Livestock Science 155 (2013) 236–243

Contents lists available at SciVerse ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci

The effect of fish and soybean oil inclusion in goat diet on their milk and plasma fatty acid profile

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ARTICLE INFO

Article history:
Received 20 February 2013
Received in revised form
18 May 2013
Accepted 18 May 2013

Keywords:
Fish oil
Soybean oil
Milk
Fatty acids
Goat

ABSTRACT

A good nutritional strategy for enhancing the bioactive fatty acids (FAs) in goat milk could be the dietary supplementation with a moderate level of a combination of soybean oil with fish oil (SFO). Thus, the objective of this study was to determine the effects of a moderate forage diet supplementation with SFO on milk chemical composition and FA profile, as well as on plasma FA. Twelve dairy goats were assigned to two homogenous sub-groups. Treatments involved a control diet without added oil, and a diet supplemented with 55.5 g soybean oil and 11.1 g fish oil/day/animal. The results showed that SFO diet modifies the milk and plasma FA profile in the absence of any effect on milk fat content and on milk yield. In blood plasma the concentrations of *trans*-11 $C_{18:2}$ (VA), *cis*-9, *trans*-11 $C_{18:2}$ CLA, *trans*-10, *cis*-12, $C_{18:2}$ CLA, $C_{20:5n-3}$ (EPA) and $C_{22:6n-3}$ (DHA) were significantly higher while those of $C_{14:0}$, $C_{15:0}$ $C_{16:0}$ and $C_{18:0}$ were lower in goats fed with SFO diet compared to control. The SFO supplementation in goat diet increased the concentrations of VA, *cis*-9, *trans*-11 $C_{18:2}$ CLA, *trans*-10, *cis*-12, $C_{18:2}$ CLA, EPA, DHA, monounsaturated FA (MUFA), polyusaturated fatty acids (PUFA) and *n*−3 FA and decreased those of short chain FA (SCFA), medium chain FA (MCFA), the saturated/unsaturated ratio and the atherogenicity index value in milk compared with the control. In conclussion, the SFO supplementation at the above levels in a goat diet, with moderate forage to concentrate ratio, improved the milk FA profile from human health standpoint.

1. Introduction

Consumers demand interest in the field of food production of animal origin, has changed considerably in the last few decades. Consumers, more and more, believe that food contributes directly to their health (Elsanhoty et al., 2009). Due to the above there is an increasing demand of functional foods in developed countries which contain significant levels of biological active components (Bhat and Bhat, 2011). The health benefits of milk and dairy products can be attributed partly to their bioactive lipids such as butyrate, conjugated linoleic acid (CLA), vaccenic acid (VA=*trans*-11 $C_{18:2}$) and *n*−3 polyunsaturated fatty acids (PUFA) which have been shown a range of positive health effects (Shingfield et al., 2008).

It is well known that all these fatty acids (FA) are strongly influenced by goats diets. Indeed, supplementation of goats diet with vegetable oils, rich in linoleic acid, induce an increase in CLA and VA content (Bouattour et al., 2008; Li et al., 2012; Luna et al., 2008; Martínez Marín et al., 2011, 2012) while, the inclusion of fish oil enhances *n*−3 PUFA content in their milk fat (Cattaneo et al., 2006; Kitessa et al., 2001). Despite the promising results obtained from the separate inclusion of vegetable and fish oil in goats diets, today there is scare information concerning the dietary supplementation with a combination of plant and fish oil aiming to a better milk FA profile from consumer health point of view. More specifically, Bernard et al. (2010) and Gagliostro et al. (2006) using a limited number of grazing goats studied the effect of

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http://dx.doi.org/10.1016/j.livsci.2013.05.020

dietary supplementation with sunflower oil (60 and 138 g/day/animal respectively) plus fish oil (30 and 27.6 g/day/animal respectively) on their milk FA profile. According to the results of Martínez Marín et al. (2012) the effect of sunflower oil used in both studies was quite high since they proved that 48 g sunflower gave better results as the *trans*-10 $C_{18:1}$ milk FA concerns whose intake could be considered a risk factor for cardiovascular diseases in humans. Further to the high oil level used in the above studies, the pasture as a forage source causes confounding results, since it has been proved in ruminants that pasture has similar effects with the plant lipid supplements on milk FA profile (Chilliard et al., 2007). In addition, it is well documented that changes in milk chemical composition and FA profile are largely dependent not only from the amount of oil and the forage which are included in the diet but also to its forage to concentrate ratio (*F*/*C*) (Chilliard et al., 2007). In fact, higher milk yield and milk fat content have been observed in goats fed a moderate to high forage diet supplemented with plant oils (Mele et al., 2008). Due to the above reasons it was hypothesized that the inclusion of plant oil in combination with fish oil, at a level lower from that used in the studies of Bernard et al. (2010) and Gagliostro et al. (2006), in a diet with moderate *F*/*C* ratio will results a healthier milk FA profile.

Thus, this work was conducted with the aim to study the effect of diet supplementation with soybean oil in combination with fish oil (SFO) on milk chemical composition and on milk and plasma FA profile in dairy goats fed with a moderate *F*/*C* ratio diet indoors.

2. Materials and methods

Twelve 3-years-old Alpine crossbred dairy goats at 90–98 days in milk were kept at the experimental animal house of the Agricultural University of Athens. The average initial body weight (BW) of the animals was 44.9 ± 1.1 kg. Housing and care of animals conformed to Ethical Committee guidelines of the Faculty of Animal Science. The goats were assigned to two homogeneous sub-groups ($n=6$) that were balanced by their BW and milk yield. Each goat of each group was fed individually according to its requirements (Zervas, 2007) throughout the experimental period. The animals of both groups were fed after two weeks adaptation period with a ration consisted of oat hay and concentrates with an $F/C=50/50$ which was offered to the animals twice a day (two equal parts at 0800 and 1600 h). The concentrate of the control group had no added oil, while that of the treated group was supplemented with 55.5 g soybean oil and 11.1 g fish oil per day.

The concentrate diets were prepared every week for both groups and were formulated to be isoenergetic and isoproteic. In order to have isoenergetic and isoproteic concentrate diets, due to oil inclusion in the concentrate diet of the treated group, some different raw ingredients were used which resulted in concentrate chemical composition differences between control and treated groups (Table 1). That was unavoidable with the feedstuffs available for the experiment.

Table 1
Ingredients of the concentrates diets used in the experiment.

	Concentrates	
	Control	***Treated***
Ingredients (g/kg)		
Corn grain	670	300
Soybean meal	200	–
Sunflower meal	–	280
Sugar beet pulp	–	70
Wheat middlings	100	260
Minerals and vitamins premix	30	30
Soybean oil	–	50
Fish oil	–	10
Energy content[a] (MJ NEL/kg)	7.41	7.42

[a] Calculated.

Table 2
Mean daily nutrients and fatty acids intake (g/animal) from the diets used throughout the experimental period.

Fatty acids intake (***oat hay and concentrates***)	***Control***	***Treated***
Dry matter	1801	1850
Organic matter	1680	1710
Crude protein	234	240
Starch	400	214
NDF	729	875
ADF	492	567
$C_{14:0}$	0.86	1.22
$C_{16:0}$	12.86	21.69
$C_{18:0}$	2.53	5.06
cis-9 $C_{18:1}$	9.02	20.40
cis-9 *cis*-12 $C_{18:2}$	25.47	55.39
cis-9 *cis*-12 *cis*-15$C_{18:3}$	6.06	9.03
$C_{20:5n-3}$	–	2.44
$C_{22:6n-3}$	–	0.60
Starch/NDF	0.55	0.24

The quantities of food offered to the animals were adjusted at the 0, 7, 14, 21, 28, 35 and 42 experimental day according to their individual requirements based on their BW and milk fat corrected yield. The mean daily intake of the whole ration is presented in Table 2. The average daily DM intake throughout the experimental period for the control and the treated groups was 2.09 and 2.15 kg respectively. The whole experimental period lasted 42 days. Animals had free access to fresh water.

2.1. Samples collection

All animals were milked twice a day at 8 am and 6 pm by a milking machine. Individual milk samples were collected from goats at day 0, 7, 14, 21, 28, 35 and 42 for chemical analyses, and at day 28 and 42 for FA determination after mixing the yield from the evening and the morning milking on a percent volume (5%). Blood samples were collected at day 28 and 42 for FA determination from the jugular vein into EDTA-containing tubes and subsequently centrifuged at 2700*g* for 15 min to separate plasma from the cells.