SHORT COMMUNICATION

# Influence of canola oil on the fatty acid profile in goats' milk

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[1]*Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, Alberta, Canada T6G 2P5 (e-mail: erasmus.okine@ualberta.ca);* [2]*Alberta Agriculture, Food and Rural Development, # 204-7000-113 Street, Edmonton, Alberta, Canada T6H 5T6;* [3]*Research Centre, Agriculture and Agri-Food Canada, PO Box 3000, Lethbridge, Alberta, Canada T1J 4B1;* [4]*University of Louisiana, Baton Rouge, Louisiana, 70803, USA.* *Received 8 January 2003, accepted 13 April 2003.*



Okine E. K., Goonewardene, L. A., Mir, Z., Mir, P. Wang, Z. and Chanmugam, P. S. 2003. **Influence of canola oil on the fatty acid profile in goats' milk**. Can. J. Anim. Sci. **83**: 323–325. Four Alpine does were used in a 4 × 4 Latin square design to determine the effects of feeding canola oil at four levels: 0, 2, 4 and 6% on milk fatty acid profile. The sum of $C_{12:0} + C_{14:0} + C_{16:0}$ (hypercholesterolemic fatty acids) decreased linearly and $C_{18:0} + C_{18:1}$: $C_{16:0}$ (indicator of cholesterolemic tendency of fat source) increased linearly ($P < 0.01$) with increased canola oil intake.

**Key words**: Goat, milk, fatty acids, canola oil

Okine, E. K., Goonewardene, L. A., Mir, Z., Mir, P., Wang, Z. et Chanmugam, P. S. 2003. **Incidence de l'huile de canola sur les acides gras dans le lait de chèvre**. Can. J. Anim. Sci. **83**: 323–325. Les auteurs ont utilisé quatre chèvres Alpine dans le cadre d'une expérience en carré latin 4 × 4 afin de vérifier les effets de l'addition d'huile de canola (0, 2, 4 et 6 %) sur la composition du lait en acides gras. La somme $C_{12:0} + C_{14:0 ;} C_{16:0}$ (acides gras hypercholestérolémiques) baisse de façon linéaire tandis que la somme $C_{18:0} + C_{18:1} + C_{16:0}$ (indice cholestérolémique de la matière grasse) augmente de façon linéaire ($P < 0{,}01$) à mesure que s'accroît l'ingestion d'huile de canola.

**Mots clés**: Chèvre, lait, acides gras, huile de canola

Oilseeds such as canola have been used in diets of dairy cows to increase unsaturated, long-chain fatty acids at the expense of medium-chain fatty acids such as $C_{14:0}$ and $C_{16:0}$ in milk (Khorasani et al. 1991). Canola oil has been shown to increase the conjugated linoleic acid content of goats' milk by 88 to 210% compared to the control diet (Mir et al. 1999). However, the effect of feeding canola oil on the medium- and short-chain fatty acid profile of goats' milk has not been reported. Jenness (1980) suggested that fatty acids in goats' milk are more readily digested due to a higher concentration of short-chain fatty acids. In addition, goats' milk can be used as an alternative source of milk for humans who are allergic to cows' milk (Saini and Gill 1991). Human diets rich in short- and medium-chain saturated fatty acids such as $C_{12:0}$, $C_{14:0}$ and $C_{16:0}$ have been reported to be hypercholesterolemic, whereas $C_{18:0}$ and $C_{18:1}$ fatty acids in general have been reported to have cholesterol lowering properties (Bonanome and Grundy 1988). Early research by Hegsted et al. (1965) suggested that $C_{18:1}$ did not influence low-density lipoprotein (LDL) cholesterol, but Mattson and Brundy (1985) demonstrated that it is effective in lowering LDL cholesterol. On the other hand, $C_{18:1, t\text{-}11,}$ increases both total LDL and high-density lipoprotein (HDL) cholesterol with a subsequent unfavorable LDL:HDL cholesterol ratio (Pedersen 2001). The objective of this study was to determine the effects of feeding canola oil on saturated, mono-unsaturated, poly-unsaturated, short-, medium- and long-chain fatty acids in goats' milk.

The study used four non-pregnant late lactation Alpine does with an average body weight of 74.3 ± 7.2 kg, in their first lactation in a 4 × 4 Latin square design. The four dietary treatments were: no canola oil (control), 2% (40 g oil), 4% (80 g oil) and 6% (120 g) by weight of dietary rolled barley. Mir et al. (1999) described details of feed and feeding management and supplement composition used in this study. All animals were managed in accordance with the Canadian Council on Animal Care (1993) guidelines.

Milk fat extraction and derivatization of extracted lipid has been described previously (Mir et al. 1999). Fatty acid profiles were determined by gas chromatography. The column was BPX70 (30 m, 0.22 mm i.d., 0.25 micro film; SJE Australia pty. Ltd., Victoria, Australia), installed in an HP5830 GC fitted with a 18835B capillary inlet 18850A integrator (Hewlett-Packard, Mississauga, ON) using a flame ionization detector and split less injection. Initial temperature was 50°C and was increased to 200°C at a rate of

**Abbreviations**: **LDL**, low-density lipoprotein; **HDL**, high-density lipoprotein

**Table 1. Least squares means for goats' milk fatty acids (% of total fatty acids) in response to feeding canola oil diets**

| Fatty acid (%) | 0% canola | 2% canola | 4% canola | 6% canola | SEM[z] | *P* lin[y] | *P* quad[y] |
|---|---|---|---|---|---|---|---|
| $C_{4:0}$ | 1.16 | 1.08 | 1.10 | 1.37 | 0.07 | 0.09 | 0.04 |
| $C_{6:0}$ | 2.75 | 2.65 | 2.57 | 2.75 | 0.08 | 0.78 | 0.09 |
| $C_{8:0}$ | 2.22 | 2.43 | 2.40 | 2.25 | 0.07 | 0.94 | 0.02 |
| $C_{10:0}$ | 9.01 | 9.90 | 9.32 | 9.01 | 0.36 | 0.74 | 0.11 |
| $C_{10:1}$ | 0.32 | 0.31 | 0.28 | 0.28 | 0.02 | 0.05 | 0.67 |
| $C_{11:0}$ | 0.27*a* | 0.29*a* | 0.24*a* | 0.18*b* | 0.03 | <0.01 | 0.05 |
| $C_{12:0}$ | 6.60*a* | 6.50*a* | 5.50*b* | 4.95*b* | 0.28 | <0.01 | 0.44 |
| $C_{13:0}$ | 0.20*a* | 0.21*a* | 0.19*a* | 0.15*b* | 0.01 | <0.01 | 0.10 |
| $C_{14:0}$ | 12.25*a* | 11.75*ab* | 10.57*b* | 10.68*b* | 0.29 | <0.01 | 0.30 |
| $C_{14:1}$ | 0.59 | 0.54 | 0.47 | 0.53 | 0.03 | 0.11 | 0.08 |
| $C_{15:0}$ | 1.18 | 1.17 | 1.11 | 1.01 | 0.05 | 0.02 | 0.41 |
| $C_{16:0}$ | 27.34*a* | 24.75*b* | 22.76*c* | 23.01*bc* | 0.70 | <0.01 | 0.06 |
| $C_{16:1}$ | 1.40*a* | 1.31*ab* | 1.25*b* | 1.27*b* | 0.04 | <0.01 | 0.15 |
| $C_{17:0}$ | 1.90*a* | 1.90*a* | 1.69*b* | 1.60*b* | 0.06 | <0.01 | 0.19 |
| $C_{18:0}$ | 5.93 | 6.16 | 6.47 | 6.29 | 0.45 | 0.50 | 0.62 |
| $C_{18:1}$ | 18.82*a* | 20.81*a* | 24.91*b* | 25.21*b* | 0.83 | <0.01 | 0.32 |
| $C_{18:2,\ n\text{-}6}$ | 2.80 | 2.94 | 2.80 | 3.00 | 0.12 | 0.41 | 0.81 |
| $C_{18:3,\ n\text{-}3}$ | 0.65 | 0.67 | 0.59 | 0.69 | 0.03 | 0.78 | 0.24 |
| $C_{20:1,\ n\text{-}9}$ | 0.16*a* | 0.22*b* | 0.39*c* | 0.37*c* | 0.02 | <0.01 | 0.16 |
| $C_{20:4,\ n\text{-}6}$ | 0.14*a* | 0.14*a* | 0.12*ab* | 0.10*b* | 0.01 | <0.01 | 0.02 |
| $C_{20:5,\ n\text{-}3}$ | 0.13*a* | 0.13*a* | 0.11*ab* | 0.10*b* | 0.01 | 0.01 | 0.45 |

[z]Pooled standard error of the mean.
[y]*P* lin and *P* quad = values for linear and quadratic regression effects, respectively.
*a,b* Means with different letters within rows are different ($P < 0.05$).

**Table 2. Least squares means for grouped fatty acids in goats' milk in response to feeding canola oil diets**

| Group | 0% canola | 2% canola | 4% canola | 6% canola | SEM[z] | *P* lin[y] | *P* quad[y] |
|---|---|---|---|---|---|---|---|
| Monounsaturated | 21.27*a* | 23.22*a* | 27.30*b* | 27.72*b* | 0.81 | <0.01 | 0.35 |
| Polyunsaturated | 3.70 | 3.61 | 3.60 | 3.94 | 0.15 | 0.36 | 0.21 |
| Saturated | 71.34*a* | 68.86*a* | 63.90*b* | 63.61*b* | 0.91 | <0.01 | 0.24 |
| Short-chain | 23.01*a* | 23.38*a* | 21.59*ab* | 20.11*b* | 0.81 | <0.01 | 0.27 |
| Medium-chain | 44.43*a* | 41.48*ab* | 37.83*bc* | 38.29*b* | 1.20 | <0.01 | 0.18 |
| Long-chain | 29.14*a* | 31.88*ab* | 36.66*bc* | 38.17*b* | 1.23 | <0.01 | 0.62 |
| $C_{12:0}+C_{14:0}+C_{16:0}$ | 46.24*a* | 43.00*b* | 38.84*c* | 38.83*c* | 1.04 | <0.01 | 0.13 |
| $C_{18:0}+C_{18:1}/C_{16:0}$ | 0.97*a* | 1.13*b* | 1.43*c* | 1.46*c* | 0.07 | <0.01 | 0.44 |
| Fatty acids n-6 /n-3 | 3.82 | 4.06 | 4.51 | 4.18 | 0.23 | 0.07 | 0.10 |

[z]Pooled standard error of the mean.
[y]*P* lin and *P* quad = values for linear and quadratic regression effects, respectively.
*a,b* Means with different letters within rows are different ($P < 0.05$).

25°C min$^{-1}$, from 200 to 220°C at a rate of 1°C min$^{-1}$ and from 220 to 240°C at a rate of 15°C min$^{-1}$. Individual fatty acids were expressed as percentages of the total fatty acids detected as fatty acid methyl esters.

The data were analyzed as a Latin square, using the General Linear Model of the SAS Institute, Inc. (1992) and a Student Newman Keuls' test was used to separate means (Steel and Torrie 1980). Linear and quadratic effects for the dependent variables relative to feeding incremental levels of canola oil were derived using SAS Institute, Inc. (1992).

Nutrient analysis of the diets, milk yield, fat, protein, lactose, conjugated linoleic acid and long-chain fatty acid composition of milk in response to feeding canola oil have been reported earlier (Mir et al. 1999).

The least squares means for the fatty acids in goats' milk in response to feeding canola oil are shown in Table 1. Concentrations of $C_{11:0}$, $C_{12:0}$, $C_{13:0}$, $C_{14:0}$, $C_{16:0}$, $C_{16:1}$, $C_{17:0}$, $C_{20:4,\ n\text{-}6}$ and $C_{20:5,\ n\text{-}3}$ fatty acids decreased ($P < 0.01$) linearly as the level of canola oil in the diet increased. However, the concentrations of $C_{18:1,}$ and $C_{20:1}$ fatty acids increased ($P < 0.01$) linearly with increasing levels of dietary canola oil. No changes ($P > 0.05$) were observed in $C_{4:0}$, $C_{6:0}$, $C_{8:0}$, $C_{10:0}$, $C_{10:1}$, $C_{18:0}$, $C_{18:2,\ n\text{-}6}$ and $C_{18:3,\ n\text{-}3}$ fatty acids in response to feeding canola oil.

The least squares means for the combined fatty acids and ratios of selected fatty acids in response to feeding canola oil are shown in Table 2. The monounsaturated and the long-chain fatty acids increased ($P < 0.01$) while the saturated, short-chain and medium-chain fatty acids decreased ($P < 0.01$) in response to feeding higher levels of canola oil. The polyunsaturated fatty acids did not change ($P > 0.05$) as a result of feeding canola oil. The sum of the $C_{12:0} + C_{14:0} + C_{16:0}$ (hypercholesterolemic fatty acids) decreased ($P < 0.01$) while the ratio of $C_{18:0} + C_{18:1}$: $C_{16:0}$ (indicator of cholesterolemic tendency of the fat source) increased ($P < 0.01$) with increased canola oil intake. However, changes in the fatty acid profile beyond the 4% level of canola oil intake were marginal.

The fatty acid composition of goats' milk from animals fed the control diet (0% canola oil) were similar to those reported by Jandal (1996) who reviewed the fatty acid composition of goats' milk from many dietary sources. However, $C_{12:0}$ values were higher and $C_{4:0}$, $C_{18:0}$ and $C_{18:1}$ were lower than that reported (Jandal 1996). These differences in fatty acid composition may be attributed to differences in the diets fed (Jenness 1980).

Feeding canola oil to dairy goats resulted in 30 and 31% increases in monounsaturated and long-chain fatty acids, respectively, and 11 and 14% decreases in saturated and medium-chain fatty acids, respectively. However, the short-chain fatty acids decreased and the polyunsaturated fatty acids remained unchanged in response to canola oil feeding. Changes in the concentration of the long-chain fatty acids seem to have equivocal effects on human health. Thus, the 28% decreased concentration of $C_{20:4, n-6}$ may be considered beneficial due to its anti-thrombotic effect (Scollan et al. 2001). On the contrary, the 23% decrease in the concentration of $C_{20:5, n-3}$ may lessen the beneficial effect of goats' milk on human health relating to coronary heart disease.

The concentration of $C_{18:0} + C_{18:1}$ relative to $C_{16:0}$ may be a better indicator of the cholesterolemic tendency of a fat source with a higher ratio of $C_{18:0} + C_{18:1}$ to $C_{16:}$ being deemed to nutritionally superior (Bonanome and Grundy 1988). The concentration of $C_{18:1}$ increased by 33%, with no change in $C_{18:0}$ with increased canola oil in the diet. However, the $C_{18:0} + C_{18:1}$ to $C_{16:0}$ ratio increased from 0.97 in the control to 1.46 in the 6% canola oil treatment diet, producing a fatty acid profile potentially, more beneficial for heart health of humans. The increased $C_{18:0} + C_{18:1}$ to $C_{16:0}$ ratio in the present study is associated with $C_{16:0}$ decreasing by 16% when canola oil was fed at 4 and 6% compared to the control diet. Feeding protected canola seed has been shown to reduce the proportions of $C_{16:0}$, $C_{14:0}$ and $C_{12:0}$ fatty acids in milk fat with the greatest decrease (6.9% of total fat) being in the $C_{16:0}$ fraction (Ashes et al. 1992). The 33% increase in $C_{18:1}$ with increased canola oil intake could mean possible increases in both total LDL and HDL cholesterol with subsequent unfavorable LDL:HDL cholesterol ratio (Pedersen 2001).

Inclusion of canola oil in the diet of dairy goats' resulted in changes in fat percent and specific fatty acids in milk. The monounsaturated and the long-chain fatty acids increased, while the saturated, short-chain and medium-chain fatty acids decreased in response to feeding canola oil. The total $C_{12:0} + C_{14:0} + C_{16:0}$ decreased linearly and the ratio of $C_{18:0} + C_{18:1}$: $C_{16:0}$ increased linearly with the increasing level of canola oil intake. The increase or the decrease of the combined fatty acids beyond the 4% level of canola oil resulted in marginal changes in each fatty acid.

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