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The effect of false flax (*Camelina sativa*) cake dietary supplementation in dairy goats on fatty acid profile of kefir☆

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ABSTRACT

Camelina sativa cake (CS), a rich source of unsaturated fatty acids, in the case of ruminants may improve the energy value of a diet and also increase the unsaturated fatty acid content in milk. Effects of basal diet (control) and basal diet plus 12 g 100 g^{-1} of CS in concentrate dry matter on fatty acid composition of goat's milk and kefir made from this milk were examined with particular emphasis on the contents of monoenes and conjugated isomers of linoleic acid. A total of 66 goats of the Polish White Improved breed were divided into two groups – the control and receiving CS. The diets were administered to animals for 30 days. Elevated concentrations of total monounsaturated fatty acids, the effect of an increased levels of monounsaturated fatty acids in the *trans* configuration as well as an increased content of total polyunsaturated fatty acids resulted from CS supplementation. Total saturated fatty acid concentration was decreased. Milk from CS-supplemented goats and kefir made from this milk were characterized by increased levels of beneficial nutritional factors, including mono- and polyunsaturated fatty acids.

1. Introduction

Milk fat secretion and milk fatty acid (FA) composition are of great interest with regard to human nutrition (van Arendonk, 2011). Apart from their contribution to dairy products sensorial attributes, different lipid and FA compounds (short- and medium-chain saturated, branched, mono- and polyunsaturated, *cis* and *trans*, conjugated FA) present in ruminant milk are indeed potentially positive or negative factors for the health of consumers (Parodi, 2004; Park, 2009). The unique composition of goat's fatty acids and the ability of goats to digest efficiently plants rich in secondary metabolites, suggest that they are particularly suitable for exploiting the nutritional advantages of feed sources, such as *Camelina sativa* cake (Silanikove et al., 2010). *C. sativa* (CS) or false flax ("gold of pleasure") is an oilseed crop of the Brassica (Cruciferae) family. The crop can be grown on marginal farmland, with relatively low inputs (Tańska et al., 2013). Although camelina has been cultivated in Europe for over 2000 years for oil

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and livestock fodder, the crop has gained increased popularity recently as a biofuel source due to its oil content (Putnam et al., 1993). *C. sativa* is not a food crop; however, a co-product (i.e. meal) obtained after oil extraction from the seed is valuable as animal feed (Pilgeram et al., 2007). The fatty acid composition of the camelina meal has received considerable attention due to its high content of essential fatty acids. The meal is rich in omega-3 and omega-6 essential fatty acids. The omega-6:omega-3 fatty acid ratio is 0.90–0.70. Alfa-linolenic acid is the major omega-3 fatty acid, constituting over 29%, with linoleic acid constituting up to 23% of total omega fatty acids. Oleic acid is the major mono-unsaturated fatty acid, followed by eicosenoic acid (20:1). Other mono-unsaturated fatty acids include palmitoleic and erucic acids (below 2%). Altogether, total mono-unsaturated fatty acids constitute over 32% of the total fatty acid content. Saturated fatty acids in the meal include palmitic acid (9%) and stearic acid (2.5%, Cherian, 2012). Studies have been conducted on the use of camelina in the diet of ruminants, especially beef heifers (Moriel et al., 2011) and dairy cows (Halmemies-Beauchet-Filleau et al., 2011). In their experiment Hurtaud and Peyraud (2007) examined what level of feeding the linolenic acid-rich cruciferous plant *C. sativa* can affect the fatty acid composition of cow milk and the resulting properties of butter. CS generated a greater proportion of monounsaturated fatty acids, notably C18:1 *trans* isomers, including *trans*-10 and *trans*-11. CS also led to an increase in conjugated linoleic acids, particularly rumenic acid, *cis*-9, *trans*-11. CS did not affect parameters of butter making except for a longer churning time for milk from *C. sativa* meal fed cows. The butters produced at the administration of CS diets were softer at all temperatures tested. In conclusion, feeding CS can modify milk fatty acid profile and butter spreadability (Hurtaud and Peyraud, 2007).

Literature on the subject presents a very limited body of information supplied by studies on the effect of CS supplementation on the fatty acid composition of milk produced by small ruminants. One of the scarce studies on the subject was a paper by Szumacher-Strabel et al. (2011). The authors observed that the inclusion of CS in the ewe diet reduced the level of short-, medium- and long-chain saturated fatty acids in milk, with a simultaneous increase in the content of unsaturated fatty acids and their conjugated isomers. To date results of numerous experiments have been published concerning modification of the fatty acid profile in milk by supplementation of goats' diet using seeds and oils of oil crops such as flax and sunflower, significantly increasing PUFA and CLA concentrations in milk (Chilliard et al., 2007; Bernard et al., 2005). In other respects, lipid supplementation decreased goat flavor, and linseed oil increased metallic, oxidized and fishy flavors in goat milk and cheeses (Gaborit et al., 2002).

In turn, very promising results were observed in experiments on the supplementation of another oilseed crop of the Brassica (Cruciferae) family, i.e. rape seed (Chilliard et al., 2002, 2007). In an experiment of Ollier et al. (2009) supplementing the goat diet with rape seed decreased short- and medium-chain saturated and monounsaturated FA levels and markedly increased C18:0 and *cis*-9 C18:1 contents, without important changes in *trans* C18:1 and CLA in milk fat.

In contrast, no data could be found in available literature on the effect of *C. sativa* administration on the fatty acid profile in goat milk.

The aim of the study was to indicate potential for the modification of fat composition in animal origin products, both milk and kefir, through the amount and type of fatty acids supplied in the feed ration.

2. Materials and methods

2.1. Experimental design

Analyses were conducted on raw goat milk and kefir produced from such milk. The milk was collected from goats of the Polish White Improved breed. The animals were kept in the indoor housing system on the Bukowiec goat farm, ca. 50 km north west of Poznań (western Poland). Goats were randomly allocated from the herd of 250 female goats to one of two groups: the control (33 head) and the experimental (CS; 33 head). The animals had average body weight of 55 kg (±4 kg) and were aged 3 and 4 years (the second and third lactation).

The goats in this experiment were fed with: basal diet (control) and basal diet plus 12 g 100 g^{-1} of CS concentrate dry matter. The amount of CS offered was established on the basis of a series of previous experiments with false flax supplementation to ewes diets, when 10 g 100 g^{-1} and 20 g 100 g^{-1} of CS in concentrate dry matter improved sheep milk fatty acid composition (Szumacher-Strabel et al., 2011).

All the goats were at the identical stage of lactation. Up to day 89 of lactation the animals ($n = 66$) were fed basal diet. Starting from day 90 of lactation for the next 30 days the goats in the control ($n = 33$) continued to receive basal diet, while the animals in the experimental group (CS) were fed the experimental diet, i.e. basal diet plus 12 g 100 g^{-1} of CS in concentrate dry matter (DM). After a 30-day period of animal adaptation to the experimental diet, at day 120 of lactation individual milk samples were collected during the morning and evening milkings (2× 1000 mL) from all goats ($n = 66$) for chemical analyses and for the production of kefir.

Goats were machine milked twice a day. Daily samples of milk from individual goats were prepared by mixing milk from morning and evening milkings (1:1). This milk was used for kefir production with a kefir DC starter culture (*Lactococcus lactis* spp. *lactis*, *Streptococcus delbruecki* spp. *bulgaricus*, *Leuconostoc* and kefir yeasts) from Danisco Biolacta. From this material 12 kefir batches of 5 L each were produced, with six batches from milk of each goat group.

Analyses of the basic chemical composition were performed on cooled raw milk and kefir immediately after it was produced. The fatty acid profile was determined in raw milk and kefir frozen-stored for a short time at a temperature of −20 °C.

2.2. Ration composition

During the experiment the goats were kept in group pens and were fed 1 kg concentrate and 1.2 kg alfalfa/grass silage and meadow hay (DM basis; 1 kg of alfalfa/grass silage and 0.2 kg of meadow hay) per goat per day. The diets were formulated using the INRA (1993) system to meet the animals' nutrient requirements: 1.41 UFM (unit for milk production) and 150 g PDI (protein truly digestible in the small intestine). The alfalfa/grass silage consisted of alfalfa 30%, *Festulolium* 40%, *Lolium perenne* 20% and *Lolium multiflorum* 10%. Concentrates were individually fed in two equal portions during milking, while chopped alfalfa hay was provided in individual box feeders twice daily (07.00 and 18.00). Goats had free access to water and a mineral block.

The basic composition, nutritive value and fatty acids composition of used forages are given in Tables 1 and 2.

Representative samples of concentrates and forages were collected three times during the main part of experiment and stored at −20 °C until analyses. Samples of concentrates, alfalfa/grass silage and meadow hay were analyzed according to the AOAC for dry matter (method no. 934.01) and ash (method no. 942.05). Crude protein was determined using a Kjel-Foss Automatic 16210 analyzer (A/SN. Foss Electric, Hillerød, Denmark; method no. 976.05), while crude fat was determined with the Soxtec