EFFECT OF CONJUGATED LINOLEIC ACID (CLA) ON PERFORMANCE AND QUALITY OF MEAT IN RABBITS FED CLA-CONTAINING DIETS*

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Thirty Hyplus rabbits, weaned at 35 days of age, were assigned to one of three dietary treatments. Rabbits were fed a basal (control) diet containing 0.12 mg Se/kg, the same diet supplemented with a commercial CLA preparation Luta-CLA® 60 at 10 g/kg, and the diet supplemented with CLA and Se-yeast to increase the Se concentration to 0.50 mg/kg. In CLA-fed rabbits, the feed intake was decreased ($P < 0.05$), which resulted in non-significant drop in weight gain. Rabbits were slaughtered at 77 days of age. Loin and hindleg meat and liver tissue of four rabbits from each group were analysed. CLA increased proportion of saturated fatty acids at expense of monounsaturated fatty acids in muscle lipids. Concentration of CLA in loin and hindleg meat of CLA-fed rabbits increased from 0.07 to 2.55 and 2.74 g/100 g fatty acids, respectively. Se enhanced deposition of CLA in muscle lipids, in case of the c9 t11 CLA isomer statistically significantly. Concentrations of CLA in loin and hindleg meat of CLA and Se-fed rabbits were 3.04 and 3.37 g/100 g fatty acids, respectively. Incorporation of CLA into hepatic lipids was less intensive. Loin and hindleg meat of rabbits fed the CLA and Se-supplemented diet contained about four-times more Se (ca 0.4 mg/kg) than meat of other rabbits.

fatty acids; selenium; growth

INTRODUCTION

Conjugated linoleic acid (CLA) is a collective name for positional and geometric conjugated isomers of octadecadienoic acid (C18:2). CLA has been linked to a multitude of health-promoting metabolic effects, e.g. on cancer, cardiovascular disease and diabetes (reviewed by Belury, 2002). CLA is found in foods such as beef and mutton, as well as in dairy products containing milk fat. The CLA concentration in beef varies from 1.2 to 10.0 mg/g fat, in lamb from 4.3 to 19.0 mg/g fat. On the contrary, the CLA content of pork and chicken is usually lower than 1 mg/g fat (Schmid et al., 2006). Because of the availability of feed-grade CLA, research has been initiated on effects of dietary CLA on performance and/or meat quality in non-ruminant animals, mainly pigs (Thiel-Cooper et al., 2001; Bee, 2001; Ramsay et al., 2001; Wiegand et al., 2001; Gatlin et al., 2002; Pastorelli et al., 2005). In treated pigs, the CLA concentration in pork increased and alterations of fatty acid (FA) profile of lipids extracted from tissues were observed. Treatment with CLA increased deposition of saturated fatty acids (SFA) and decreased deposition of monounsaturated fatty acids (MUFA) in skeletal muscle and adipose tissue. Effects of CLA-enriched diets in chickens were similar (Sirri et al., 2003).

Corino et al. (2002) published a paper on influence of dietary CLA on growth, meat quality and lipid metabolism in rabbits. Rabbits were fed a pelleted diet supplemented with 0, 0.25 or 0.5% of a CLA preparation containing 65% of CLA isomers. CLA supplementation did not influence growth performance, feed intake and feed/gain ratio. With regard to carcass characteristics, the only effect of CLA was reduction of carcass fat in rabbits slaughtered at medium and heavy live weights. Later, Corino et al. (2003) presented a study on effect of CLA on meat quality and intramuscular collagen of rabbits. CLA lowered the meat fat content and increased muscle lean. In neither study the authors did not follow the deposition of CLA in edible tissues, neither effect on FA profile of tissue lipids. Thus, the aim of our study was to investigate deposition of CLA in meat and liver, and alteration in performance and FA profile of rabbits fed diets supplemented with CLA. In experiment on rats, Czauderna et al. (2003) observed a significant interaction between CLA and selenium (Se) supplied as selenate. The interaction was probably based on Se-mediated protection of CLA from peroxidation and/or catabolism in muscle. Therefore, in one of two experimental groups rabbits received a Se supplement (Se-yeast) in addition to CLA.

MATERIAL AND METHODS

Animals and diets

Thirty Hyplus rabbits, weaned at 35 days of age, were assigned to one of three dietary treatments. Rabbits were housed in stainless mesh cages, two per cage. The envi-

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Table 1. Ingredients and determined chemical composition of the basal[1] rabbit diet

Ingredients (%)		Chemical composition (g/kg)	
Alfalfa meal	30	Dry matter	906
Wheat bran	26	Crude protein	166
Barley	14.5	Crude fibre	161
Oat	6	Fat	41
Sugarbeet pulp	4	Ash	73
Sunflower meal, extracted	13	Se	$1.2.10^{-4}$
Soyabean meal, ectracted	2		
Rapeseed oil	1.5		
Mineral supplement[2]	2		
Vitamin supplement	1		

[1] Experimental diets were supplemented with CLA or CLA + Se at 10 g/kg and 0.38 mg/kg, respectively
[2] Limestone, dicalcium phosphate and salt

ronmental temperature was 16°C and the humidity about 65%. The rabbits had *ad libitum* access to feed and water. Ingredients and chemical composition of diets are shown in Table 1. Control rabbits were fed the basal diet containing 0.12 mg Se/kg. Experimental rabbits received diets containing CLA at 10 g/kg, or CLA and Se at 10 g/kg and 0.5 mg/kg, respectively. The CLA source was Luta-CLA® 60 provided by BASF (Germany). According to manufacturer's specifications, LUTA-CLA® 60 contained min. 56% CLA as equimolar amounts of c9t11 and t10c12 isomers. Selenium was supplied as Se-yeast (Sel-Plex, Alltech). Consumption of feeds was measured individually. Animals were weighed in one-week intervals. Rabbits were slaughtered at 77 days of age.

Analyses and calculations

Loin and hindleg meat of four rabbits from each group was analysed. Meat dry matter (DM) was determined by oven drying at 105°C, and fat by extraction with petrol ether in Soxtec 1045 apparatus (Tecator Comp., Sweden). FA composition of meat was determined after extraction of total lipids according to Folch et al. (1957). Alkaline trans-methylation of FA was carried out according to ISO 5509 (2001). Gas chromatography of methyl esters was performed using a HP 6890 gas chromatograph (Agilent Technologies, Inc.) with a programmed 60 m DB-23 capillary column (150 to 230 °C). In order to determine cholesterol, lipids were saponified and unsaponified matter extracted with diethyl ether according to ISO 3596 (2001). Silyl derivatives were prepared using TMCS and HMDS silylation reagents (Sigma-Aldrich), and quantified on the gas chromatograph equipped with a SAC-5 capillary column (Supelco) operated isothermally at 285 °C.

To determine Se, samples of feed and meat were mineralized using the microwave digestion technique in a closed system, in the presence of HNO_3 and H_2O_2. Se was then determined by atomic absorption spectrometry using Solaar M6 instrument (TJA Solutions, UK). The procedure was validated by the analysis of a certified reference material RM 8414 Bovine Muscle (NIST).

Carcass yield was calculated as the proportion of commercial carcass weight with head, including heart, liver, kidney and perirenal fat from live weight. One-way analysis of variance was used to evaluate the effects of supplements. Comparison of means was done by the Tukey test, when appropriate.

RESULTS AND DISCUSSION

Neither CLA nor CLA + Se significantly influenced the rate of growth, feed conversion and carcass yield (Table 2). Feed intake in CLA-fed rabbits, however, was significantly decreased, which resulted in a non-significant drop in weight gain in comparison with the control. This was not observed in pigs (Weber et al., 2001; Thiel-Cooper et al., 2001; Ramsay et al., 2001; Wiegand et al., 2001) and hens (Raes et al., 2002) at similar level of CLA supplementation. A lower concentration of CLA and/or shorter period of CLA feeding should be examined in a future experiment.

Loin and hindleg meat of rabbits fed the Se-supplemented diet contained four-times more Se than meat of other rabbits (Table 3). There was no treatment effect on DM, fat and cholesterol content of meat.

Table 4 presents FA profile of loin and hindleg meat and liver tissue. Saturated, monounsaturated and polyunsaturated FA were summarized. Dietary supplementation with CLA increased proportion of SFA at expense of MUFA in muscle lipids (Table 4). Supplementation of the rabbit diet with CLA increased CLA concentration in loin and hindleg meat from 0.07 to 2.55 and 2.74 g/100 g FA, respectively. It can be roughly estimated that CLA concentration in meat of CLA-treated rabbits ranged from 20 to 25 mg/g fat, which exceeded values reported in ruminants (Schmid et al., 2006). Supplementation of the CLA diet with Se increased deposition of CLA both in the loin and hindleg meat. This effect was statistically significant with the c9 t11 CLA isomer. Concentrations of CLA in loin and hindleg meat of CLA and Se-fed rabbits were 3.04 and 3.37 g/100 g fatty acids, respectively. CLA supplementation also significantly increased concentration of polyunsaturated fatty acids (PUFA) in muscle lipids, mainly due

Table 2. Growth, feed intake, feed conversion and carcass yield in rabbits[1] fed a basal diet and diets supplemented with CLA and CLA + Se

	Control	CLA	CLA + Se
Initial weight (g)	1015 ± 19	1016 ± 24	1017 ± 24
Final weight (g)	2944 ± 319	2670 ± 252	2638 ± 321
Weight gain (g)	1929 ± 320	1653 ± 267	1621 ± 330
Feed intake (kg)	6.21 ± 0.96[a]	5.24 ± 0.54[b]	5.22 ± 0.66[b]
Feed/gain (kg/kg)	3.22 ± 0.14	3.17 ± 0.28	3.22 ± 0.25
Carcass yield (%)	60.1 ± 1.3	60.0 ± 1.6	61.5 ± 1.3

[1] 10 rabbits/group
[ab] Values in the same row with unlike superscript differ significantly ($P < 0.05$)

Table 3. Dry matter (DM), fat, cholesterol and Se concentration in loin and hindleg meat of rabbits[1] fed a basal diet and diets supplemented with CLA and CLA + Se

	Loin			Hindleg		
	Control	CLA	CLA + Se	Control	CLA	CLA + Se
DM (g/kg)	250 ± 4	258 ± 5	253 ± 5	267 ± 12	270 ± 4	263 ± 4
Fat (g/kg)	10.6 ± 1.5	10.0 ± 1.5	7.7 ± 2.5	44.8 ± 13.8	38.9 ± 8.5	33.4 ± 10.1
Cholesterol (mg/kg)	494 ± 53	525 ± 38	494 ± 37	nd	nd	nd
Se (μg/kg)	93 ± 3[a]	104 ± 7[a]	413 ± 15[b]	98 ± 13[a]	95 ± 10[a]	355 ± 45[b]

[1] Meat of 4 rabbits per group was analyzed
nd – not determined
[ab] Values in the same row with unlike superscript differ significantly ($P < 0.05$)

Table 4. Fatty acid profile (g per 100 g of fatty acids determined) of loin and hindleg meat, and liver tissue of rabbits1 fed a basal diet and diets supplemented with CLA and CLA + Se

	Control	CLA	CLA + Se
Loin			
SFA	38.44[a] ± 0.62	42.72[b] ± 1.93	41.92[b] ± 1.44
MUFA	33.79[a] ± 2.16	22.93[b] ± 0.48	23.61[b] ± 0.79
CLA c9t11	0.05[a] ± 0.01	1.16[b] ± 0.10	1.49[c] ± 0.23
CLA t10c12	0.02[a] ± 0.01	1.39[b] ± 0.12	1.55[b] ± 0.22
Total PUFA	27.77[a] ± 2.26	34.36[b] ± 2.45	34.46[b] ± 1.79
Hindleg			
SFA	37.08[a] ± 1.01	42.22[b] ± 2.59	41.78[b] ± 2.85
MUFA	37.00[a] ± 2.05	24.67[b] ± 1.45	23.36[b] ± 1.50
CLA c9t11	0.05[a] ± 0.01	1.18[b] ± 0.26	1.50[c] ± 0.10
CLA t10c12	0.02[a] ± 0.01	1.56[b] ± 0.36	1.87[b] ± 0.09
Total PUFA	25.86[a] ± 1.59	33.11[b] ± 2.23	34.86[b] ± 4.02
Liver			
SFA	43.35 ± 2.91	44.82 ± 0.95	46.85 ± 1.10
MUFA	21.18[a] ± 3.42	13.95[b] ± 4.17	12.09[b] ± 2.02
CLA c9t11	0.06[a] ± 0.02	0.64[b] ± 0.15	0.64[b] ± 0.14
CLA t10c12	0.02[a] ± 0.01	0.57[b] ± 0.17	0.66[b] ± 0.09
Total PUFA	36.25 ± 1.56	41.92 ± 4.93	41.47 ± 1.43

SFA, MUFA and PUFA are saturated. monounsaturated and polyunsaturated FA, respectively
[1] Meat of 4 rabbits from each group was analyzed
[abc] Values in the same row with unlike superscript differ significantly ($P < 0.05$)

to increased concentration of linoleic acid. The increase in the relative proportion of linoleic acid suggests that the *de novo* synthesis of FA in rabbit tissues was decreased, but the uptake of dietary FA was not affected. Effects of CLA on FA profile of lipids of the liver tissue were similar, but less pronounced. Traces of CLA in meat of control rabbits may be the consequence of caecotrophy. In any case, CLA content in meat of control rabbits was lower than that reported in pork and meat of poultry (Schmid et al., 2006). Alterations in FA profiles of muscles in CLA-fed rabbits were similar to those observed in pigs (Ramsay et al., 2001; Bee, 2001) and chicks (Sirri et al., 2003). CLA depresses the activity of stearoyl-CoA desaturase (Belury, 2002), which may explain higher proportion of SFA and lower proportion of MUFA in CLA-treated rabbits.

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Účinek konjugované kyseliny linolové (CLA) na užitkovost a kvalitu masa králíků krmených dietami s CLA.

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Třicet králíků odstavených ve věku 35 dnů bylo rozděleno do třech skupin po 10 zvířatech. Králíci kontrolní skupiny byli krmeni základní dávkou s obsahem 0,12 mg Se/kg. Další skupina přijímala stejné krmivo s doplňkem komerční konjugované kyseliny linolové Luta-CLA® 60 v množství 10 g/kg. Králíci třetí skupiny dostali rovněž krmivo s CLA, navíc doplněné selenovými kvasnicemi tak, aby obsah Se byl zvýšen na 0,50 mg/kg. U obou skupin s CLA byl signifikantně nižší příjem krmiva ($P < 0,05$), což se projevilo snížením rychlosti růstu ($P > 0,05$). Králíci byli poraženi ve věku 77 dnů. K rozborům bylo vzato maso hřbetu, stehna a tkáně jater čtyř králíků z každé skupiny. CLA v lipidech masa zvýšila podíl nasycených mastných kyselin na úkor kyselin mononenasycených. Doplňkem CLA se zvýšila koncentrace CLA v mase hřbetu z 0,07 na 2,55 g/100 g mastných kyselin, v mase stehna na 2,74 g/100 g. Doplněk Se zvýšil koncentraci CLA v mase, toto zvýšení bylo v případě izomeru c9t11 statisticky významné. Koncentrace CLA v mase hřbetu králíků krmených s přídavkem obou aditiv byla 3,04 g/100 g mastných kyselin, v mase stehna 3,37 g/100 g. Inkorporace CLA do lipidů jater byla méně intenzivní. U králíků krmených s doplňkem Se byl obsah Se v mase zhruba čtyřikrát větší (cca 0,4 mg/kg) než u králíků ostatních skupin.

mastné kyseliny; selen; růst

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