Potential Application of Conjugated Linoleic Acids in Nutrient Partitioning

Lance H. Baumgard,1 Chel E. Moore1 and Dale E. Bauman2
1University of Arizona
2Cornell University

Summary:
- Conjugated linoleic acids (CLA) may offer potential as a management tool in animal agriculture
- CLA may improve energy balance and alleviate energy demands in lactating dairy cattle and thus may:
  - Increase milk yield
  - Increase milk protein yield
  - Prevent decrease in milk yield during heat stress
  - Improve reproduction in early lactation and during heat stress
  - Reduce incidence of metabolic disorders in early lactation
  - Help manage milk fat quota systems
- CLA may reduce carcass fat in beef, swine and poultry thus:
  - Improve feed efficiency
  - Increase carcass value
- CLA may reduce negative side effects of an activated immune system
  - Prevent decrease in weight gain when animals are immune challenged

CONJUGATED LINOLEIC ACIDS

Conjugated linoleic acids (CLA) are a group of fatty acids that are microcomponents of ruminant fat. Chemically, they are a mixture of positional and geometric isomers of octadecadienoic acid with conjugated double bonds. Theoretically, a number of CLA isomers are possible that differ in the positions of the double bond pairs (e.g. 7-9, 8-10, 9-11, 10-12 etc.). Additional differences can exist in the geometric configuration of the double bond so that cis-trans, trans-cis, cis-cis or trans-trans configurations are possible. Fatty acids with conjugated double bonds were first demonstrated in ruminant food products over 65 years ago and later shown to consist of primarily cis-9, trans-11 octadecadienoic acid over 25 years ago (Bauman et al., 2000). The occurrence of CLA in ruminant fat is a result of rumen biohydrogenation of dietary polyunsaturated fatty acids and as a consequence fat from monogastric animals contains little, if any, CLA (see reviews by Bauman et al., 2000; 2001).
Human Health Benefits

Pariza and co-workers were the first to discover a “functional food” role for CLA when they observed that synthetic conjugated dienoic isomers of linoleic acid possessed anticarcinogenic effects (see review by Pariza, 1999). Subsequent work has identified additional beneficial health effects and these are listed in Table 1. As a consequence of their biological effects and origin, CLA have received considerable attention from not only the medical community and human nutritionists but also animal scientists. The range of physiological processes affected by CLA is impressive. In general, effects have been identified using biomedical studies with animal models and utilizing chemically synthesized supplements containing a variety of CLA isomers.

The anticancer effect is the most extensively investigated response to CLA. Conjugated linoleic acids have been found to be anticarcinogens in animal models for mammary, skin, stomach, intestinal, lung and prostate cancers (Parodi, 1997). Identifying the CLA isomer(s) responsible for each specific biological effect has been difficult, as most studies have used a fatty acid supplement containing a variety of CLA isomers. However, recently it has been shown that cis-9, trans-11 CLA is anticarcinogenic (Ip et al., 1999). This is particularly important for animal and food scientists as cis-9, trans-11 CLA is the predominant CLA isomer in ruminant-derived food products (Bauman et al., 2000). This study also revealed, for the first time, that a naturally occurring component in an animal food product (milk fat/butter) had the ability to prevent tumor development.

As a consequence of the aforementioned biological effects, there is substantial interest in the medical community to utilize CLA as a therapeutic nutrient or at least as a preventative dietary agent for many common human diseases such as heart disease, cancer, Type II diabetes and obesity. Although CLA has been demonstrated effective in many different animal models it has not yet been extensively evaluated in human trials.

Table 1. Beneficial health effects of CLA reported from biomedical studies with animal models.¹

<table>
<thead>
<tr>
<th>Biological effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticarcinogenic (in vivo and in vitro studies)</td>
</tr>
<tr>
<td>Antiatherogenic</td>
</tr>
<tr>
<td>Alter nutrient partitioning (lipid metabolism modulator)</td>
</tr>
<tr>
<td>Antidiabetic</td>
</tr>
<tr>
<td>Immune stimulant</td>
</tr>
<tr>
<td>Alleviates cachexia</td>
</tr>
<tr>
<td>Stimulates bone mineralization</td>
</tr>
<tr>
<td>Alleviates symptoms of lupus</td>
</tr>
</tbody>
</table>

¹Adapted from Jahreis et al. (2000) and Whigham et al. (2000).
Conjugated linoleic acids effect on nutrient partitioning has also generated interest from animal agriculture due to its ability to decrease fat synthesis in lactating and growing animals (Baumgard et al., 2000a). Efforts to decrease the fat content of growing and milk from lactating farm animals is important as consumers continue to request leaner food products and demand “healthier” dietary fat. The following sections will speculate on how CLA could be used by the animal industry to improve feed efficiency, enhance performance, produce a healthier product and boost farm profits.

**CLA and DAIRY CATTLE**

In an attempt to increase milk fat CLA content in lactating dairy cows it was discovered that administration of CLA dramatically decreased milk fat yield and percentage (Chouinard et al., 1999b; Loor and Herbein, 1998). Subsequent studies confirmed that abomasal infusion of a supplemental mixture of CLA isomers significantly reduced milk fat yield (Chouinard et al., 1999c, Mackle et al., 2002). Rumen-protected CLA (Ca++ salts) also decrease milk fat when fed to cows consuming either a TMR or rotationally grazed (Geisy et al., 1999; Medeiros et al., 2000). The effects of CLA supplements on milk fat synthesis in lactating dairy cows are summarized in Table 2. In addition, a dietary supplement of CLA has been reported to decrease the milk fat content in lactating pigs (Harrell et al., 2000; Poulos et al., 2000) and nursing women (Masters et al., 1999).

The CLA supplements used in the aforementioned studies contained a mixture of isomers. Based on the increase in milk fat content of trans-10 C\textsubscript{18:1} observed with diet-induced milk fat depression (Griinari et al., 1997), we hypothesized that CLA isomers containing a trans-10 double bond were the cause of the milk fat reduction and examined this by abomasally infusing relatively pure CLA isomers (Figure 1). After 4 days of infusion, the trans-10, cis-12 CLA isomer resulted in over a 40 % reduction in milk fat percentage and yield whereas cis-9, trans-11 CLA had no effect (Baumgard et al., 2000b). We recently extended this work and observed a curvilinear relationship between the increase in trans-10, cis-12 CLA dose and the reduction in milk fat yield (Baumgard et al., 2001). This isomer is a very potent inhibitor of milk fat synthesis with a dose of 3.5 g/d eliciting a 25% reduction in milk fat yield.

The effects of CLA on milk fat are rapid and apparent within 24 hrs (Figure 1). Equally important is that milk fat production returns to normal levels within a few days after removal of CLA. Effects also appear to be specific for the fat component of milk. Most of the CLA studies have utilized cows in mid to late lactation and in these trials milk yield, milk protein, and dry matter intake have generally been unchanged in short term studies (Baumgard et al., 2000b; Baumgard et al., 2001; Chouinard et al., 1999b; Chouinard et al., 1999c; Loor and Herbein, 1998). However, the decrease in milk fat secretion without a reduction in feed intake would cause a more positive net energy balance. CLA
could have many benefits on production and animal well being by improving whole animal energy status during specific stages of lactation and at certain times of the year. These benefits may include increased milk yield, increased synthesis of other milk components, decreased metabolic disorders and improved reproductive efficiency.

![Figure 1](image)

**Figure 1.** Temporal pattern of milk fat content during abomasal infusion of conjugated linoleic acid (CLA) isomers. Infusions were 10 g/d of cis-9, trans-11 CLA or trans-10, cis-12 CLA. Adapted from Baumgard et al. (2000b).

Production of low fat milk can be easily accomplished by a number of dietary situations including low fiber/high concentrate rations, small fiber particle size and the inclusion of certain oils. However, often a deleterious side effect of diet induced milk fat depression is the increased risk of metabolic disorders including rumen acidosis, ketosis, displaced abomasums and lameness. Therefore, utilizing CLA to reduce milk fat synthesis while maintaining animal well-being and production offers an exciting new management tool for dairymen.

Historically, milk fat has been the primary, sometimes the only, marketable component of milk meaning milk fat depression was a large economic problem. As a consequence, dairy scientists have been studying milk fat depression and developing strategies to prevent its occurrence for more than a century. For a review of milk fat depression and CLA role in diet-induced milk fat depression see review by (Bauman et al., 2000; Bauman and Griinari, 2001).
<table>
<thead>
<tr>
<th>CLA g/d</th>
<th>Duration Days</th>
<th>Milk Yield kg/d</th>
<th>%</th>
<th>Milk Fat g/d</th>
<th>%</th>
<th>Milk Protein g/d</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abomasal Infusion of Mixed CLA Isomers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 1</td>
<td>16.0 3.31&lt;sup&gt;a&lt;/sup&gt;</td>
<td>540&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>790</td>
<td>Loor and Herbein, 1998</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>15.0 2.66&lt;sup&gt;b&lt;/sup&gt;</td>
<td>400&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.99&lt;sup&gt;b&lt;/sup&gt;</td>
<td>760</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 5</td>
<td>21.5 2.81&lt;sup&gt;a&lt;/sup&gt;</td>
<td>599&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.31</td>
<td>696</td>
<td>Chouinard et al., 1999b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30.6</td>
<td>20.4 1.43&lt;sup&gt;b&lt;/sup&gt;</td>
<td>290&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.37</td>
<td>675</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60.2</td>
<td>20.9 1.38&lt;sup&gt;b&lt;/sup&gt;</td>
<td>295&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.53</td>
<td>717</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>91.8</td>
<td>18.3 1.23&lt;sup&gt;b&lt;/sup&gt;</td>
<td>222&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.46</td>
<td>627</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 3</td>
<td>26.9 3.34&lt;sup&gt;a&lt;/sup&gt;</td>
<td>883&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.14</td>
<td>831</td>
<td>Chouinard et al., 1999c</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.5</td>
<td>29.4 2.36&lt;sup&gt;b&lt;/sup&gt;</td>
<td>691&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.04</td>
<td>882</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29.1</td>
<td>26.8 2.43&lt;sup&gt;b&lt;/sup&gt;</td>
<td>633&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.15</td>
<td>829</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.7</td>
<td>27.5 2.40&lt;sup&gt;b&lt;/sup&gt;</td>
<td>655&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.03</td>
<td>826</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abomasal Infusion of Pure CLA isomers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 4</td>
<td>35.2 3.04&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1068&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.74&lt;sup&gt;a&lt;/sup&gt;</td>
<td>965</td>
<td>Baumgard et al., 2000b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 (c9, t11)</td>
<td>36.9 2.94&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1086&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.73&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1008</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 (t10, c12)</td>
<td>36.2 1.92&lt;sup&gt;b&lt;/sup&gt;</td>
<td>696&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.57&lt;sup&gt;b&lt;/sup&gt;</td>
<td>930</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5 (t10, c12)</td>
<td>26.4 3.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>772&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.02</td>
<td>799</td>
<td>Baumgard et al., 2001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.0 (t10, c12)</td>
<td>26.5 2.28&lt;sup&gt;b&lt;/sup&gt;</td>
<td>579&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.00</td>
<td>801</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 (t10, c12)</td>
<td>25.8 1.90&lt;sup&gt;c&lt;/sup&gt;</td>
<td>515&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.10</td>
<td>795</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 5</td>
<td>23.5 1.61&lt;sup&gt;d&lt;/sup&gt;</td>
<td>383&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.12</td>
<td>720</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 (t10, c12)</td>
<td>19.9 3.13&lt;sup&gt;a&lt;/sup&gt;</td>
<td>618&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.20</td>
<td>639</td>
<td>Baumgard et al., 2002b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 (c9, t11)</td>
<td>17.1 1.80&lt;sup&gt;b&lt;/sup&gt;</td>
<td>320&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.36</td>
<td>536</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 (t10, c12)</td>
<td>31.8 3.22&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1033&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.95</td>
<td>930</td>
<td>Baumgard et al., 2002a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5 (t10, c12)</td>
<td>32.0 3.44&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1106&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.91</td>
<td>929</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.0 (t10, c12)</td>
<td>30.9 2.36&lt;sup&gt;b&lt;/sup&gt;</td>
<td>741&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.95</td>
<td>908</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rumen-Protected CLA Supplements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 5</td>
<td>31.3 3.12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>970&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.66</td>
<td>830</td>
<td>Peterson et al., 2002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.25 (t10, c12)</td>
<td>31.4 2.91&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>900&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.62</td>
<td>820</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.50 (t10, c12)</td>
<td>31.5 2.60&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>810&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>2.62</td>
<td>810</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.00 (t10, c12)</td>
<td>28.9 2.40&lt;sup&gt;c&lt;/sup&gt;</td>
<td>690&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.75</td>
<td>780</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 70</td>
<td>46.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1480&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.00</td>
<td>1380</td>
<td>Chouinard et al., 1999a</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>50.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.68&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1360&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.99</td>
<td>1500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 35</td>
<td>16.6 2.80&lt;sup&gt;a&lt;/sup&gt;</td>
<td>458&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.79&lt;sup&gt;a&lt;/sup&gt;</td>
<td>457&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Medeiros et al., 2000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>17.0 2.11&lt;sup&gt;b&lt;/sup&gt;</td>
<td>361&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.07&lt;sup&gt;b&lt;/sup&gt;</td>
<td>517&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 140</td>
<td>44.1 3.61&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1570</td>
<td>2.77</td>
<td>1210</td>
<td>Bernal-Santos et al., 2001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>47.0 3.15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1450</td>
<td>2.74</td>
<td>1260</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 140</td>
<td>35.2 3.72&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1310&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.09</td>
<td>1088</td>
<td>Perfield et al., 2001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>36.9 2.82&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1048&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.03</td>
<td>1118</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Transition Period

The period immediately prior to and following calving is associated with large metabolic adaptations. Characteristically, cows in this stage of lactation are synthesizing and secreting more energy than they consume (Drackley, 1999). As a consequence, animals experience a severe negative energy balance and this is associated with an increased risk of metabolic disorders and health problems (Drackley, 1999; Goff and Horst, 1997) and reduced reproductive performance (Beam and Butler, 1999; Lucy et al., 1992).

Reducing the nutrient demand for milk synthesis via inhibiting milk fat production should conceivably both alleviate the magnitude of negative energy balance and also reduce DIM to energy balance nadir. Improving energy balance should decrease the demand for adipose tissue mobilization and thus decrease blood NEFA concentrations thereby reducing the incidence of fatty liver and ketosis.

The extent of negative energy balance during the first few weeks postpartum negatively influences ovarian activity and largely determines the interval of anestrus. Recovery of energy balance from its most negative level in early lactation toward a more positive balance provides an important signal for initiation of ovarian activity (Beam and Butler, 1999; Lucy et al., 1992). Reduced milk fat yield early in lactation may shorten the time to energy balance nadir and allow a more rapid return of ovulatory estrous cycles. Similarly, conception rates are affected by energy balance (Lucy et al., 1992) and thus a CLA-induced reduction in milk fat may improve conception rates. Thus, an improvement in energy balance during early lactation may have positive effects on several dimensions of reproductive performance. Consistent with this, cows fed rumen-protected CLA, which caused a minor reduction in milk fat yield, tended to have improved reproductive success including days to first ovulation and conception rates (Overton et al., 2001).

Heat Stress

Heat stress negatively impacts milk synthesis and impairs reproductive performance. As a consequence, heat stress is a significant financial problem in many areas of the United States and most of the world. The mechanism by which this occurs is mainly via reduced feed intake but also includes reduced rumination, digestion and absorption of nutrients and an increase in maintenance requirements (Collier and Beede, 1985). Essentially, because of the reduced feed intake the dairy cow is putting herself in a negative energy balance, similar to the negative energy balance observed in early lactation. Inhibiting milk fat synthesis during periods of heat stress may attenuate or eliminate the negative energy balance. As a result of the extra available energy, synthesis of other milk and milk components may increase (i.e., lactose and protein). In addition to
enhancing milk yield, inhibiting milk fat synthesis and thus improving energy balance may improve animal well-being and reproductive success.

**Milk Yield**

Peak milk yield usually occurs approximately 40-60 DIM. Prior to and during this stage of lactation animals are in a negative energy balance. As a consequence, milk synthesis in high producing dairy cows may be limited by energy availability. This is especially pertinent during peak milk synthesis. Alleviating the energy crisis due to milk fat synthesis during this stage of lactation may cause an increase in production of other milk components and thus allow the animal to achieve its genetic potential. In the limited work-to-date utilizing rumen-protected CLA, cows treated in early lactation responded with an increase in milk yield and milk protein yield (Table 2; Bernal-Santos et al., 2001; Chouinard et al., 1999a; Medeiros et al., 2000) whereas no increases were observed in cows treated during established lactation (Table 2; Perfield et al., 2001).

To illustrate the bioenergetic potential, consider a cow producing 45 kg/d of milk (normal composition). Feeding CLA during peak yield (40-60 DIM) and inhibiting milk fat synthesis by 50% would free up enough energy to produce an extra 11 kg of milk. Assuming energy was limiting genetic potential for milk production and 100% of additional energy was utilized for milk synthesis, this would result in a peak milk yield of 56.1 kg/d. This is particularly significant because each kg increase in peak milk yield equates to an increase in total lactation milk yield of approximately 127 kg (Dr. Bob Everett, Cornell University; Personal Communication; Figure 2). Therefore, in this example, using CLA to reduce milk fat synthesis during peak milk yield would result in an increase in total lactation yield of 1,400 kg (normal composition). It is presumed the value of the extra milk (normal composition) would be more than the loss of money due to the production of low fat milk during CLA feeding (40-60 DIM).

**Milk Protein and Fat Quota’s**

Decreasing milk fat reduces the energy requirement for milk synthesis and as a consequence dietary CLA could increase milk protein yield if protein synthesis was limited by energy availability. This situation would often occur in grazing dairy cows, and Medeiros et al. (2000) demonstrated milk protein percentage and yield were increased 10 and 13%, respectively, when grazing cows received 90 g/d of a rumen protected CLA supplement (Table 2).
**Figure 2.** Hypothetical lactation curve using conjugated linoleic acid to reduce milk fat synthesis during peak yield. Assuming 100% of additional energy was utilized for milk synthesis and that every kg increase in peak milk yield equates to an increase in total lactation milk yield of approximately 127 kg.

As the economic value of milk fat continues to decrease, relative to that of milk protein, there is greater interest in discovering methods of regulating milk composition and in particular milk fat synthesis. For example, Canada and several European countries have quotas for the quantity of saleable milk fat, and these economies may favor milk production with a higher protein and lower fat content. Therefore, depending upon marketing regulation, in some instances a reduction in milk fat yield would be of economic value to producers.

**CLA and BODY COMPOSITION**

Excess body fat represents inefficient nutrient utilization and therefore reduced economic return for producers. This is especially true when carcasses are sold based on a grading scheme. Dietary CLA represent a metabolic modifier that effects body composition in growing animals and is currently being evaluated for possible commercial use as a management tool to increase or improve productivity in growing farm animals.

Dietary supplements of CLA were first reported to dramatically decrease the fat content of growing and adult mice by Park et al. (1997). Although the magnitude of effects varies, subsequent research has corroborated the ability of CLA to reduce body fat in rodents (see reviews by Baumgard et al., 2000a; Jahreis et al., 2000) and adult humans (Blankson et al., 2000). However, CLA effects on lipid metabolism may be dependent upon other variables because
some studies have observed little or no effect of CLA on the body fat content of growing rats (Azain et al., 2000), growing bass (Twibell et al., 2000) and adult humans (Medina et al., 2000).

Based upon whole animal composition data, feeding CLA also reduces adipose accretion rates in finishing pigs (Ostrowska et al., 1999). In agreement, dietary CLA reduces fat content in commercial pork cuts (Dugan et al., 1997) and back fat thickness in finishing hogs (Swan et al., 2001; Thiel-Cooper et al., 2001; Wiegand et al., 2001). However, CLA was ineffective in decreasing back fat in finishing genetically lean pigs (Eggert et al., 2001) and younger growing pigs (Averette et al., 2001; Basswaganya-Riera et al., 2001; Ramsay et al., 2001).

Inconsistent effects on carcass composition between CLA studies may be due to differences in CLA isomer composition, differences in CLA dose, duration of CLA feeding, differences in genotype and physiological age (growing vs. finishing phase) at which CLA is fed.

Most CLA investigations of lipid metabolism in growing animals have used a commercial supplement containing a mixture of CLA isomers. As a consequence, it was not clear if the physiological effects are the result of one, all, or a combination of isomers. Similar to our investigations with lactating dairy cows, recent studies with growing mice demonstrated the reduced body fat content was due to trans-10, cis-12 CLA, whereas the cis-9, trans-11 CLA had no effect (Park et al., 1999).

Little or no research has been conducted looking at CLA ability to reduce body fat in beef cattle. As a consequence, many questions remain and include 1) is CLA effective in beef cattle, 2) if effective, at what dose, 3) at what stage of growth is CLA most effective, 4) are there effects on animal health and well being, 5) what are the effects on marbling, 6) what are the effects of CLA on ADG, feed intake and feed efficiency and 7) what are the effects on organoleptic qualities (i.e. taste, tenderness, pH, color etc…).

CLA and the IMMUNE SYSTEM

It has been estimated that economic losses in the USA due to immune induced cachexia symptoms are close to one-half billion dollars (Cook and Pariza, 1998). These symptoms include reduced weight gains and milk production due to disease and unsanitary living conditions and some traditional management practices including 1) vaccinations, 2) transportation or shipping fever, 3) castration, 4) weaning, 5) animal grouping and 6) dehorning.

The immune response is in large part mediated by cytokines, immune hormones synthesized and released by macrophages to stimulate lymphocyte proliferation. However, cytokines also reduce feed intake, stimulate muscle wasting (proteolysis) and reduced rates of weight gain or even cause a loss of
body weight (Klasing et al., 1987). These catabolic symptoms are usually grouped together and referred to as cachexia.

In mice, rats and chicks, dietary CLA alleviates or prevents the immune-induced weight loss and other symptoms of cachexia when experimentally immune challenged (Cook et al., 1993; Miller et al., 1994). Importantly, CLA does not impair or hinder the immune systems ability to fight infection. Ironically, there is evidence suggesting CLA actually enhances immune system effectiveness rodents and growing pigs (Bassaganya-Riera et al., 2001; Cook and Pariza, 1998).

Although work-to-date has been limited, the potential for dietary CLA to prevent growth depression due to immune stimulation in beef cattle and growing pigs is exciting. Much more research is needed in this area but economic potential to animal producers and animal well-being is encouraging.

References


