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Lipid complex effect on fatty acid profile and chemical composition of cow milk and cheese

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ABSTRACT

The effect of administration of lipid complex (LC) on cow milk and cheese characteristics was studied. Lipid complex was elaborated based on grapeseed oil with synthesized conjugated linoleic acid (CLA) and Atlantic mackerel oil enriched in n-3 fatty acids. The 4-wk experiment was conducted on 30 Polish Holstein Friesian cows. The experimental group cow diet was supplemented with 400 g/d of LC (containing 38% CLA, and eicosapentaenoic acid + docosahexaenoic acid in a relative amount of 36.5%) on a humic-mineral carrier. The chemical composition and fatty acid profile of milk and rennet cheese from raw fresh milk were analyzed. Lipid complex supplementation of the total mixed ration had no effect on milk yield and milk composition, except fat content, which decreased from 4.6 to 4.1%, a 10.9% decrease. Milk from cows treated with LC had greater relative amounts of unsaturated fatty acids, particularly polyunsaturated fatty acids, and lesser relative amounts of saturated fatty acids. Lipid complex addition changed milk fat fatty acid profile: C18:2 *cis*-9,*trans*-11 and *trans*-10,*cis*-12 isomer (CLA) contents increased by 278 and 233%, respectively, as did eicosapentaenoic acid (C20:5) and docosahexaenoic acid (C22:6) contents. Milk fat fatty acid profile changes were correlated with the modifications in rennet cheese fatty acid profile. Lipid complex supplementation of dairy cows produced considerable changes in the biological value of milk and cheese fat.
Key words: dairy cow, lipid complex, milk and cheese, fatty acid

INTRODUCTION

In recent years, functional foods and bioactive food components have drawn a lot of attention and interest of food scientists, nutritionists, and general consumers. Milk and milk products are valuable foods constituting an important part of the human diet. Fatty acid composition largely determines the quality of fat, and their properties depend on carbon chain length, number of unsaturated bonds, and *cis* or *trans* geometric configuration (Markiewicz-Kęszycka et al., 2013).

Essential fatty acids of the n-3 and n-6 families are PUFA that are not synthesized by the human organism and must be supplied in the diet. The fatty acids essential for normal human development are linoleic C18:2 (n-6), α-linolenic C18:3 (n-3), eicosapentaenoic C20:5 (n-3; **EPA**), docosahexaenoic C22:6 (n-3; **DHA**), γ-linolenic C18:3 (n-6), and arachidonic C20:4 (n-6) acids (Simopoulos, 2008). Health-promoting properties are also attributed to CLA (Dilzer and Park, 2012).

Products derived from ruminants, especially milk fat, are an important source of CLA in the human diet (Khanal and Olson, 2004). High biological activity is exhibited by the *cis*-9,*trans*-11 C18:2, which constitutes about 75 to 95% of all milk fat CLA isomers (Bauman et al., 2008). Even up to 80% of the CLA *cis*-9,*trans*-11 isomer may originate from endogenous synthesis in the mammary gland (Kay et al., 2004). Milk fat is in turn characterized by a small amount of EPA and DHA (Donovan et al., 2000; Osborne et al., 2008).

Generally, the fatty acid profile of milk fat shows considerable variation, with diet being the primary determinant (Moate et al., 2008). Milk from pasture-fed cows had statistically significantly greater amounts of unsaturated fatty acids, including CLA and C81:3, and smaller amounts of SFA, compared with milk from TMR-fed cows (Rego et al., 2004; Schroeder et al., 2005). The concentration of CLA and n-3 can be increased in cow milk by the application of plant oils (Puppel et al., 2013), raw (Donovan et al., 2000; Osborne et al., 2008) and protected fish oil (Castañeda-Gutiérrez et al., 2007; Kupczyński et al., 2012), fish and plant oils used concomitantly (AbuGhazaleh and Holmes, 2007), fish oil with algae (AbuGhazaleh et al., 2009), and encapsulated fish oil or microalgae (Vahmani et al., 2013).

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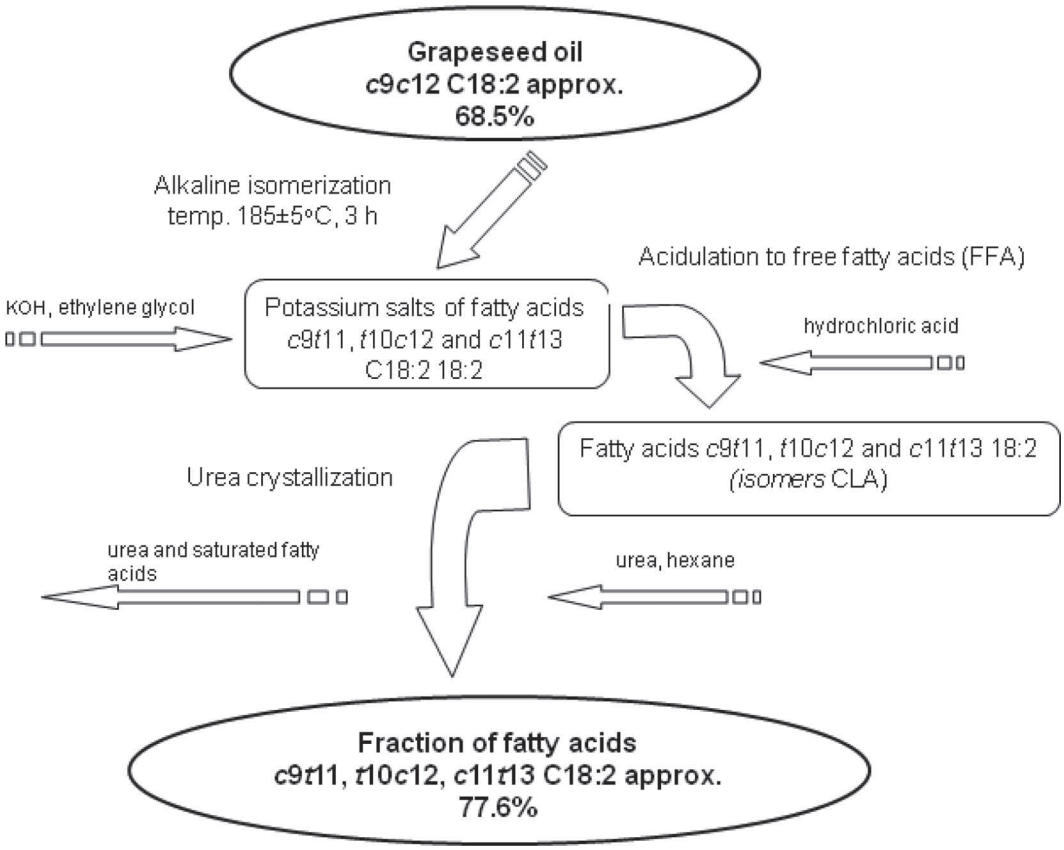

Figure 1. Scheme of grapeseed oil enrichment in c-9,t-11 and t-10,c-12 C18:2 acids. c = *cis*; t = *trans*, approx. = approximately.

The concentration of CLA in milk can be increased through supplementing the ration of animals with CLA in nonprotected (Bodkowski et al., 2008) or protected form (Medeiros et al., 2010).

The aim of the present feeding trial was to investigate the influence of lipid complex (**LC**) based on grapeseed oil with synthesized CLA and Atlantic mackerel oil enriched in n-3 PUFA, on the content of fatty acids and chemical composition of milk and cheese.

MATERIALS AND METHODS

Production of Oil Preparations and Elaboration of LC and Feed Additive

The synthesis of CLA isomers from plant oil was conducted according to the methodology elaborated by Walisiewicz-Niedbalska et al. (2009) using the process of alkaline isomerization and urea crystallization (Figure 1). The raw material was grapeseed oil of food-grade quality (Monini Polska Ltd., Poznań, Poland). The synthesis also involved ethylene glycol (pure for analysis grade, **p.a.**), potassium hydroxide (p.a.), concentrated hydrochloric acid (p.a.), anhydrous sodium sulfate (p.a.), urea (p.a.), and hexane as a solvent (all reagents: Avantor Performance Materials Poland Inc., Gliwice, Poland).

Fatty acid methyl esters were determined using the procedures described previously by Christopherson and Glass (1969). The chromatographic analysis was performed on a Hewlett Packard 5890 gas chromatograph with a flame ionization detector (**FID**), Supelco SP-2560 capillary GC column [100 m length × 0.25 mm i.d., film thickness ($\mathbf{d_f}$) = 0.20 μm; Supelco, Bellefonte, PA]. The following oven program was used: 140°C for 1 min, increase by 1°C/min up to 180°C, isotherm for 26 min, increase by 5°C/min up to 245°C, isotherm 25 min; detector temperature 255°C; dispenser temperature: split 245°C; helium as a carrier gas (0.98 mL/min). Identification of common fatty acids was accomplished by comparison of sample peak retention times with those of FAME standard mixtures (47885-U Supelco; Sigma-Aldrich Chemie GmbH, Schelldorf, Germany), *trans*-11-octadecenoic methyl ester (46905-U Supelco; Sigma-Aldrich Chemie GmbH), *cis*-9,*trans*-11-octadecadienoate methyl (20–1823–7; Larodan Fine