixture (g/100g)		
wheat meal	55	55
barley grain	25	25
dried grass	9	9
rapeseed meal	10	10
polfamix OK*	1	1
Daily intake (g/lamb)		
concentrate mixture	950	950
meadow hay	250	250
humokarbowit	100	87
isomerised grapeseed oil**	-	18

*1 kg of minerals (Polfamix OK) contains: 300 000 j.m. of vitamin A, 30 000 j.m. vitamin D3, 1.5 g of vitamin E, 0.5 g Fe, 2.5g Zn, 65 g Mg, 0.015 g Co, 3 g Mn, 0.01 g J, 0.003 g Se, 60 g Na, 240 g Ca, 120 g P.
**Isomerised grapeseed oil (IGO) - contains CLA isomers: 38.3% *cis*9,*trans*11, 35.6% *trans*10,*cis*12, 3.7% *cis*11,*trans*13.

mix was based on cereal components (80%), post extractive rapeseed oil meal (10%), dried grass (9%) and mineral/vitamin premix (1%) – Table 1. The nutritive value of 1 kg concentrate mixture in both groups was: 0.85 UFV, 89.8 g PDIE and 92.7 g PDIN.

The factor differentiating groups was an addition of isomerised grapeseed oil which was a mixture of CLA isomers (c9t11, t10c12, c11t13), and was applied in the amount of 18g/head/day. The amount of isomerised grapeseed oil given to the experimental group was calculated to allow the effective daily dose of *trans*-10,*cis*-12 isomer of about 6.5 g/head. Due to its oily form, isomerised grapeseed oil (IGO) was applied to a mineral carrier "Humokarbowit". The developed feed supplement was patented in the Patent Office of the Republic of Poland – PL 386645.

After 6 weeks all lambs were slaughtered at about 32±3.5 kg body weight and 50 g samples of subcutaneous and intermuscular fat from leg and 100 g samples of *M. longissimus dorsi* (LD) and *M. semitendinosus* (MS) were collected, immediately frozen and stored at -20°C until chromatographic analyses of fatty acid profiles.

Analytical

Chromatographic analysis of grapeseed oil and fatty acid determination (profiles) of fatty tissue were performed at the Industrial Chemistry Research Institute in Warsaw, Poland.

Before and after enrichment with CLA, fatty acid methyl esters of grapeseed oil were obtained according to the AOCS Official Method Ce2-66, while the analysis was performed according to the AOCS Official Method Ce1f-96 [AOAC 2000]. Capillary gas chromatography was used for qualitative analysis. The conditions were as follows: a HEWLETT PACKARD 5890 gas chromatograph with a FID detector, a SUPELCO SP-2560 column (L x 100 m ID x 0.25 mm, d_f = 0.20 μm), furnace programme: 140°C for 1 min, heating rate 1°C/min up to 180°C, isotherm for 26 min, heating rate 5°C/min up to 245°C, isotherm for 25 min, a FID detector at 255°C, a split/splitless injector at 245°C, helium as carrier gas (0.98 ml/min).

Fatty acids were identified based on SIGMA and LARODAN standards, standard soybean, rapeseed and coconut oils, and literature data [Roach *et al*. 2002]. Heptadecanoic acid C17 was used as an internal standard.

Fat was extracted from muscle tissue according to the modified version of the method described by Folch *et al*. [1957] (2:1 chloroform : methanol solution). The separation and quantitative determination of fatty acids in subcutaneous and intermuscular fat of leg, and in intramuscular fat of LD and MS were conducted using a HEWLETT PACKARD 5890 gas chromatograph with a FID detector and a SUPELCO SP-2560 column (L x 100 m ID x 0.25 mm, d_f = 0.20 μm). Conditions of separation were as follows: initial isotherm, 160°C (30 min); 3°C/min up to 180°C; 17 min at 180°C; 5 min to 210°C; 20 min at 210°C. The other conditions were as follows: column temperature 160°C; detector temperature 230°C; injector temperature 220°C; carrier gas helium at 80 PSI.

Qualitative identification was carried out by comparing retention times of the peaks with retention times of SIGMA and LARODAN standards.

Statistical

The effect of supplementing the diet with isomerised grapeseed oil on fatty acid profile of adipose tissue was examined using one-way analysis of variance (ANOVA). A probability of $P \leq 0.05$ and $P \leq 0.01$ was adopted as the criterion for significant differences. A STATISTICA 8.0 for Windows (StatSoft, Poland) software package was used. Differences among treatment means were tested for significance with Duncan test.

Results and discussion

CLA synthesis and feed supplement composition

Like most unprocessed oils of plant origin, grapeseed oil used in the present study contained no CLA. However, it was characterised by favourable fatty acid profile from the viewpoint of CLA synthesis, *i.e.* was characterized by relatively high level of linoleic acid (about 69%) and low level of saturated fatty acids (about 13%). The alkaline isomerisation of grapeseed oil changed the position of double bonds in the chains of unsaturated fatty acids (positional) and altered the arrangement of radicals in relation to the double bond axis (geometric). This resulted in the formation of three conjugated dienes of linoleic acid (not occurring naturally in grapeseed oil): of *cis*-9,*trans*-11, *trans*-10,*cis*-12 and *cis*-11,*trans*-13 configuration with completely different properties to *cis*-9,*cis*-12C18:2 linoleic acid from which they originated. These two processes produced oil preparation in the form of isomerised grapeseed oil containing conjugated dienes of linoleic acid amounting to 38.3% (*cis*-9,*trans*-11), 35.6% (*trans*-10,*cis*-12) and 3.7% (*cis*-11,*trans*-13) of the pool of all fatty acids. Apart from CLA, IGO also contained saturated fatty acids of a chain length C16-18:0 (0.4%) and oleic *c*9C18:1, linoleic – *c*9*c*12C18:2 and linolenic acids – *c*9*c*12*c*15C18:3 amounting to 20.5, 1.6 and 0.1%, respectively.

In order to elaborate the feed additive, isomerised grapeseed oil was applied to a humic-mineral carrier "Humokarbowit". IGO was applied at 18% per kg of the carrier using a nozzle spray. "Humokarbowit" is composed of natural mineral humic raw materials containing humic acids and their salts, bitumens, hemicellulose, lignin, wax, resins, phytohormones, phytoenzymes, proteins and amino acids, polysaccharides and a wide range of macro- and microelements. It is characterised by high sorptive capacity and antioxidative properties. The preparation is fed to poultry, pigs, cattle and sheep on account of its biostimulating and prophylactic properties. Other mineral preparations such as Bentonite or Vermiculite could have been used as a carrier [Da Silva Jr *et al*. 2003, Patkowska-Sokoła *et al*. 2008], but because the lambs preferred to eat Humokarbowit, we decided to use this preparation.

The effect of using isomerised grapeseed oil on the fatty acid profile of lamb fat

Tables 2 and 3 present the results concerning the fatty acid profile of subcutaneous and intermuscular fat of the leg (Tab. 2), and intramuscular fat from *M. longissimus dorsi* (LD) and *M. semitendinosus* (MS) – Table 3.

In the case of subcutaneous and intermuscular fat, IGO supplementation reduced the content of short- and medium-chain saturated fatty acids (Tab. 2). There were reductions in the content of lauric acid (C12:0) in subcutaneous and intermuscular fat by 24.3 (P≤0.01) and 20.4 (P≤0.05) percentage points (pp), in the content of myristic acid (C14:0) by 7.5 and 12 pp, and in the content of palmitic acid (C16:0) by 8.3 and 6.3 pp, respectively (Tab. 2). Both types of adipose tissue also showed a trend

Table 2. Fatty acid content (% of total fatty acids) in subcutaneous and intermuscular fat of leg of lambs (means and SEM)

Fatty acid	Subcutaneous fat			Intermuscular fat		
	control*	experimental**	SEM	control*	experimental**	SEM
C12:0	1.617^{A}	1.224^{B}	0.058	1.521^{a}	1.211^{b}	0.085
C14:0	4.016	3.714	0.137	3.467	3.052	0.224
C15:0	2.452	2.356	0.159	2.221	2.134	0.121
C16:0	23.015	21.113	0.611	23.554	22.067	0.585
C16:1	1.943	1.887	0.247	2.743	2.652	0.103
C17:0	3.342	2.982	0.205	4.356	3.789	0.187
C18:0	25.357	27.002	1.071	23.486	25.215	0.851
C18:1 *cis-9*	30.167	29.324	1.235	29.117	28.273	0.765
C18:1 *trans-11*	1.657^{A}	3.442^{B}	0.215	1.942^{A}	3.456^{B}	0.152
C18:2 *cis-9, cis-12*	2.289	2.428	0.124	2.973	3.112	0.086
C18:2 *cis-9,trans-11 CLA*	0.311^{A}	0.544^{B}	0.037	0.325^{A}	0.529^{B}	0.034
C18:2 *trans-10, cis-12 CLA*	0.041^{A}	0.080^{B}	0.006	0.034^{A}	0.078^{B}	0.011
C18:2 *other CLA isomers*	0.012^{a}	0.015^{b}	0.001	0.011	0.013	0.002
C18:3 *cis-9, cis-12, cis-15*	1.211	1.365	0.105	1.216	1.415	0.072
SFA	60.101	58.707	0.931	58.929	57.755	0.794
UFA	38.132	39.618	0.511	38.956	40.190	0.485
including						
MUFA	34.153	35.054	0.646	34.286	34.883	0.588
PUFA	3.979^{a}	4.564^{b}	0.174	4.670^{a}	5.307^{b}	0.071
UFA:SFA	0.634	0.674	0.044	0.661	0.696	0.036
CLA	0.364^{A}	0.639^{B}	0.038	0.370^{A}	0.620^{B}	0.042
IA	0.777^{a}	0.639^{b}	0.027	0.748^{a}	0.638^{b}	0.043
Δ^{9} DI	0.620	0.642	0.015	0.640	0.659	0.011
C18:2 c9,t11/18:1 t11	0.188^{a}	0.158^{b}	0.012	0.167	0.153	0.023

*Standard concentrate mixture + grass hay + Humokarbowit.
**Standard concentrate mixture + grass hay + Humokarbowit with isomerised grapeseed oil.
SFA – saturated fatty acids, UFA – unsaturated fatty acids, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids,
SFA – Σ C8:0 C10:0, C12:0, C13:0, C14:0, C15:0, C16:0, C17:0, C18:0, C19:0, C20:0, C22:0, MUFA – Σ C14:1, C16:1, C18:1 *c9*, C18:1 *t9,* C18:1 *t11*, C18:1 *other isomer trans*, C20:1, PUFA – Σ C18:2 *c9c12,* C18:2 *c9t11,* C18:2 *t10c12,* C18:2 *other isomer,* C18:3 *c9c12c15,* C20:5, C22:5, C22:6.
UFA = MUFA + PUFA
CLA – Σ C18:2 *c9t11* + C18:2 *t10c12* + C18:2 *other isomer.*
IA (index of atherogenic) = (Σ C12:0, C14:0, C16:0) : (Σ PUFA n-6 +PUFA n-3+MUFA).
Δ^{9} DI (index of Δ^{9} desaturase) = (Σ C14:1, C16:1, C18:1) : (Σ C14:0, C16:0, C18:0).
$^{aA...}$ Means in rows marked with different superscripts differ significantly at: small letters – P≤0.05; capitals – P≤0.01.

towards a decrease in the total concentration of saturated fatty acids (Tab. 2). As a result of IGO supplementation, the content of stearic acid (C18:0) in subcutaneous and intermuscular fat increased by 7.5 and 7.2 pp, vaccenic acid (*t*11C18:1) by 107.7 and 78 pp (P≤0.01), linoleic acid isomers of *c*9,*t*11 and *t*10,*c*12 configuration by 74.9 and 95.1 (P≤0.01) and by 62.8 and 129.4 pp (P≤0.01), and the total content of CLA by 75.5 and 67.6 pp, respectively (P≤0.01) – Table 2. Moreover, from the fatty acid profile it was calculated that the application of IGO increased the ratio of unsaturated (UFA) to saturated (SFA) fatty acids in subcutaneous and intermuscular fat by 6.3 and 5.3%, as well as the index of Δ^9 – desaturase activity by 3.5 and 3%, respectively. On the other hand, the atherogenic index fell by 17.8 and 14.7% (P≤0.05), respectively (Tab. 2).

Similar trends in fatty acid changes resulting from the diet supplementation with IGO were also observed for intramuscular fat of *M. longissimus dorsi* (LD) and *M. semitendinosus* (MS) (Tab. 3). In intramuscular fat from both LD and MS decreases were observed in the content of saturated fatty acids by 1.6 and 3.2 pp, including lauric acid (C12:0) by 21.6 (P≤0.01) and 13.4 (P≤0.05) pp, myristic acid (C14:0) by 20 (P≤0.05) and 10.4 pp, and palmitic acid (C16:0) by 9.7 and 8.7 pp, respectively (Tab. 3). Meanwhile, the content of stearic acid (C18:0) in intramuscular fat of *M. longissimus*

Table 3. Fatty acid content (% of total fatty acids) in intramuscular fat of *Longissimus dorsi* (LD) and *Semitendinosus* muscles (MS) of lambs (mean and SEM)

Fatty acid	LD			MS		
	control*	experimental**	SEM	control*	experimental**	SEM
C12:0	1.215^{A}	0.952^{B}	0.063	1.172^{a}	1.015^{b}	0.088
C14:0	2.143^{a}	1.715^{b}	0.123	2.021	1.811	0.109
C15:0	1.892	1.903	0.172	1.717	1.685	0.131
C16:0	22.173	20.015	0.802	23.242	21.209	1.154
C16:1	2.515	2.312	0.179	2.312	2.089	0.159
C17:0	2.942	2.805	0.242	2.672	2.242	0.236
C18:0	27.135	29.174	1.215	27.242	29.216	0.963
C18:1 *cis-9*	30.423	28.953	1.071	30.711	30.442	1.453
C18:1 *trans-11*	1.715^{A}	4.262^{B}	0.211	1.437^{A}	3.930^{B}	0.187
C18:2 *cis-9, cis-12*	3.234	3.421	0.156	2.911	3.171	0.124
C18:2 *cis-9,trans-11 CLA*	0.323^{A}	0.515^{B}	0.028	0.331^{a}	0.526^{b}	0.021
C18:2 *trans-10, cis-12 CLA*	0.040^{A}	0.068^{B}	0.007	0.043^{A}	0.072^{B}	0.006
C18:2 *other CLA isomers*	0.012	0.014	0.001	0.014	0.013	0.002
C18:3 *cis-9, cis-12, cis-15*	1.489	1.617	0.089	1.761	1.828	0.076
SFA	57.715	56.765	0.898	58.218	56.339	0.781
UFA	40.383	41.844	0.567	40.097	42.681	0.163
including						
MUFA	35.155	36.055	0.763	34.927	36.943	0.032
PUFA	5.228	5.789	0.211	5.170	5.738	0.027
UFA:SFA	0.700	0.737	0.025	0.689	0.757	0.021
CLA	0.375^{A}	0.597^{B}	0.023	0.388^{A}	0.611^{B}	0.013
IA	0.646^{a}	0.520^{b}	0.017	0.741	0.638	0.021
Δ^9 DI	0.650	0.657	0.016	0.638	0.644	0,012
C18:2 c9,t11/18:1 t11	0.188^{A}	0.121^{B}	0.014	0.230^{A}	0.134^{B}	0,011

For abbreviations and significance of differences, see Table 2.

dorsi and *M. semitendinosus* increased by 7.5 and 7.2 pp; vaccenic acid (*t*11C18:1) by 148.5 and 173.5 pp (P≤0.01); linoleic acid (C18:2) isomer of *c*9,*t*11 configuration by 59.4 and 58.9 pp (P≤0.01); linoleic acid (C18:2) isomer of *t*10,*c*12 configuration by 70 and 67.4 pp (P≤0.01), and total CLA content by 59.2 and 57.5 pp, respectively (P≤0.01) – Table 3. Furthermore, supplementation with IGO caused an increase in the ratio of unsaturated to saturated fatty acids in intramuscular fat of LD and MS by 5.3 and 9,9%, respectively. The atherogenic index of fat fell by 19.5 (P≤0.05) and 13.9% respectively, and the ratio of linoleic acid isomer *cis*-9,*trans*-11C18:2 to oleic acid isomer *trans*11C18:1 decreased by 35.6 and 41.7%, respectively (P≤0.01) (Tab. 3).

Favourable fatty acids composition modification and an increase in CLA content of adipose tissues as a result of dietary CLA supplementation, similar to that observed in the present study, has been reported by Cordero *et al*. [2010], Gillis *et al*.[2004], Ostrowska *et al*. [2003] and Wynn *et al*. [2006].

Gassman [2000] feeding steers with 1 or 2.5% CLA as CLA salt of fatty acids in a corn-based diet for an average of 130 d increased CLA in lipids extracted from muscle (5.2-6.3 to 12.4-12.6 mg/g total fatty acids) and adipose (5.4-5.5 to 12.4-20.4 mg/g total fatty acids). Studies by Thiel-Cooper *et al*. [2001] and Wiegand *et al*. [2001] on the content of CLA as a percentage of total lipids indicated that CLA isomers, especially *cis*-9,*trans*-11 and *trans*-11,*cis*-12 were incorporated into both subcutaneosus fat and lean tissue of pork loins in increasing concentrations with either increasing amount of CLA in the diet or length of feeding, respectively. Both CLA isomers were identified in samples from all fat tissues in this study, with the proportion of *cis*-9, *trans*-11 CLA remaining higher than that of *trans*-10, *cis*-12 CLA. Content of *trans*-10,*cis*-12 isomer increased to a higher level as a result of IGO addition in fatty tissues when compared to *cis*-9,*trans*-11. The incorporation of dietary CLA isomers into the tissue is in accordance with Chin *et al*. [1994], Park *et al*. [1997] and Sugano *et al*. [1997]. Cook *et al.* [1998] and Kramer *et al*. [1998] both reported that CLA was incorporated into tissue in a dose-dependance relationship.

The result of Thiel-Cooper *et al*. [2001] on the effects of CLA on fatty acid composition of loin subcutaneous fat of pigs fed CLA demonstrated decreased C16:0 content, as shown in the present study.

We also observed that the content of palmitoleic and oleic acids in fatty tissues decreased as a result of application of CLA – enriched IGO. Reduced concentrations of monosaturated fatty acids in adipose tissue as a result of feeding rumen-protected CLA, are also confirmed by Park *et al*. [2000], Smith *et al*. [2002] and Wynn *et. al*. [2006] what is probably related to stearoyl-CoA desaturase activity. Studies examining the effect of CLA appear to vary with species as Lee *et al*. [1998], Choi *et al*. [2000] and Baumgard *et al*. [2002] have shown CLA to reduce both stearylo-CoA desaturase enzyme activity and mRNA levels whereas Park *et al*. [2000] and Choi *et al*. [2001] report CLA decreases in stearoyl-CoA desaturase activity directly without changes in gene expression. In reports where CLA inhibited SCD activity [Park *et al*. 2000, Smith *et al*. 2002], tissue levels of palmitoleic and oleic acid were found reduced.

Most probably, the differences observed in the fatty acid profile of adipose tissues of lambs between the control and experimental group result from varying supplies of dietary CLA, which undergoes further changes in the rumen. In the presence of rumen microorganisms, the overwhelming majority of these isomers are biohydrogenated, first to *trans*-11C18:1 (from isomer *cis*-9,*trans*-11) and *trans*-10C18:1 acids (from isomer *trans*-10,*cis*-12), and then to stearic acid (C18:0) and in this form it saturates adipose tissues [Bauman *et al*. 1999, Griinari *et al*. 1999]. However, some conjugated dienes of linoleic acid rich the further sections of the alimentary tract unchanged where are absorbed and later incorporated into adipose tissues [Griinari *et al*. 1999]. In addition, vaccenic acid (*t*11C18:1) being an intermediate product of *cis*-9,*trans*-11C18:2 isomer biohydrogenation, is also used in adipose tissues as a substrate for endogenous CLA synthesis in the presence of Δ^9 – desaturase [Corl *et al*. 2001].

As a result of alkaline isomerisation and crystallisation with urea, the grapeseed oil was synthesized and later enriched with conjugated dienes of linoleic acid *cis*-9,*trans*-11 and *trans*-10,*cis*-12 at 38.3 and 35.6% of the pool of all fatty acids, respectively.

The addition of isomerised grapeseed oil had favourable effects on the fatty acid profile of lamb adipose tissues, in which the content of unsaturated fatty acids having health-promoting properties (*i.e.* conjugated dienes of linoleic acid *cis*-9,*trans*-11 and *trans*-10,*cis*-12, CLA) and vaccenic acid (VA) increased, whereas the content of atherogenic and saturated fatty acids decreased.

Acknowledgements. *The authors gratefully acknowledge Dr. W. Walisiewicz-Niedbalska and her team from the Industrial Chemistry Research Institute, Warsaw for the enrichment of grapeseed oil with CLA and chromatographic analysis, and we thank Dr S. Tronina for preparing the feed supplement based on Humokarbowit.*

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