**ABSTRACT**

This review summarises the effects of nutritional factors on fat content, different isomers of trans 18:1 and conjugated linoleic acids (CLA) in milk fat from dairy cows and goats. Main dietary factors taken into account are the nature of forages and pasture, and supplementation with oil seeds, vegetable or marine oils. The effects of interactions between the nature of forages and lipid supplements in cows or goats are reviewed with particular attention. Lipid supplements could highly increase mean trans-vaccenic acid (TVA) and cis-9, trans-11 CLA content in ruminant milk fat, and interact with the quantity of concentrate in the diet or the type of preserved forage. Vegetable or fish oil supplementation increased milk cis-9, trans-11 CLA up to 4% (in total milk fatty acids (FA)). The content of copper or vitamin E in the diet could modify the milk percentage of TVA and cis-9, trans-11 CLA. Other isomers of trans-18:1 (e.g. trans-10) and CLA (e.g. cis-11, trans-13 or trans-11, trans-13 or trans-7, cis-9 or cis-9, cis-11 CLA) may be manipulated by diet composition. However, further studies are needed to establish their responses to different feeding strategies. The trans-10, cis-12 CLA in percentage in milk fat was always lower than 0.15% of total FA. The proportions of different trans-18:1 isomers in milk fat are similar in caprine and bovine species. Recent studies showed that the CLA content of goat milk fat was similar to values (0.4 - 0.9% and up to 4% for winter and lipid-supplemented diets, respectively) observed in the cow.

**Key words:** Cow, Goat, Milk, Conjugated linoleic acid, Trans fatty acids.
e di cis-9, trans-11 CLA nel grasso del latte di specie ruminanti, interagendo con la quantità di concentrato presente nella dieta o con il tipo e la forma di conservazione del foraggio. L'integrazione con oli vegetali o di pesce ha aumentato fino a 4% il contenuto di cis-9, trans-11 CLA espresso sul totale degli acidi grassi nel grasso del latte. Il contenuto di rame o di vitamina E della dieta può modificare la percentuale di TVA e cis-9, trans-11 CLA nel latte. La presenza nel latte di altri isomeri del trans-18:1 (es. trans-10) e dei CLA del latte (es. cis-11, trans-13 o trans-11, trans-13 o trans-7, cis-9 o cis-9, cis-11 CLA) può essere manipolata attraverso una modificazione della composizione della dieta. Ulteriori studi sono tuttavia necessari per definire la loro risposta a diverse strategie di alimentazione. La percentuale di trans-10, cis-12 CLA risulta sempre inferiore al 0.15% del grasso totale del latte. La specie bovina e caprina presentano una simile proporzione dei diversi isomeri trans 18:1 nel grasso del latte. Recenti studi hanno dimostrato che il contenuto di CLA nel grasso del latte caprino (pari a 0.4-0.9% per diete invernali e fino a 4% per diete integrate con fonti lipidiche) era simile a quanto osservato nei bovini.

Parole chiave: Vacca, Capra, Latte, Coniugati dell’acido linoleico, Acidi grassi trans

Introduction

Fatty acid (FA) composition is an important determinant of milk nutritional quality, because certain FA have potential negative or positive effects on human health (Sébédio et al., 1999; Jensen, 2002). Short-chain free FA or products of polyunsaturated FA (PUFA) oxidation (effects on rancid or oxidized flavour) or long-chain FA (effects on texture) could also modify the sensorial quality of dairy products. In this review, particular emphasis is placed on trans-vaccenic (trans-11 18:1, TVA) and conjugated linoleic acids (CLA) in milk of cows and goats. The term CLA refers to various positional and geometric isomers of linoleic acid, each with a conjugated double-bond. The cis-9, trans-11 CLA (rumenic acid, RA) is the major isomer (80-90%) found in ruminant milk fat (Bauman et al., 2001).

The precursors of CLA are PUFA present in ruminant diets, mainly linoleic (LA) and α-linolenic (LNA) acids. LNA is primarily found in forages and linseeds, whereas LA predominates in corn silage, cereals, and several oil seeds. The extent of ruminal biohydrogenation of LNA and LA is on average 90 and 80%, respectively (Chilliard et al., 2000). Rumenic acid is an intermediate in the ruminal hydrogenation of linoleic acid, whereas TVA is a common intermediate in the biohydrogenation of LA and LNA (Figure 1).

The final step during hydrogenation of PUFA results in production of stearic acid. Milk RA originates in part from the intestinal absorption and transfer to the mammary gland of RA produced in the rumen, but the major part (more than 2/3 of total milk RA, according to Griinari et al., 2000b) originates from the enzymatic delta-9 desaturation of rumen-derived TVA by mammary cells. The milk CLA yield was up to 4 times higher than the duodenal flow of total CLA in the same cows (Loor et al., 2002b; Loor et al., 2002d). The range of CLA in cow milk varied from 0.3 to 3% of total FA and the range of trans-11 C18:1 from 1 to 12% (Jahreis et al., 1997; Chilliard et al., 2001). The range of RA content of caprine milk fat was from 0.2 to 4% and the range of trans-11 C18:1 from 0.4 to 10% (Alonso et al. 1999; Chilliard et al., 2003).

This paper summarises the effects of nature of forage or fresh pasture, and lipid supplementation on trans-18:1 and CLA composition in cow and goat milk fat.

Effects of dietary factors in cows

Rumenic acid in milk fat results from ruminal production of both RA and TVA, and from mammary delta-9 desaturase activity. Dietary factors that increase milk RA are: i) lipid ingredients rich in LA or LNA; ii) factors changing the rumen environment and leading to reduced hydrogenation of TVA into 18:0; and iii) the interaction of both factors (Griinari and Bauman, 1999).
The addition of plant oils rich in PUFA (LA or LNA) to dairy diets increases the total CLA and RA content of milk. As reviewed by Chilliard et al., (2000), the response to soybean oil was linear up to 4% of added oil in the diet. Free oils are more effective than whole oilseeds; whereas extruded, micronized, or heat-treated oil seeds have an intermediate effect (Dhiman et al., 2000; Chouinard et al., 2001). It is likely that the gradual release of PUFA from oil seeds, compared with free oils, results in greater hydrogenation of TVA, thus yielding more 18:0 and less TVA available for absorption in the intestines.

Marine oils.

One of the more effective means to increase milk CLA and RA content (up to 2.5-3.0% of CLA in total milk FA, or +300%) is to add a small amount of marine oil to the cow’s diet (ca. 1 to 2% of diet DM) (Figure 2). Fish oil supplementation increased mainly TVA but also other isomers of 18:1, such as trans-10 (Offer et al., 1999; Griinari et al., 2000a) or cis-6 18:1 (Donovan et al., 2000; Whitlock et al., 2002), to variable extents. A likely mechanism for the increase in milk RA in response to fish oil involves the inhibition of TVA biohydrogenation in the rumen by eicosapentaenoic acid (EPA, C20:5 n-3) and docosahexaenoic acid (DHA, C22:6 n-3) (or their intermediates resulting from biohydrogenation), followed by RA synthesis in the mammary gland. This may explain why supplementation of cow diets with extruded soybeans (provision of lipid substrate) plus fish oil (inhibition of TVA biohydrogenation) increased milk RA more than when fed separately (Whitlock et al., 2002).

Figure 1. Main metabolic pathways of synthesis of milk trans-vaccenic and rumenic acids (adapted from Bauman et al. 2001).
An increase in milk fat CLA content of up to 6% was also reported when feeding a combination of fish oil plus sunflower oil (Palmquist, 2001).

High-concentrate diets.

An interaction between forage: concentrate ratio and PUFA content of the diet on trans-10: trans-11 18:1 ratio was first demonstrated by Grinari et al. (1998). When soybean oil (5% of DM) was fed with a high-concentrate (75% of DM) diet (Piperova et al., 2000), milk fat content greatly decreased, but milk RA content increased only marginally (from 0.45 with the control diet to 0.54% of total milk FA with the experimental diet).

A possible reason for this effect is that TVA availability did not increase greatly; whereas, the trans-10 18:1 isomer (which is not a precursor of CLA in the mammary gland) increased up to 9% of total milk FA. The high-concentrate diet may have shifted the bacterial biohydrogenation of dietary LA towards production of trans-10, cis-12 CLA and trans-10 18:1, instead of RA and TVA. However, the resulting increase in milk fat content of trans-10, cis-12 CLA was small (0.01 to 0.1%, or 0.05 to 0.5 g/d). This suggests that, when oil is added to a high-concentrate diet, the main product of C18:2 biohydrogenation is trans-10 18:1, which is not a precursor of trans-10, cis-12 CLA in the mammary gland. It remains to be shown if the strong antilipogenic effects observed in the mammary gland with such diets are due to trans-10 18:1, trans-10, cis-12 CLA, or both. The latter has been hypothesized as a likely candidate because from 1.25 g/d to 5 g/d infused post-ruminally decreased milk fat secretion by 7% to 36% (Bauman et al., 2001; Loor et al., 2002a; Peterson et al., 2002), respectively. However, this CLA isomer was not always related to milk fat depression in cows fed high-concentrate diets (Loor et al., 2002b; Loor et al., 2002d).

Figure 2. Response of cow milk CLA to increasing marine oil intake (from Chilliard et al. 2001 and Donovan et al. 2000)

![Figure 2](image_url)
The combined effects of the levels of dietary concentrate and plant oils may result in different responses than described above. For example, feeding a diet containing 55% concentrate plus 5% sunflower oil, coupled with the selection of more responding cows allowed a marked, but transient, increase in milk TVA and RA (up to 7.2 and 3.7% of milk total FA, respectively) without an increase in trans-10 18:1 (Bauman et al., 2000). In a recent experiment, 3% linseed oil added to a high-concentrate (65%) diet increased duodenal flow and milk secretion of trans-11 rather than trans-10 18:1. Secretion of milk TVA and RA also increased largely but yield of trans-10, cis-12 CLA was not affected (Loor et al., 2002b; Loor et al., 2002d). The increase in milk RA content is likely to be due to the C18:3 from linseed oil. Although C18:3 is not a precursor of RA in the rumen, its biohydrogenation results in a large increase in the production of ruminal trans-11 C18:1, which can be used by the mammary gland for RA synthesis (Chilliard et al., 2000 and Figure 1). Furthermore, milk fat depression was observed only with diets which increased milk trans-10 18:1, i.e. with high-concentrate diets, although it was not related to the addition of linseed oil, even in presence of a high-concentrate diet (Loor et al., 2002b).

Grazing
Pasture has been associated with high conjugated diene content in milk for decades (Kuzdzal-Savoie and Kuzdzal, 1961). Elevated values for TVA and CLA have been reported in response to grazing (e.g. 5.8 and 1.8%, respectively; Lawless et al., 1999). Concentrations of TVA and RA increased from 1.2 and 0.4% before grazing to 2.1% and 1.0% by week 4 on pasture, and 5.1 and 1.8% on week 8 on pasture (Loor et al., 2002c). However, large variations in responses can be observed due to seasonal changes in grass availability or maturity, fiber, lipid and LNA concentrations, and other unknown factors (Chilliard et al., 2001; Loor et al., 2002c and Table 1). Greater pasture allowance (33 to 100% of DM intake) resulted in a linear increase in RA concentration in milk fat (up to 2.2%) (Dhiman et al., 1999); whereas, restricted pasture intake (Mackle et al., 1999) or low grass DM allowance (Stanton et al., 1997) decreased milk CLA levels. The addition of lipid-rich feedstuffs in the concentrate increased the CLA content at higher levels than in milk fat from cows receiving pasture alone (Table 1).

We recently conducted a study comparing a concentrate-rich diet (35% hay of DMI) with 6 diets rich in either corn silage (87%), ryegrass silage (86%), ryegrass hay (90%), natural grassland hay (87%), pasture (100%) of either young or aged natural mountain grassland (Perlay et al., 2002). Milk RA contents varied from 0.4 to 1.7% of total FA, and were highly correlated with milk TVA content (Figure 3). This suggests that pasture will most often increase milk RA compared with hay when grass is young enough, i.e. with high total FA and LNA content (Bauchart et al., 1984; Loor et al., 2002c). In some experiments using winter diets the response of RA secretion after dietary changes has been transient and difficult to maintain for a long term (Bauman et al., 2000; Whitlock et al., 2002). Overall data at pasture (Table 1) show that treatment duration may be less important than other factors for explaining the variability in milk fat CLA content in pasture-fed cows.

In grazing cows consuming 7.3 kg of corn grain-based concentrate mixture, trans-10, cis-12 CLA increased from 0.03% of total milk FA before grazing to no more than 0.06, 0.07, and 0.13%, respectively, at week 4, 8 and 12 on pasture and was not correlated with depressed milk fat content (Loor et al., 2002c).

Botanical composition is another important factor, as suggested by the high value of CLA in milk from highlands (2.4%) compared with lowlands (0.9%) (Collomb et al., 2001). In a similar manner, milk CLA content was more important from diets containing forages of semi-natural grasslands than from those containing monoculture grasslands (ryegrass) (Pievez et al., 2002). However, CLA and trans-11 18:1 did not change greatly when cows consumed either diploid perennial ryegrass, tetraploid perennial ryegrass or tall fescue (Delagarde and Peyraud, 2002). Differences in total FA and LNA content between grass or legume species (e.g. Loor et al. 2002c) may be useful to explain their different effects on milk TVA and RA responses.
Other dietary factors.

The content of copper in the diet was inversely correlated to the level of milk CLA (Palmquist, 2001). Addition of vitamin E to a high-concentrate diet supplemented with PUFA increased milk fat content and the percentage of TVA and RA, while decreasing trans-10 18:1 (Focant et al., 2001). Thus, pro/antioxidant balance may be involved in the regulation of rumen and/or mammary metabolism and RA synthesis.

Table 1. Effects of pasture with or without lipid supplements on milk CLA concentration in dairy cows.

| Milk fat CLA (% of total FA) | Treatment duration | References |
|-----------------------------|--------------------|------------|
| Winter diet | Pasture | Pasture+Lipid supplement | |
| 0.3a | 1.3b | n.s. | Timmen and Patton (1988) |
| 0.3c | 0.6d | 4 mo | Jahreis et al., (1997) |
| 0.4e | 1.2f | 3 wk | Precht and Molkentin (1997) |
| 0.5g | 1.1h | 4 wk | Kelly et al., (1998) |
| 0.4i | 0.7j | 4 mo | White et al., (2001) |
| 0.4k | 1.1l/1.4m | 3 mo | Loor et al., (2002c) |
| 0.5n | 0.5/o.8p | 8 wk | Stanton et al., (1997) |
| 1.7q | 2.5/2.2r | 3 wk | Lawless et al., (1998) |
| 0.8t | 1.3/1.8u | 6 wk | Tesfa et al., (2001) |
| 0.3w | 1.3x | 4 wk | Agenäs et al., (2002) |

* grass or wheat silage + grain concentrate,
† pasture + corn cob silage,
‡ cereal-rich corn silage rations,
§ conventional pasture farming during summer season,
¶ 44% concentrate, 26% grass silage, 19% green corn, 11% hay,
∥ pasture + 1.75 kg concentrate,
* The major feed components were 24.0% corn silage, 18.8% legume silage, 4.2% legume hay, 25.0% high moisture shelled corn, and 12.5% whole cottonseed,
+ pasture only,
& 29.3% corn silage, 29.7% wilted alfalfa silage, 17.8% whole cottonseed, 13.4% corn grain, 4.6% bypass blend, 3.5% soybean meal, 1.7% premix,
* pasture + 4.5 kg concentrate + 1.0 kg soybean meal,
| total mixed diet,
| pasture + solvent-extracted soybean meal (25% of the concentrate; 7.3 kg concentrate),
| pasture + mechanically extracted soybean meal (31% of the concentrate; 7.3 kg concentrate),
| pasture only,
| pasture + 0.82 kg rapeseeds, 2.02 kg beet pulp, 0.15 kg molasses,
| pasture + 1.65 kg rapeseeds, 1.2 kg beet pulp, 0.15 kg molasses,
| pasture + 3.1 kg concentrate,
| pasture + 3.1 kg raw full fat soybeans,
| pasture + 1.45 kg concentrate + 1.65 kg rapeseeds,
| pasture + dairy concentrate,
| pasture + 234 g soybean oil fatty acids,
| pasture + 439 g soybean oil fatty acids,
| grass silage and concentrate,
| pasture + 385 g soybean oil,
| n.s., not specified.

Other CLA and non-conjugated isomers.

Trans-7, cis-9 CLA is the most abundant minor CLA in milk and cheese and a range of 8-11% of total CLA was reported (Yurawecz et al., 1998). It is probably synthesized in the mammary gland (and intestinal or adipose tissue) via delta-9 desaturation of ruminally-derived trans-7 18:1.

Only limited data are available regarding dietary influences on the distribution of the different minor CLA isomers. Milk fat from cows fed
diets that result in formation of high levels of biohydrogenation intermediates in the rumen i.e. pasture feeding or supplementation of corn silage diets with dietary oils (peanut, sunflower, linseed, and fish oil) were used to evaluate CLA isomers profiles. These dietary treatments produced a wide range of cis/trans-CLA isomer concentrations. The following positive associations between dietary treatment and specific cis/trans-CLA isomers were observed: pasture feeding and cis/trans 11, 13; peanut oil and trans-7, cis-9; sunflower oil and trans-10, cis-12; linseed oil and cis-12, trans-14; fish oil and cis-9, trans-11 (Griinari et al., 2000a). 

The following positive associations between dietary treatment and specific cis/trans-CLA isomers were observed: pasture feeding and cis/trans 11, 13; peanut oil and trans-7, cis-9; sunflower oil and trans-10, cis-12; linseed oil and cis-12, trans-14; fish oil and cis-9, trans-11 (Griinari et al., 2000a). 

Trans-10, cis-12 CLA is generally found in very small amounts, and does not exceed 10% of total CLA (0.13% of total milk FA), even with milk fat-depressing diets (Piperova et al., 2000; Loor et al., 2002b). Feeding a high concentrate plus 5% soybean oil diet, increased trans-7, cis-9 CLA from 8 to 23% of total CLA (0.04 to 0.22% of total milk FA); whereas, cis-8, trans-10 CLA remained low (Piperova et al., 2000).

We recently observed that low-fiber diets increased the yield of milk cis-11, trans-13 CLA and cis-9, cis-11 CLA (Loor et al., 2002b). Furthermore, linseed oil supplementation to a hay-based diet increased principally RA but also cis-9, cis-11 CLA and trans-11, trans-13 CLA. Trans-11 and trans-13+14 18:1 also increased due to linseed oil. Trans-11, cis-15 18:2 (a non-conjugated isomer formed during hydrogenation of LNA) increased in duodenum and milk lipids from

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**Table 2. Interactions between forage nature and vegetable oil supplementation on goat milk yield and composition (from Chilliard et al, 2002).**

| Forage          | Corn silage | Alfalfa hay | P² | P³ | P int⁴ |
|-----------------|-------------|-------------|----|----|--------|
| Oil             | C           | LO¹          | OSO¹ |   |        |
| Milk yield kg.d¹ | 3.62a       | 3.98a       | 3.48a |   | 3.47a  |
| Milk fat g.kg⁻¹ | 34.4a       | 36.4a       | 36.6a |   | 29.8b  |

Fatty acids (w% of total FA):
- 18:0: 7.5a, 9.2b, 13.7a, 6.0b, 10.8a, 12.7a
- 18:1 t11: 1.3a, 6.6a, 3.4a, 0.4a, 9.1c, 2.3c
- 18:1 c9: 15.7a, 14.8a, 23.5a, 16.6a, 16.0a, 27.9c
- 18:2 (LA): 2.0a, 1.5a, 1.4a, 2.3a, 1.7a, 1.6a
- 18:3 (LNA): 0.32a, 0.68a, 0.17a, 0.60a, 1.38a, 0.42a
- 18:2 c9t11 (RA): 0.59a, 2.25b, 0.79a, 0.34b, 3.24b, 1.01c

Atherogenicity Index: 3.4a, 1.7b, 1.6c, 3.5a, 1.5b, 1.4a

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1 C, LO, OSO, LA, LNA, RA = control, linseed oil, oleic sunflower oil, linoleic, a-linolenic, rumenic acid respectively; twelve goats per group, except hay-control group (n=10). Data were analysed by general linear model procedures of SAS (1996). The model included: basal diet, type of supplementation, interaction between basal diet and type of supplementation. The 6 treatment means were compared by the Student-Newman-Keuls test. Data in same row with similar superscript letters do not differ at P<0.05 level.

2, 3 Probability for LO or OSO effect, respectively (see footnote 4 for statistical model).

4 Probability for Forage-Oil interaction (the effects of either LO (or OSO) was calculated in a 2x2 factorial model for 4 treatment groups with basal diet and LO (or OSO) as main factors and their interaction; l or s indicates significant interaction for LO or OSO, respectively).

5 Linseeds oil contains 6% 16:0 + 17% 18:1+15% 18:2 + 57% 18:3.

6 Oleic sunflower oil contains 4% 16:0 + 83% 18:1 + 7% 18:2.

7 (12:0 + 4.14:0 + 16:0) : (Sum of unsatured FA) (Ulbricht and Southgate, 1991).
cows supplemented with linseed oil (Loor et al., 2002b; Loor et al., 2002d).

**Effects of dietary factors in goats**

Dairy goats could be used as a model to simulate dairy cow responses to dietary manipulation. However, the dairy goat generally responds to fat supplementation with a sharp increase in milk fat content without a change in milk yield; whereas, the cow responds with an increase in milk yield and either an increase or a decrease in milk fat content (Chilliard and Bocquier, 1993; Chilliard and Lamberet, 2001). This suggests that the regulation of lactose and lipid metabolism may differ between both ruminant species. However, the proportions of different trans-18:1 isomers in milk fat are similar in caprine (LeDoux et al., 2002) and bovine (Precht and Molkentin, 1999) species. Milk fat CLA was higher during summer in goats as well as cows, when animals consumed fresh grass (Jahreis et al., 1999). In that study, goat milk fat contained ca. 30% less CLA than cow milk fat. However, recent studies showed that the CLA content of goat milk fat was similar to values observed in the cow: 0.4 - 0.9% of total FA in animals receiving conventional winter diets (Alonso et al., 1999; Gulati et al., 2000) and up to 3.2% in goats receiving lipid-supplemented diets (Mir et al., 1999; Chilliard et al., 2002; Chilliard et al., 2003).

Raw full fat whole seeds such as linseeds,
sunflower seeds, lupin seeds or soybeans are less efficient in increasing TVA and RA in goat milk fat than free linseed or sunflower oils (Chilliard et al., 2003). This suggests that, as in cows, when oil is released slowly from the seeds, PUFA are biohydrogenated to a large extent, whereas free oil changes the ruminal metabolism towards the yield of trans 18:1 without complete biohydrogenation into stearic acid (see Figure 1).

We recently evaluated (Table 2) the interaction between type of winter diet (alfalfa hay vs. corn silage) and oil supplements (linseed oil vs. high oleic sunflower oil, at 5-6% of diet DM). In the absence of added oil, there were few differences between hay and corn silage diets. Corn silage increased the percentage of 18:0, and decreased the percentage of LA and LNA. Linseed or high-oleic sunflower oil increased 18:0, TVA, and RA, but decreased percentage of LA and atherogenicity index (\( \sum (C_{12:0} + 4C_{14:0} + C_{16:0}) / \sum (\text{unsaturated} FA) \)). Linseed oil increased LNA percent whereas high-oleic sunflower oil increased \( \text{cis}-9 \) 18:1 percent and decreased LNA percent. The \( \text{trans}-10 \) 18:1 isomer was increased by oil supplementation when corn silage was the basal diet, but not when it was alfalfa hay (Chilliard et al., 2003). This could explain why milk fat content did not increase when oils were added to corn silage diets (Table 2). RA and TVA concentrations were highly correlated \((r=0.96; n=140)\), and the response of TVA was 2.7 fold that of RA (Figure 3). In other respects, lipid supplementation decreased goat flavour, and linseed oil increased metallic, oxidised and fishy flavours in goat milk and cheeses (Gaborit et al., 2002).

The main findings concerning RA in goat milk fat are: \( i \) there are significant interaction effects between oil and forage type, with higher responses with both oils when the forage is alfalfa hay compared with corn silage; \( ii \) linseed oil increases RA very sharply, confirming that dietary LNA is efficient in increasing TVA and RA secretion; \( iii \) linseed oil in combination with alfalfa hay increases RA by 85%, up to 3.2% of milk total FA, i.e. within range of highest values found with dairy cows (Bauman et al., 2000; Chilliard et al., 2001); \( iv \) oils rich in oleic acid increase TVA and RA when fed with alfalfa hay, in agreement with the recent demonstration that oleic acid could be isomerised to \( \text{trans}-11 \) and other \( \text{trans}-18:1 \) isomers in microbial cultures from bovine rumen (Mosley et al., 2002).

**Conclusions**

Nutritional studies with cows and goats indicate that milk FA with potential positive roles in human health can be enhanced substantially, inexpensively, and in the short term by dietary manipulation. Large increases in milk RA, TVA, LA, or LNA concentrations are observed with diets rich in feedstuffs containing polyunsaturated FA, marine oils, concentrates and/or pasture. Hence, this knowledge could be used to elaborate new feeding strategies for dairy ruminants in order to increase the nutritional value of milk fat. In other respects, milk or dairy products rich in PUFA appear to be more sensitive to oxidation. Further studies are needed to determine if antioxidants (e.g. vitamin E) and/or other micronutrients could interact with PUFA metabolism, in order to better control the potential effects of these feeding strategies on the sensorial quality of dairy products.

Part of this paper was presented first at the Symposium CheeseART02 (Consorzio Ricerca Filiera Lattiero-Casearia), Ragusa, Italy, June 6-9, 2002.

The help of Pascale Béraud during manuscript preparation was highly appreciated.

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