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Effects of a commercial feed containing conjugated linoleic acid on the production of milk components and the value of milk

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ABSTRACT

This study was to evaluate changes in cow productivity and milk value from feeding a rumen-protected form of CLA to pasture-fed dairy cows in early lactation. 30 New Zealand Friesian dairy cows were randomly assigned at calving to either 0g (control) or 120g/d of a commercial rumen protected feed containing CLA from 4 days post-calving for 16 weeks. Milk yield and composition data was collected weekly. A simulation model was used to calculate yield of dairy products based on accumulated yields of milk and its components per cow during the experimental period. Feeding CLA reduced (P<0.001) fat concentration (3.1% vs 4.2%) and increased (P<0.05) milk yield (2688 kg vs 2423 kg), and protein yield (89.9 kg vs 81.2 kg). The effect of CLA on milk fat concentration was reflected in the yield of dairy products and milk value. Milk from cows fed CLA had less (P<0.01) excess of fat sold as butter (48.4 vs 69.4 kg butter). The value of milk ($/kg MS) was higher (P<0.001) from cows fed CLA than from control cows at 2002/03 prices ($3.87 vs $3.66) and when butter price was low ($3.56 vs $3.24).

Keywords: CLA; milk fat depression; cow productivity; milk income; milk value.

INTRODUCTION

Conjugated linoleic acids (CLA) are long chain fatty acids found in ruminant fat as a result of rumen biohydrogenation of dietary polyunsaturated fatty acids (see reviews by Bauman *et al.,* 2000, 2001). There are many studies examining the beneficial health effects of CLA supplementation in biomedical studies, both in animal models and human clinical trials.

CLA supplements are made up of many different isomers of CLA and identifying the isomer(s) responsible for specific biological effects is difficult but specific effects have been attributed to two of the main isomers, *cis*-9, *trans*-11 and *trans*-10, *cis*-12 isomers. The *cis*-9, *trans*-11 form of CLA has been shown to be anticarcinogenic (Ip *et al.,* 1999) and many clinical studies are being conducted into its reported health benefits. However, CLA supplementation has also been shown to decrease milk fat concentration and yield in lactating cows (Chouinard *et al.,* 1999a, 1999b; Loor & Herbein 1998), pigs (Harrell *et al.,* 2000) and women (Masters *et al.,* 1999). Although commercial products used in these studies contain a mixture of CLA isomers, the milk fat reducing effect has been attributed specifically to the *trans*-10, *cis*-12 isomer (Baumgard *et al.,* 2000). A study comparing the effect of 2 different pure CLA isomers, *trans*-10, *cis*-12 and *cis*-9, *trans*-11, demonstrated that *trans*-10, *cis*-12 inhibited milk fat synthesis, whereas the *cis*-9, *trans*-11 (the major CLA isomer in milk fat) had no effect. However, based on comparisons of different CLA mixtures, the *trans*-8, *cis*-10 isomer may also cause a reduction in milk fat yield (Bauman *et al.,* 2001) but this has not been demonstrated.

There is potential for this milk fat reducing technology to be developed for on-farm application. The use of *trans-10, cis -12* CLA potentially alters nutrient partitioning, so that energy and nutrients spared from synthesising fat can be used for other processes in the lactating dairy cow. Therefore, in early lactation when cows are typically in negative energy balance, this altered partitioning could result in increased milk yield and milk protein yield. In addition, it could increase body condition and reproductive performance.

Dairy cattle in New Zealand have been selected to produce milk with higher concentrations of fat and protein (milk solids, MS) than dairy cattle in other countries because milk is processed into dairy products for sale in the international market as commodities. Current trends (MAF, 2003) show that in OECD (Organization of Economic Cooperation and Development) countries the consumption of dairy products is expected to increase only modestly, driven by convenience, nutrition and health concerns. The OEDC forecasts a static consumption of butter. In non-OECD countries, however, the OECD forecasts strong growth in demand for dairy products but annual rises in the international butter price will be relatively low, largely because of falling demand from many of butter's traditional consumers, who are increasingly listening to nutritional advice encouraging the consumption of edible oils, such as olive or avocado oils, rather than animal fats. The value of milk to the industry depends upon its composition and the aggregate profit of the product mix manufactured from the milk. Reducing fat

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concentration in milk may affect the yield of dairy products and value of milk because potentially less butter would be produced. This trial was designed to evaluate changes in cow productivity and milk value from feeding a rumen-protected form of CLA to pasture-fed dairy cows in early lactation.

MATERIAL AND METHODS

All procedures involving the dairy cows used in this study were approved by the Ruakura Animal Ethics Committee. 30 New Zealand Friesian cows (448 ± 60 kg; average ± SD) were randomly assigned to one of two treatments (0 or 120 g/d of Ca-CLA) after they left the colostrum mob (5 days post-partum). The experimental period ran for 16 weeks from July 2003 until November 2003. A dose rate that was calculated to cause 30% milk fat reduction was used. This level was targeted as Mackle *et al.* (2003) demonstrated that the effect of increasing dose rates of CLA on milk yield and milk protein yield was curvilinear, with the maximal effect on milk and milk protein yield occurring at approximately 30% milk fat depression.

The cows were grazed as one herd, receiving a daily pasture allowance of approximately 35 kg DM/d of ryegrass (*Lolium perenne L.*) – white clover (*Trifolium repens L.*) pasture.

Cows were milked at approximately 0630 and 1530 h daily. Every seven days, PM and AM milk yields were weighed and samples collected. The samples were analysed for milk composition (fat, protein, casein, lactose and total solids) on an infrared milk analyser (FT120, Foss Electric, Hillerød, Denmark).

After the AM milking, cows were individually fed in a supplementary feeding area. The treatment cows received approximately 0 or 120 g/d of a commercially available rumen protected source of Ca-salts of palm fatty acids containing 5.71% *trans*-10, *cis*-12 CLA (Bioproducts Inc., Fairlawn, OH, USA) in a total amount of 360 g/d of feed. The feed was energetically balanced by the addition of golden flake (Golden Flake Prills, Nutrition Trading International Ltd, UK) and copra. The golden flake product (min ME 37 MJ/kg) is a palm oil based product and was fed in an attempt to balance the treatments for energy offered as by-pass fat.

Calculation of yield of dairy products and value of milk

A simulation model (Garrick & Lopez-Villalobos, 2000) was used to calculate yields of dairy products based on accumulated yield of milk and milk components from individual cows and it components during the experimental period. Milk value ($/kg MS) was calculated assuming that milk was processed into a representative New Zealand mix of dairy products for export and sold at international prices. Two dairy product price scenarios were considered. In scenario 1, values of dairy products were averages prices for the 2002/03 season (MAF, 2003): US$1534/tonne of whole milk powder, US$1501/tonne of skim milk powder, US$1678/tonne of Cheddar cheese, US$1167/tonne of butter, US$1501/tonne of butter milk powder, US$3441/tonne of casein, US$1201/tonne of whey powder. In scenario 2, the values were the same as in scenario 1 but the price for butter was 50% of that assumed in scenario 1 (US$584). An average exchange rate between New Zealand and American dollar for the season 2002/03 was calculated at NZ$0.516/US$1.00.

Costs were included in the model for the storage, collection, reception and standardisation of milk, the processing of milk and for packaging, storage, transport and marketing of the dairy products. The model recognises three classes of costs: volume-related costs, composition-related costs and costs determined by the quantities of products manufactured. Milk income was calculated as milk value multiplied by yield of milk solids per cow.

Statistical analysis

All variables were analysed using the MIXED procedure of SAS (2002) with a linear model that included the effect of treatment. Results are given as least squares means and their standard errors. Multiple comparison between least squares mean for each treatment was performed.

RESULTS

Feeding CLA for 16 weeks in early lactation resulted in an 11% increase in milk yield (Table 1). However, milk fat concentration was reduced by 26% and the milk fat yield of cows fed CLA was reduced by 18% (Table 1). Feeding CLA did not influence milk protein concentration but there was an 11% increase in protein yield due to the increased milk yield (Table 1). Despite the changes in fat and protein yields, there was no difference in milk solids yield produced by control and CLA fed cows.

Altering the ratio of fat:protein in the milk (Table 1) produced different yields of dairy products. Cows fed CLA had significantly greater yields of whole milk powder, skim milk powder and casein (Table 2). As a result of the decreased availability of fat for processing, yields of cheese, butter and butter milk powder were significantly lower from cows fed CLA (Table 2). There was no significant difference in the amount of whey powder produced.

In Scenario 1 where average prices for the 2002/03 season were used, milk value ($/kg MS) was significantly higher for cows fed CLA (Table 2).

TABLE 1: Effect of feeding rumen protected conjugated linoleic acid (CLA) on milk yield, milk component concentrations and yields of milk components to dairy cows during the first 16 weeks of lactation.

	Control	CLA	P value
Days in milk	111 ± 2	111 ± 2	ns
Milk yield (litres)	2427 ± 83	2688 ± 74	P<0.05
Milk component concentrations (%)			
Fat %	4.2 ± 0.1	3.1 ± 0.1	P<0.001
Protein %	3.4 ± 0.1	3.4 ± 0.1	Ns
Fat:Protein ratio	1.25 ± 0.02	0.92 ± 0.02	P<0.001
Casein %	2.7 ± 0.03	2.6 ± 0.02	P<0.01
Yields of components (kg)			
Fat yield	101.4 ± 3.4	83.0 ± 3.0	P<0.001
Protein yield	81.2 ± 2.7	89.9 ± 2.5	P<0.05
Milk solids yield	182.6 ± 6.0	172.9 ± 5.2	ns

TABLE 2: Effect of feeding rumen protected conjugated linoleic acid (CLA) on yields of dairy products, milk value and milk income.

	Control	120 g	P value
Yield of dairy products (kg)[1]			
Whole milk powder	78.7 ± 2.1	89.0 ± 3.1	P<0.01
Skim milk powder	45.9 ± 1.4	63.0 ± 2.1	P<0.001
Cheese	57.9 ± 2.0	48.5 ± 1.7	P<0.001
Butter	69.4 ± 2.7	48.4 ± 2.1	P<0.001
Butter milk powder	7.4 ± 0.3	5.1 ± 0.3	P<0.001
Casein	25.6 ± 1.3	27.3 ± 0.9	P<0.001
Whey powder	70.6 ± 0.3	72.9 ± 3.4	ns
Scenario 1: average prices of dairy products			
Milk value ($/kg MS)	3.66 ± 0.02	3.87 ± 0.02	P<0.001
Milk income ($/cow)	669 ± 39	669 ± 28	ns
Scenario 2: low value for butter			
Milk value ($/kg MS)	3.24 ± 0.02	3.56 ± 0.04	P<0.001
Milk income ($/cow)	590 ± 27	614 ± 25	ns

[1]Total yields per treatment over the 16 week experimental period

However, this did not result in a higher milk income (Table 2). In Senario 2, where a lower value for butter was used, milk value again was significantly higher for cows fed CLA (Table 2). Although there was a $24/cow increase in milk income for Ca-CLA fed cows, this was not statistically significant (Table 2).

DISCUSSION

Feeding CLA to pasture-fed dairy cows during early lactation resulted in cows producing on average 1.5 L/day more milk, with a concurrent increase in milk protein yield. This is in contrast to overseas studies (Chouinard *et al.,* 1999a, 1999b; Loor & Herbein 1998; Baumgard *et al*., 2001) where inducing milk fat depression with *trans*-10, *cis*-12 CLA did not cause an increase in milk or protein yield. Many of these studies were short (4 day) abomasal infusion studies whereas in the current study a rumen-protected product was fed for 16 weeks. Additionally the cows in the overseas study were at different stages of lactation, which would influence the availability of precursors for milk fat synthesis.

We estimate that approximately 6.85g/d *trans*-10, *cis*-12 CLA was fed in the CLA product, which is similar to Baumguard *et al*. (2001) where they fed 7 g/d. In the Baumgard study this dose rate caused a reduction in milk fat concentration of 37% and fat yield of 33% but there was no change in milk or milk protein yield. The change in milk yield and milk protein yield observed in the current study may be due to the CLA feed altering energy balance and nutrient partitioning differently in cows fed pasture. It must be acknowledged that although the control and CLA feeds were balanced energetically, if there was a difference in energy intake between treatments, this may have influenced the results. However, Mackle *et al*. (2003) abomasally infused pasture-fed cows (for 4 days) and reported an 11% increase in milk yield (the same as in our study) and as a consequence of the increased milk yield, CLA-infused cows produced an extra 52 g milk protein/day. The only published information on an extended feeding trial in early lactation is Medeiros *et al*. (2000) where Zebu x Holstein cows grazing tropical pasture were supplemented with rumen protected CLA and concentrates. This also resulted in an increase in milk protein yield, but this increase was a result of increased milk protein concentrations. Hence, it is difficult to compare these results to our study.

Feeding Ca-CLA did not significantly change the amount of total milk solids produced but altered the amount of fat and protein produced and hence changed the yields of the resulting dairy products (Table 2). Manipulating the amounts of fat and protein produced is important for farmers in a differential payout system such as in the New Zealand dairy industry where milk protein has a much higher value. For processors, this gives them the ability to manipulate production of low value products such as butter that are subject to fluctuations in demand and price.

By feeding Ca-CLA and altering the composition of milk supplied, the reduction in milk fat resulted in a 30% decrease in butter production. However, the reduction in milk fat did not alter the production of butter alone but affected the production of other products. For products where fat is not required e.g. skim milk powder, there was a 37% increase in yield. However for cheese production, which requires fat, there was a 16% decrease in yield.

In both scenario 1 and 2, milk value was significantly increased by reducing the fat composition of the milk. However, in scenario 1, milk income was not increased because cows fed with CLA had numerically lower yields of milk solids. The increased value of milk was eroded by the slight reduction in yield. But as demonstrated by scenario 2, when butter was worth less, the change in product yields resulted in an increase in milk income for cows fed CLA.

The results from this study show that use of this technology to alter milk composition for processing can change milk value and milk income. This analysis did not include a costing for feeding or measure if there were changes in energy balance, reproductive indicators or liveweight. It is not known if all the spared energy from reduced fat production in this study was used for the increased milk and protein yield or if some was partitioned to alleviate the negative energy balance found in early lactation, thereby influencing liveweight gain and reproductive parameters. This needs to be determined, and a dollar value for these parameters defined so that a more detailed analysis can be conducted. This would allow the impact of this technology on total farm production and profitability to be calculated.

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