Milk production and milk composition of dairy cows fed Lac100® or whole flaxseed

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Cows were fed whole flaxseed or calcium salts of soybean oil as a fat source. Cows fed flaxseed had lower (P < 0.01) milk yield and higher (P < 0.01) percentages of fat and protein than cows fed calcium salts. Feeding whole flaxseed and calcium salts of soybean oil increased, respectively, the concentrations of alpha-linolenic acid and conjugated linoleic acid in milk.

Key words: Flaxseed, fatty acids, fat supplement


Mots clés: Graine de lin, acides gras, supplément de gras

Protection against biohydrogenation of polyunsaturated fatty acids by rumen microbes helps to overcome the negative effects of feeding fat on rumen fermentation. For example, rumen-protected soybean oil as butylsoyamide (Jenkins et al. 1996), which is a mixture of butylamine and soybean oil, or as a mixture of soy lecithin and soap (Abel-Caines et al. 1998), which are two co-products of soybean oil processing, and whole flaxseed (Petit 2002), has had no effect on feed intake. Although feeding calcium salts of unsaturated fatty acids has had no effect on dry matter intake, they increased conjugated linoleic acid (CLA) concentration in milk (Chouinard et al. 1998), probably as a result of lower protection against ruminal biohydrogenation for calcium salts of unsaturated than saturated fatty acids (Wu and Palmquist 1991). Lac100®, which is a commercial calcium salt of soybean oil, could then be an interesting fat source to increase milk concentration of CLA without decreasing feed intake. The objectives of this experiment were to compare the effects of feeding rich sources of either alpha-linolenic acid (whole flaxseed) or linoleic acid (Lac100®) on milk production and composition and milk fatty acid profile. Flaxseed was used for the comparison as it has been shown to be a good source of fat for early lactating dairy cows (Petit 2002).

Ten multiparous Holstein cows averaging 510 kg of BW (SE = 16 kg) and 80 d in lactation were fed the two diets in a crossover design with two 45-d periods. The two total mixed diets (Table 1) consisted of fat supplements based on either whole flaxseed (FLA) or Lac100® (LAC), which is a calcium salt of soybean oil (> 82% ether extract, Yakult, Bragança Paulista, São Paulo, Brazil). Fatty acid composition of Lac100® was 10.9% palmitic acid, 3.7% stearic acid, 24.7% oleic acid, 55.5% linoleic acid, and 5.2% linolenic acid. The experiment was conducted at the Iguatemi Experimental Farm, Maringa State University, Brazil. Cows were housed in tie stalls, fed individually, and milked...
twice daily at 0645 and 1545. Milk production was recorded at every milking and data that were collected on the last 10 d were used to determine the effect of diets on milk yield. Cows were managed according to the guidelines of the Canadian Council on Animal Care (1993).

Milk samples were obtained weekly from each cow for two consecutive milkings and were analyzed separately to determine milk composition. Milk samples were also collected weekly to determine milk fatty acid composition. Body weight of cows was determined every 2 wk. Feed consumption was recorded daily. Diets were fed twice daily at 0600 and 1400 for 10% ors. Samples of each diet were taken weekly, frozen, and pooled on a 45-d basis. Chemical composition of diets and milk was determined using the methods previously quoted by Petit (2002). All results were analyzed using the MIXED procedure of SAS Institute, Inc. (2000) software with the following general model:

\[
Y_{ijk} = \mu + a_i + \beta_j + \pi_k + e_{ijk},
\]

where \(Y_{ijk}\) = the dependent variable, \(\mu\) = overall mean, \(a_i\) = random effect of cow (\(i = 1\) to 5), \(\beta_j\) = fixed effect of period (\(j = 1,2\), \(\pi_k\) = fixed effect of treatment (\(k = \text{FLA}, \text{LAC}\)), and \(e_{ijk}\) = random residual error. Periods were considered long enough (45 d each) not to produce any carryover effects regarding the effects of diets on milk production, milk composition, and milk fatty acid profile. Probability values greater than 0.05 were considered nonsignificant.

Intake of dry matter (Table 2), expressed in kilogram per day, was significantly greater for cows fed FLA than for those fed LAC although it was similar between treatments when expressed as a percentage of body weight. Untreated whole flaxseed is readily accepted by dairy cows and has no negative effect on dry matter intake when fed at 10% (Petit 2002). Similarly, feeding butylsoyamide, a form of rumen-protected soybean oil, did not affect intake of dry matter over a 14-d period when the diet contained 6.4% ether extract (Jenkins et al. 1996) and adding 2.25% of protected soybean oil in the form of a mixture of soy lecithin and soap compared to a control diet with no fat supplement resulted in similar feed intake (Abel-Caines et al. 1998). Milk yield of cows fed FLA was significantly lower than that of cows fed LAC (Table 2) and values were similar to those for production in Brazil (Santos et al. 2001). In general, digestibility of diets containing flaxseed is lower than that of diets containing either micronized soybeans or calcium salts of palm oil (Petit 2002), which would result in lower milk yield for similar feed intake as observed in the present experiment. Supplementation with calcium salts of long-chain fatty acids has been reported to augment fat digestibility in several experiments as the inclusion of highly digestible fats in the diets dilutes the contributions of poorly digested lipids other than fatty acids (Garcia-Bojalil et al. 1998). Supplementation of a control diet with rumen protected soybean oil in the form of a mixture of soy lecithin and soap (Abel-Caines et al. 1998) or as butylsoyamide (Jenkins et al. 1996) has had no effect on milk yield.

Percentages of fat, protein, and total solids in milk were significantly higher for cows fed FLA than for those fed LAC (Table 2). Yield of 4% fat corrected milk was similar for both treatments. Feeding fat through seeds maintains or increases milk fat content (Dhiman et al. 2000), while feeding free oil in the form of fish oil decreases milk fat percentage (Cant et al. 1997) likely as a result of the generation of high levels of trans-fatty acids in the rumen (Baumgard et al. 2000). This would suggest that oil from flaxseed was released more gradually over time or in lower amount in the rumen than from the Lac100® supplement as fat percentage was greater for cows fed FLA than for those fed LAC. In fact, in vitro biohydrogenation of calcium salts of unsaturated fatty acids from diets containing a blend of animal and vegetable fat (Wu and Palmquist 1991) was as high as 71%, which would corroborate this hypothesis. Feeding whole flaxseed as compared with calcium salts of palm oil has previously been reported to increase milk protein percentage (Petit 2002) and Mohamed et al. (1988) observed a milk protein-depressing response to soybean oil products such as soy oil, whole soybeans, and roasted whole soybeans, in agreement with the present findings.

Milk fatty acids concentrations (Table 2) of \(C_6:0\), \(C_8:0\), \(C_10:0\), \(C_11:0\), \(C_12:0\), \(C_{13:0}\), \(C_{14:1}\), \(cis-7\), \(C_{18:0}\), \(C_{18:1}\), \(cis-7\), and \(C_{18:3}\) were higher for cows fed FLA than for those fed LAC while the inverse was observed for concentrations of \(C_{16:0}\), \(C_{16:1}\), \(cis-9\), \(C_{18:1}\), \(trans-11\), \(C_{18:2}\), \(cis-9\), \(cis-12\), and \(C_{18:3}\). Milk composition of cows fed FLA was similar to that reported by Petit (2002). Feeding LAC

### Table 1. Ingredient and chemical composition of the diets²

<table>
<thead>
<tr>
<th>Ingredient (% of DM)</th>
<th>FLA</th>
<th>LAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn silage</td>
<td>55.1</td>
<td>55.1</td>
</tr>
<tr>
<td>Ground corn</td>
<td>18.1</td>
<td>20.7</td>
</tr>
<tr>
<td>Whole flaxseed</td>
<td>11.5</td>
<td>0.0</td>
</tr>
<tr>
<td>Soybean meal (49% CP)</td>
<td>13.6</td>
<td>19.0</td>
</tr>
<tr>
<td>Lact100®</td>
<td>0</td>
<td>4.5</td>
</tr>
<tr>
<td>CaCO₃</td>
<td>1.2</td>
<td>0.4</td>
</tr>
<tr>
<td>Mineral and vitamin premix²</td>
<td>0.5</td>
<td>0.3</td>
</tr>
</tbody>
</table>

²FLA = supplement with whole flaxseed; LAC = supplement with LAC100®.

³Yakult, Milk Specialties, Araçatuba, São Paulo, Brazil.

⁴Premix contained (as fed basis): 200 000 IU of vitamin A kg⁻¹, 60 000 IU of vitamin D₃ kg⁻¹, 600 IU of vitamin E kg⁻¹, 30 g kg⁻¹ of Ca, 120 g kg⁻¹ of P, 24 g kg⁻¹ of Mg, 900 mg kg⁻¹ of F, 700 mg kg⁻¹ of Cu, 2700 mg kg⁻¹ of Zn, 1250 mg kg⁻¹ of Mn, 2000 mg kg⁻¹ of Fe, 80 mg kg⁻¹ of I, 100 mg kg⁻¹ of Co, and 20 mg kg⁻¹ of Se.

⁵Calculated using published values of feed ingredients (National Research Council 2001).
 increased concentrations of C18:3 and CLA compared with feeding FLA. A greater dietary supply of C18:3 is known to increase milk CLA concentration through ruminal biohydrogenation (Dhiman et al. 1995) with a parallel decrease in milk fat (Dhiman et al. 2000). It is also possible that the slow release of oil from flaxseed in the rumen reduced the amount of trans-fatty acids leaving the rumen. Trans-10 C18:1 and trans-10, cis-12 isomer of CLA have been linked to the inhibition of de novo synthesis of short- and medium-chain fatty acids in the mammary gland (Bauman and Griinari 2001). The concentration of C18:1 may also increase dramatically if the amount of unsaturated fatty acids fed is excessive due to inhibition of the conversion of trans-C18:1 to C18:0 by rumen bacteria (Jenkins et al. 1996). This would increase concentrations of trans-C18:1 and decrease those of C18:0 as observed in the present experiment for cows fed LAC as compared with those fed FLA. On the other hand, according to Lock and Garnsworthy (2002) the C18:3 fatty acids can be biohydrogenated in the rumen although they do not increase CLA secretion in milk as is the case with C18:2 fatty acids. The C18:3 fatty acids might restrict the formation of the C18:1 trans-11, which is converted to CLA in the mammary gland (Griinari and Bauman 1999). Feeding whole flaxseed and Lac100® increased, respectively, the concentrations of alpha-linolenic acid and CLA in milk, which are both important components for human health. Therefore, both sources of fat would be acceptable fat supplements for lactating dairy cows depending on which fatty acid one wishes to increase in milk.

The authors gratefully acknowledge Mr. D. R. Veiga from the Laboratory of PARLPR of APCBRH and Mr. C. Volpato from the Laboratory of Nutrition and Animal Science, Curitiba, PR, Brazil for assistance in laboratory analysis and Mr. E. S. Sakaguti for his help in performing the statistical analysis. This study was funded by the Universidade Estadual de Maringá, the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and the Centro Universitário de Maringá (CESUMAR).


