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Effect of the inclusion of soybean oil in the diet of dairy goats on meat fatty acid composition of their suckling kids

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SUMMARY – Ten lactating Saanen goats and their suckling kids were randomly assigned to two isonitrogenous diets: control diet (C) or soybean oil diet (SO); the two diets differed only by the inclusion of soybean oil (100 g/d in SO diet). At one month of age kids were slaughtered and from each one three muscle samples were collected: *longissimus dorsi* (LD), *caput longum triceps brachii* (CLOTB) and *semimembranosus* (SM). Lipids of milk and meat samples were extracted and analysed for fatty acid (FA) composition. Results showed that milk fat from goats fed the SO diet was richer in vaccenic acid and rumenic acid that increased respectively more than 500% and 600% if compared to C diet. With SO diet, also the other *trans* isomers of octadecenoic acid increased, included *trans*-10 $C_{18:1}$, while saturated and medium chain fatty acid levels decreased. The intramuscular lipid content of kids fed SO milk resulted lower than that of kids fed C milk (1.58 g/100 g sample *vs* 1.81 g/100 g sample). The FA composition of intramuscular lipids of kids fed SO milk showed higher *trans* $C_{18:1}$ and CLA isomers proportions (1.15 *vs* 0.2 and 0.81 *vs* 0.26 g/100 g extracted fat, respectively for vaccenic acid and rumenic acid), while lower levels of saturated FA, branched chain FA, oleic acid and n-3 unsaturated FA (UFA) as compared to that from kids fed C milk. The ratio between *cis*-9 monounsaturated FA and their tissue precursors in the Δ9 desaturation pathway was negatively affected by the SO milk, especially for the rumenic acid/vaccenic acid pair. The n-6/n-3 ratio in the intramuscular lipids of kids fed C milk resulted lower than that of kids fed SO milk (5.25 *vs* 6.19, respectively).

Keywords: Meat fatty acid composition, CLA, suckling kid, *trans* fatty acids, dairy goat, soybean oil supplementation.

RESUME *– "Effet de l'inclusion d'huile de soja dans le régime de chèvres laitières sur la composition en acides gras de la viande de leurs agneaux allaitants". Cette étude rapporte l'utilisation de 10 chèvres de race Saanen avec leurs chevreaux pour un essai expérimental où elles furent distribuées au hasard selon deux régimes d'alimentation, ayant le même niveau d'azote : régime témoin (C) et régime expérimental avec inclusion d'huile de soja (SO, 100 g/d)). A l'âge dun mois les chevreaux ont été abattus et sur la carcasse de chacun d'eux on a prélevé trois échantillons des muscles* longissimus dorsi *(LD),* caput longum triceps brachii *(CloTB) et* semimembranosus *(SM). On a extrait les lipides du lait et de la viande et on en a déterminé la composition en acides gras (AG). Les résultats ont montré que les lipides du lait des chèvres soumises au régime SO étaient plus riches en acide vaccénique et en acide ruménique de plus de 500% et 600%, en comparaison avec les lipides du régime C. Dans le régime SO il y avait même augmentation des trans-isomères de l'acide octadécénoïque, y compris le trans-10 C18:1; au contraire les acides saturés et les acides gras à chaîne moyenne diminuaient. Les lipides contenus dans le gras intramusculaire des chevreaux allaités avec le lait SO étaient en plus faible quantité que les lipides des chevreaux alimentés avec le lait C (1,58 g/100 g* vs *1,81 g/100 g). La composition en AG des lipides intramusculaires des chevreaux SO montrait une proportion plus élevée de trans C18:1 et de CLA isomères (1,15* vs *0,2 et 0,81* vs *0,26, respectivement pour l'acide vaccénique et l'acide ruménique), au contraire les chevreaux SO avaient un niveau plus faible en AG saturés, AG à chaîne ramifiée, acide oléique et n-3 insaturés AG (IAG) par rapport à la viande des chevreaux alimentés avec le régime C. Le rapport entre cis-9 mono insaturés AG et leurs précurseurs dans l'itinéraire de désaturation au niveau du tissu, était négativement influencé par le lait SO, surtout pour le rapport acide ruménique/acide vaccénique. Le rapport n-6/n-3 dans les lipides intramusculaires des chevreaux alimentés avec le lait C, était plus bas que celui des chevreaux SO (5,25* vs *6,19, respectivement).*

Mots-clés : *Acides gras, viande, chevreaux, CLA, acides gras trans.*

Introduction

In Italy, consumers appreciate goat meat from very young animals such as kids aged no more than 30-40 days old, which is characterised by low fat and low-calorie content. Only in a few investigations the fatty acid (FA) composition of muscle lipids and, particularly, FA composition of meat from suckling

kids, has been studied (Todaro *et al*., 2004). Since the diet given to suckling kids is nearly totally liquid, kids are to be considered monogastric animals, provided that their rumen activity is limited. Therefore, milk fat of lactating goats is the main source of FA for the development of the lipid depots of suckling kids. In the last decade, several studies were focused on to modify FA composition of milk from ruminants (Antongiovanni *et al*., 2003), in order to enhance the content of some nutraceutical FA such as conjugated linoleic acid (CLA), n-3 polyunsaturated fatty acids (PUFA), monounsaturated fatty acids (MUFA), but a few information are available about the effect of this kind of milk on suckling kids.

The aim of this trial was to evaluate the effect of milk enriched with CLA and *trans* fatty acids (TFA), due to a soybean oil inclusion in goat diet, on the intramuscular FA composition of suckling kids.

Material and methods

Ten lactating Saanen goats and their ten suckling kids were randomly assigned to two isonitrogenous diets: control diet (grass hay, barley meal, corn meal, soybean meal, C) or soybean oil diet (C diet added with 100 g/d soybean oil; SO). Milk samples of goats were collected at the beginning and the end of the suckling period. When kids were one month old, they were slaughtered and three muscle samples were collected from each kid: *longissimus dorsi* (LD), *caput longum triceps brachii* (CLOTB) and *semimembranosus* (SM). Lipids from milk samples were extracted according to the Rose-Gottlieb method (AOAC, 1990) modified by Secchiari *et al*. (2003), while lipid from meat samples were extracted according to Folch *et al*. (1957) method. After the extraction, lipids of meat and milk were analysed for FA composition by a gas-chromatograph apparatus equipped with a FID and a high polar fused silica capillary column (Chrompack CP-Sil 88 Varian, Middelburg, Netherland; 100m x 0.25 i.d.; film thickness 0.20 μm), able to separate *cis* and *trans* isomers of $C_{18:1}$. The conjugated linoleic acid (CLA) content of milk and meat samples was determined by silver ion HPLC, using the procedure reported in Sehat *et al*. (1998). Data of total fat content and FA composition of muscle samples were analysed by a mixed linear model that included the fixed effects of goat diet and kid muscle and the random effect of kid. Growth performance and slaughter data were covariated for the birth body weight.

Results and discussion

As expected, the inclusion of soybean oil in the diet of lactating goats resulted in an increase of the long chain FA (LCFA), MUFA, CLA and TFA and in a decrease of the medium chain and saturated FA (MCFA and SFA) in milk fat (Table 1). Similar results were obtained in dairy sheep (Antongiovanni *et al*., 2004; Mele *et al*., 2006) and in dairy cows (Kelly *et al*., 1998) with similar supplementation of soybean oil. However, unlike dairy cows, the inclusion of soybean oil in the ration of dairy goats had no apparent effect on the milk fat content (Table 1) Although the limits of significance were not reached, the final body weight (FBW) and the average daily gain (ADG) of the kids fed SO milk tended to be lower than that of kids fed C milk (10.14 *vs* 11.54 kg and 179.2 *vs* 222 g/d for FBW and ADG, respectively, P = 0.1), while the crude warm dressing percentage tended to be higher for the kids fed SO milk (52.7 *vs* 48.5 % for SO and C kids, respectively, P = 0.1).

The carcasses of all kids were generally lean (total fat < 2%), but total meat fat content of SO kids was significantly lower than that of C kids (1.58 *vs* 1.81 g/100 g of meat, respectively, P<0.01), probably as a consequence of a lower accumulation of neutral lipids in the intramuscular fat (42.42 *vs* 50.31 g/100 g lipids, respectively P<0.01, data not shown). Among muscle samples, CloTb resulted significantly richer of neutral lipids than other muscles (1.88 *vs* 1.66 and 1.54 g/100 g of meat, for CloTb, LD and SM, respectively, $P \leq 0.05$). Meat fatty acid composition substantially reflected the FA composition of the goat milk. In fact, meat fat of SO kids resulted richer of TFA and CLA and with lower levels of SFA (Tables 2 and 3). In particular, SO milk seemed to affect both *de novo* synthesis of FA in intramuscular lipids, as reflected by the lower level of FA from C12 to C17, and the Δ9 tissue FA desaturation, measured by the ratio *cis*-9 $C_{14:1}/(C_{14:0}+$*cis*-9 $C_{14:1})$. According to literature, some *trans* $C_{18:1}$ isomers may be responsible for the inhibition of fat synthesis in mammary gland (Loor *et al*., 2005), while *trans*-10, *cis*-12 CLA induced body composition changes in growing animals including mice and pigs (Pariza *et al*., 2001). Mir *et al*. (2000) reported that feeding lambs during pre-weaning with 50 ml of milk-replacer containing 0.33 g of a commercial mixture of CLA, the average daily growth

rate of lambs and their meat CLA content did not differ among CLA and control group. In the present study, the inhibition of *de novo* FA synthesis seems to be related to the increase of *trans* FA, but not to *trans*-10, *cis*-12 CLA that did not differ in milk fat of goats among treatments (Table 3). All *trans* $C_{18:1}$, and *trans*, *trans* CLA isomers increased with SO milk: the content of vaccenic and rumenic acid (*trans*-11 $C_{18:1}$ and *cis*-9, *trans*-11 CLA, respectively) in the intramuscular fat was similar to that reported for weaned lambs fed with whole linseed (Demirel *et al*., 2004). *Trans*-10 $C_{18:1}$ increased as well with SO milk while *cis*-9 and *cis*-11 $C_{18:1}$ isomers resulted higher with C milk (Table 2). Rumenic acid (RA) resulted the most represented CLA isomer (81 and 90% of total intramuscular CLA content for C and SO meat samples, respectively), while the *trans*-7, *cis*-9 CLA isomer was the second one.

Table 1. Composition of milk from lactating goats fed with Control (C) or supplemented with soybean oil (SO) diets

	C	SO	SE	P
Protein %	3.62	3.59	0.19	NS
Fat %	4.69	4.50	0.15	NS
Milk FA composition (g/100 g fat)				
Short chain FA	11.79	11.05	0.40	NS
Medium chain FA	47.96	34.44	1.34	**
Long chain FA	35.75	50.52	1.76	**
Saturated FA	67.61	56.41	1.46	**
Monounsaturated FA	24.16	32.97	1.46	**
Trans FA	1.88	9.31	0.25	**
Rumenic acid	0.57	3.07	0.023	**
Trans-10, *cis*-12 CLA (mg/100 g fat)	2.2	3.0	0.3	NS
Total CLA	0.69	3.33	0.023	NS
Polyunsaturated FA n-6	3.29	3.52	0.17	NS
Polyunsaturated FA n-3	0.74	0.58	0.016	**
n-6/n-3	4.53	6.00	0.25	**

**: P<0.01; NS: not significant.

Table 2. Meat fatty acid composition of suckling kids (g/100 g extracted fat), according to goat diets

	C	SO	SE	P
$C_{10:0}$	0.05	0.05	0.005	NS
$C_{12:0}$	0.16	0.11	0.013	*
$C_{14:0}$	1.86	1.31	0.151	*
$C_{14:1}$ *cis*-9	0.12	0.06	0.001	**
$C_{15:0}$	0.18	0.11	0.016	*
$C_{15:0}$ anteiso	0.05	0.03	0.004	*
$C_{16:0}$	11.28	7.38	0.622	**
$C_{16:0}$ iso	0.08	0.05	0.006	**
$C_{16:1}$ *cis*-9	1.26	0.72	0.091	**
$C_{17:0}$	0.39	0.24	0.022	**
$C_{17:0}$ anteiso	0.21	0.12	0.012	**
$C_{17:1}$	0.08	0.05	0.008	*
$C_{18:0}$	5.98	5.19	0.221	*
$C_{18:1}$ *trans*-6 - *trans*-8	0.02	0.05	0.004	**
$C_{18:1}$ *trans*-9	0.09	0.12	0.008	*
$C_{18:1}$ *trans*-10	0.06	0.11	0.006	**
$C_{18:1}$ *trans*-11	0.2	1.15	0.05	**
$C_{18:1}$ *trans*-12	0.05	0.08	0.004	**
Total $C_{18:1}$ *trans*	0.43	1.51	0.07	**
$C_{18:1}$ *cis*-9	18.13	12.6	1.11	**
$C_{18:1}$ *cis* 11	0.84	0.49	0.03	**
$C_{18:1}$ *cis* 12	0.08	0.17	0.004	**
$C_{18:1}$ *cis* 13	0.06	0.04	0.006	NS
$C_{18:1}$ *cis* 14	0.03	0.04	0.002	NS
$C_{18:1}$ *cis* 15	0.02	0.02	0.001	NS
$C_{18:2}$ n-6	4.27	3.98	0.12	NS
$C_{18:3}$ n-3	0.24	0.18	0.011	*
$C_{18:3}$ n-6	0.03	0.01	0.001	*
$C_{20:0}$	0.03	0.03	0.005	NS
$C_{20:1}$	0.07	0.04	0.004	*
$C_{20:3}$ n-6	0.13	0.1	0.005	*
$C_{20:4}$ n-6	2.1	1.81	0.09	*
$C_{20:5}$ n-3	0.2	0.16		NS
$C_{22:5}$ n-3	0.55	0.4	0.02	**
$C_{22:6}$ n-3	0.26	0.21	0.02	0.07
SFA	20.43	14.71	1.02	**
MUFA	21.19	15.78	1.3	*
PUFA	8.33	7.92	0.26	NS
n-6/n-3	5.25	6.19	0.14	**
$C_{14:1}/C_{14:0}+C_{14:1}$	0.05	0.04	0.001	*

*: P<0.05; **: P<0.01; NS: not significant.

Table 3. CLA isomers in meat fat from suckling kids (mg/100 g extracted fat), according to goat diets

	C	SO	SE	P
Trans-6, trans-8	0.20	0.70	0.05	*
Trans-8, trans-10	0.70	1.10	0.1	*
Trans-9, trans-11	4.1	7.5	0.6	**
Trans-10, trans-12	0.71	1.73	0.2	*
Trans-11, trans-13	1.50	2.40	0.1	**
Trans-12, trans-14	0.70	1.17	0.15	*
Trans-7, cis-9	22.36	31.36	2.5	*
Cis-8, trans-10	12.62	22.56	1.1	**
Cis-9, trans -11	258.38	812.65	44.6	**
Trans-10, cis-12	2.10	4.24	0.8	0.1
Trans-11, cis-13	5.23	4.58	0.7	NS
Cis-11, trans -13	1.88	3.27	0.2	*
Cis-12, trans -14	0.95	0.66	0.2	NS
Cis-8, cis-10	0.38	0.64	0.1	NS
Cis-9, cis-11	5.51	4.11	0.7	NS
Cis-10, cis-12	0.90	1.13	0.3	NS
Cis-11, cis-13	0.80	1.06	0.2	*

*P<0.05; **P<0.01; NS: not significant.

Conclusion

The suckling kids fed CLA and TFA enriched milk, depending on soybean oil inclusion in goat diets, showed changes in meat fat content and quality. The SO carcasses were leaner than C ones and the intramuscular fat was richer in CLA, TFA and LCFA and with lower levels of SFA and MCFA, probably as a consequence of a negative effect of TFA on the *de novo* synthesis of FA in growing kids.

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