

# The effect of linseed oil and selenium on the content of fatty acids and some elements in the liver and selected tissues of sheep\*

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## ABSTRACT

The effect of selenium (as Na<sub>2</sub>SeO<sub>4</sub>) and linseed oil on the mass of *M. biceps femoris* and liver of sheep, as well as on the fatty acid composition and Se, Zn, Fe, Mg and Ca levels of *M. biceps femoris*, liver and intermuscular fat was investigated. Twenty male lambs of body weight of 25±2 kg were divided into four groups and fed a control diet or experimental diets enriched in 5% linseed oil (LO), 2 ppm Se (SE) or combined addition of 5% LO and 2 ppm Se (LOSE). All experimental diets statistically or numerically decreased the concentration of *cis*-9C18:1 and saturated fatty acids in muscles and liver, while feeding Se usually significantly or numerically decreased the sum of all assayed fatty acids in muscles and liver. Diets enriched in Se and/or LO (SE and LOSE) significantly increased the Se level in these samples, as well as numerically increased the Zn content in muscles and liver. LO and LOSE significantly or numerically decreased Δ9 desaturation in muscles, liver and fat. LOSE numerically decreased the content of conjugated linoleic acid isomers in all assayed samples.

KEY WORDS: linseed oil, selenium, sheep, fatty acids, CLA, HPLC

## INTRODUCTION

Increasing the polyunsaturated fatty acid (PUFA) content and modifying the fatty acid (FA) profile of food derived from ruminants, without lowering their organoleptic quality, is an effective way of helping humans to meet nutritional guidelines recommending elevating PUFA consumption (Demirel et al., 2004). Another potential route of obtaining high quality foods is to increase the content of essential elements in products originating from ruminants. Therefore, the main

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objectives of the present trial were to determine whether supplementing diets of lambs with 2 ppm Se (as  $\text{Na}_2\text{SeO}_4$ ) and 5% linseed oil (LO) (as a precursor of FAs containing conjugated double bonds (CFA)) changed the FA profile and altered the content of Se, Zn, Fe, Mg and Ca in *M. biceps femoris*, intermuscular fat and liver.

## MATERIAL AND METHODS

Twenty male Polish Merino lambs with an average body weight (BW) of  $25 \pm 2$  kg at the beginning of the experiment were individually housed. Each group comprised 5 lambs. During a 1-week preliminary period the animals were given *ad libitum* access to the standard concentrate-hay diet. Then, for 35 days the sheep (5 animals) were fed the standard concentrate-hay diet (Control) or experimental diets enriched in 5% linseed oil (LO), 2 ppm Se (SE) or the experimental diet with the combined addition of 5% LO and 2 ppm Se (LOSE). The rations were adjusted weekly to ensure *ad libitum* access to feed. All of the chemicals used, the method of hydrolysis, derivatization, Waters HPLC equipment (USA), were described previously (Czauderna et al., 2002, 2004). Underivatized conjugated linoleic acid (CLA) isomers and other fatty acids containing conjugated double bonds (CFA) were determined according to Czauderna et al. (2003), while all derivatized FA were determined according to Czauderna and Kowalczyk (2002). Se, Zn, Fe, Mg and Ca in the assayed samples were determined by the CPI-MS method (Czauderna et al., 2004). Statistical analyses of the effect of LO or SE treatments were conducted using the nonparametric Mann-Whitney U test, while statistical analyses of the simultaneous SE and LO treatment were performed applying two-factorial analysis. The Statistica (version 6) and Excel 2000 programs were used.

## RESULTS AND DISCUSSION

The effects of administrating Se and/or LO on the fatty acid composition of *M. biceps femoris*, intermuscular fat and liver after 35 days of feeding Se and/or LO are summarized in Table 1. Feeding the diet enriched in LO or LOSE increased the content of CFA in fat and the PUFA level in the liver. All of the experimental diets statistically significantly or numerically decreased the concentration of *cis*-9C18:1 and saturated fatty acids (SFA) in the assayed samples, while extra Se in the diet (SE) usually significantly or numerically decreased the sum of all assayed FAs in *M. biceps femoris* and liver, as well as the SFA, MUFA and PUFA concentrations in the muscles and liver. Feeding the diet enriched with LO and Se (LOSE) numerically decreased the content of CLA isomers in all assayed samples. LO and LOSE significantly or numerically decreased  $\Delta 9$  desaturation in muscles, liver and fat. The SE and LOSE treatments increased the Se level in muscles and liver, while numerically elevated the Zn content in these samples.

TABLE 1

Effects of diets on the content of selected FAs, elements, and on the weight<sup>1</sup> of liver, muscle and fat of sheep

Item	Group					Significance of effect <sup>2</sup>		
	Control	LO	SE	LOSE	SD	LO	SE	LOSE
<i>M. biceps femoris</i> , kg						NS	NS	*
CLA, µg/g	357	307	178	305	76	NS	*	NS
CFA <sup>3</sup> , µg/g	116	73	92	157	36	NS	NS	NS
<i>cis</i> -9C18:1, mg/g	3.05	2.11	2.29	1.88	0.87	NS	NS	*
<i>cis</i> -MUFA, mg/g	5.86	5.93	3.20	7.00	1.62	NS	**	NS
MUFA, mg/g	5.98	6.01	3.27	7.12	1.64	NS	**	NS
Sum of FAs, mg/g	11.12	10.52	6.87	12.75	2.48	NS	*	NS
PUFA, mg/g	8.02	8.26	4.82	9.88	2.12	NS	*	NS
SFA <sup>4</sup> , mg/g	3.10	2.27	2.05	2.87	0.50	*	*	NS
Δ9 desaturase index <sup>5</sup>	0.730	0.666	0.711	0.683	0.028	**	NS	**
Se, µg/g	0.19	0.17	0.36	0.40	0.11	NS	**	**
Zn, µg/g	72	68	81	80	10	NS	NS	NS
Fe, µg/g	61	60	72	63	12	NS	NS	NS
Mg, mg/g	1.21	1.24	1.34	1.30	0.09	NS	*	NS
Ca, µg/g	242	262	257	293	40	NS	NS	NS
Liver, g	618	625	563	659	54	NS	NS	NS
CLA, mg/g	1.04	1.57	1.73	0.92	0.77	NS	NS	NS
CFA, mg/g	2.40	2.36	0.85	2.13	1.61	NS	*	NS
<i>cis</i> -9C18:1, mg/g	6.12	4.25	5.70	4.15	1.44	NS	NS	NS
<i>cis</i> -MUFA, mg/g	21.8	48.8	19.1	35.8	14.4	**	NS	NS
MUFA, mg/g	22.2	49.3	19.6	36.2	14.4	**	NS	NS
Sum of FAs, mg/g	41.9	65.7	37.5	50.6	14.6	**	NS	NS
PUFA, mg/g	29.4	57.4	26.4	43.9	15.2	**	NS	**
SFA, mg/g	12.5	8.3	11.1	6.7	3.7	NS	NS	*
Δ9 desaturase index <sup>5</sup>	0.924	0.847	1.042	1.083	0.106	NS	NS	NS
Se, µg/g	0.53	0.41	4.92	4.43	2.32	NS	**	**
Zn, µg/g	66	61	79	77	11	NS	NS	NS
Fe, µg/g	131	204	179	73	61	*	*	*
Mg, mg/g	745	744	875	846	93	NS	NS	*
Ca, µg/g	181	178	214	210	55	NS	NS	NS
<i>Intermuscular fat</i> <sup>6</sup>								
CLA, mg/g	4.56	2.45	4.55	3.48	2.02	*	NS	NS
CFA, mg/g	0.117	0.534	0.183	0.625	0.286	**	NS	**
<i>cis</i> -9C18:1, mg/g	27.2	12.2	34.2	19.8	13.3	**	NS	NS
<i>cis</i> -MUFA, mg/g	72.4	60.2	75.9	71.8	26.5	NS	NS	NS
MUFA, mg/g	74.6	60.9	77.6	72.7	26.0	NS	NS	NS
sum of FAs, mg/g	110	82	112	101	26.0	NS	NS	NS
PUFA, mg/g	85.0	68.6	88.4	84.0	31.0	NS	NS	NS
SFA, mg/g	25.2	13.9	23.4	17.2	7.1	**	NS	**
Δ9 desaturase index <sup>5</sup>	0.745	0.682	0.797	0.739	0.047	NS	NS	NS

<sup>1</sup> weight derived from fresh organs and fresh muscle tissues<sup>2</sup> significance of effects: \*\* - P<0.01; \* - P<0.05; NS - P≥0.05; SD - pooled standard deviation<sup>3</sup> non-CLA conjugated fatty acids (e.g.: C18:3, C20:3 and C20:4, see ref. Czauderna et al., 2004)<sup>4</sup> SFA - saturated fatty acids (from C8:0 to C22:0)<sup>5</sup> concentration ratio: *cis*-9C18:1/(C18:0+*cis*-9C18:1)<sup>6</sup> Se - below the limit of quantification

## CONCLUSIONS

Adding LO and/or Se to the diet for 35 days improved the nutritional quality of *M. biceps femoris*, intermuscular fat and liver by decreasing the concentration of saturated fatty acids. In particular, feeding LO with Se (LOSE) improved the nutritional value of products derived from sheep since this diet significantly elevated the content of MUFA, PUFA, Zn and Se (an essential element) in the meat and liver of sheep. Unfortunately, the LOSE treatment decreased the level of CLA isomers in all examined samples.

## REFERENCES

- Demirel G., Wachira A.M., Sinclair L.A., Wilkinson R.G., Wood J.D., Enser M., 2004. Effects of dietary n-3 polyunsaturated fatty acids, breed and dietary vitamin E on the fatty acids of lamb muscle, liver and adipose tissue. *Brit. J. Nutr.* 91, 551-565
- Czauderna M., Kowalczyk J., 2002. HPLC separation of some unsaturated and saturated fatty acids. *Chem. Anal. (Warsaw)* 47, 867-882
- Czauderna M., Kowalczyk J., Wąsowska I., Niedźwiedzka K.M., 2002. A highly efficient method for derivatization of fatty acids for high performance liquid chromatography. *J. Anim. Feed Sci.* 11, 517-526
- Czauderna M., Kowalczyk J., Wąsowska I., Niedźwiedzka K.M., 2003. Determination of conjugated linoleic acid isomers by liquid chromatography and photodiode array detection. *J. Anim. Feed Sci.* 12, 269-382
- Czauderna M., Kowalczyk J., Niedźwiedzka K.M., Wąsowska I., Pastuszewska B., Bulska E., Rusczyńska A., 2004. Liver and body mass gain, content of conjugated linoleic acid (CLA) isomers and other fatty acids in the liver of rats fed CLA isomers and selenium. *J. Anim. Feed Sci.* 13, 353-369

## STRESZCZENIE

**Wpływ oleju lnianego i selenu na skład kwasów tłuszczowych oraz zawartość pierwiastków w wybranych tkankach i wątrobie owiec**

Badano wpływ dodatku oleju lnianego (LO) i/lub Se w postaci  $\text{Na}_2\text{SeO}_3$  na masę wątroby, mięśnia udowego oraz stężenie wybranych kwasów tłuszczowych i pierwiastków w tłuszczu śródmięśniowym, wątrobie oraz mięśniu udowym owiec. Diety z dodatkiem LO lub/i Se zmniejszają stężenie *cis*-9C18:1 oraz nasyconych kwasów tłuszczowych w mięśniach i wątrobie, natomiast dodatek Se spowodował zmniejszenie zawartości sumy kwasów tłuszczowych w mięśniach i wątrobie. Skarmianie diet z dodatkiem Se stymulowało gromadzenie Se oraz Zn w mięśniach i wątrobie. Diety z dodatkiem LO, bez względu na obecność Se, zmniejszają wydajność  $\Delta 9$ -desaturacji w mięśniach oraz tłuszczu śródmięśniowym. Diety z dodatkiem LO i Se (LOSE) liczbowo zmniejszają zawartość izomerów CLA we wszystkich badanych próbach.