EFFECTS OF CONJUGATED LINOLEIC ACID ON MILK COMPOSITION AND BABY PIG GROWTH IN LACTATING SOWS


Summary
The lactating sow limits the growth potential of the neonatal pig by limiting the supply of nutrients and/or not providing the optimum balance of nutrients to maximize growth. Therefore, alterations in sow milk composition to provide an optimum pattern of nutrients could improve piglet weight gains. Fifty-five mixed parity lactating sows (Landrace x Chester White) were blocked by parity and randomly assigned to receive either a corn-soybean meal diet (control) or a diet with 1% CLA-60 (conjugated linoleic acid, ConLinCo Inc. Detroit Lakes, MN). Diets were formulated to meet the nutrient requirements of a high producing lactating sow (NRC, 1998) and sows were fed to appetite. The inclusion of CLA did not alter sow ADFI, ending litter weights (60.9±1.0 kg), litter size (10.5 ± .2 pigs/litter), sow weight, or backfat losses (P > .20). Milk samples from sows fed CLA had a lower percentage of total solids (P < .05) and fat (P < .05), but were not different in protein (P > .90) or ash content (P > .50). These results suggest that sow milk fat content can be reduced with the dietary addition of CLA, but this did not result in any differences in piglet growth rate or reduce the energy demands of lactation.

Introduction
Improvements through selection, management practices, and nutrition have resulted in steady improvements in postweaning growth performance, but growth rates have not been improved during the nursing phase. Performance during the nursing phase of growth is dependent on both the supply and pattern of nutrients secreted in milk, by the lactating sow (Boyd et al., 1995). Several studies have examined various means to increase the total supply of nutrients to nursing pigs by increases in milk yield, such as hormonal (Harkins et al., 1989), nutrition (Boyd et al., 2000), and nursing stimuli (Sauber et al., 1994). Pig growth rates observed from artificial rearing studies (Harrell et al., 1993) demonstrate the growth potential of neonatal pigs. Due to the poor handling properties of fat, manufactured liquid diets do not contain the high proportion of calories from fat as found in sow’s milk. This suggests that the pattern of nutrients secreted in sow’s milk is not adequate to realize maximum growth potential. This hypothesis is further substantiated in growth experiments (Auldist et al., 1997) conducted in baby pigs where weight gains were maximum when the lysine:energy ratio was greater than is present in sow’s milk. These data suggest that altering the composition of sow’s milk to increase the supply of amino acids relative to energy concentration could improve the growth performance of the baby pig. The objective of this study was to reduce sow milk fat content with dietary CLA and improve baby pig growth.

Materials and Methods
Fifty-five mixed parity sows (Landrace x Chester White) were farrowed and pigs were processed by standard practices. Sows were categorically blocked into three parity groups (parity 1, 2, and 3 and older) and then randomly assigned to receive either a standard corn-soybean meal diet
(Control, n = 28) or the treatment diet (CLA, n = 27) that contained 1% CLA-60 (conjugated linoleic acid, ConLinCo Inc. Detroit Lakes, MN). Diets (Table 1) were formulated to provide the same concentration of C18:2 and to meet the nutrient requirements of a high producing lactating sow (NRC, 1998). Dietary treatments were initiated at 5.1 ± .3 d post-farrowing and continued until weaning at 20.3 ± .5 d of lactation. Sows were initially offered 2.5 kg/day in 4 equal feedings (0700, 1000, 1600 and 2200) and the amount offered was increased by 1 kg/day until refusals occurred. Thereafter, sows were fed to appetite. Feed refusals were corrected for moisture content.

Milk samples were collected from a portion of the sows (n = 18 control, n = 17 CLA) on the day prior to the initiation of treatment, 7 days post treatment, and again at weaning. Milk samples were analyzed for proximate analysis (total solids, fat, crude protein, and ash) as described by AOAC (1997).

**Statistical Analysis.** Data were analyzed for differences by ANOVA using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). Data were evaluated for the effects of dietary treatment, sow parity, day of the study, and their interactions.

**Results and Discussion**

**Animal performance.** Litter size was not affected by sow parity (P > .80, data not presented) or by dietary treatment (P > .90, Table 1). Dietary CLA did not alter average pig weight (P > .80, data not presented) or litter weights (P > .90, Figure 1). Litter weights were heavier in parity 2 and parity 3 and older sows compared to parity 1 sows (P < .05, data not presented). Voluntary sow feed consumption (Figure 2) rose steadily through d 10 of lactation, declined from d 10 to 14, and then increased to previous levels for the remainder of the study (P < .01). First parity sows consumed less feed (P < .05) than either parity 2 or parity 3 and older sows (data not presented). The dietary inclusion of CLA did not alter (P > .80) sow feed intake (Figure 2). Parity 1 sows had lower bodyweights than parity 2 sows, who had lower bodyweights than parity 3 and older sows, both initially and at the end of the study (P < .01, data not presented). The amount of sow backfat was similar across parities, both initially and at the end of lactation (P > .80). Sow body weight and backfat changes (Table 1) were not affected by parity or CLA (P > .80).

**Table 1. Effect of dietary CLA on litter size and sow body reserves.**

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>CLA</th>
<th>Statistical Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Litter size</td>
<td>10.5 ± .2</td>
<td>10.5 ± .2</td>
<td>NS</td>
</tr>
<tr>
<td>Sow weight change, kg</td>
<td>-15.4 ± 2.3</td>
<td>-15.6 ± 2.5</td>
<td>NS</td>
</tr>
<tr>
<td>Sow backfat change, mm</td>
<td>-2.7 ± .4</td>
<td>-2.4 ± .4</td>
<td>NS</td>
</tr>
</tbody>
</table>

1Values represent the least square means ± SEM for sows fed either corn oil (Control, n = 28) or 1% CLA-60 (CLA, n = 27) from d 5 of lactation and continued through weaning at d 20 of lactation.

2Statistical significance examined differences for the effects of diet, time, parity, and the interactions. NS indicates no significant differences detected (P > .10), * indicates significant differences detected at P < .01 and ** denotes significant differences detected at P < .05.
Milk composition. Milk total solids and fat content (Table 2) were higher initially than on either day 12 or at the end of lactation ($P < .01$). Dietary CLA reduced total solids content and milk fat content ($P < .05$) and the magnitude of the reduction increased with time ($P < .01$). Total solids and fat content interacted with parity and time ($P < .01$), in that parity 3 and older sows had higher initial milk fat content and therefore, decreased milk fat content to a greater extent than either parity 1 or parity 2 sows as the stage of lactation progressed. Milk protein and ash content was higher initially, decreased by day 12 and then increased by the end of lactation, but did not attain the initial values ($P < .01$). CLA did not affect milk protein or ash content ($P > .50$).
Table 2. Effect of dietary CLA on sow milk composition.

<table>
<thead>
<tr>
<th>Item</th>
<th>Day</th>
<th>Control</th>
<th>CLA</th>
<th>Statistical Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Solids,%</td>
<td>5</td>
<td>19.8 ± .4</td>
<td>20.6 ± .4</td>
<td>Diet**, Time*, Parity x Time*,</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>17.2 ± .3</td>
<td>15.7 ± .3</td>
<td>Diet x Time*, Diet x Parity*</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>17.5 ± .3</td>
<td>15.7 ± .3</td>
<td></td>
</tr>
<tr>
<td>Fat, %</td>
<td>5</td>
<td>8.2 ± .3</td>
<td>9.1 ± .4</td>
<td>Diet*, Time**, Parity*</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>5.9 ± .3</td>
<td>4.7 ± .3</td>
<td>Parity x Time**, Diet x Time**</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>6.2 ± .3</td>
<td>4.0 ± .3</td>
<td></td>
</tr>
<tr>
<td>Protein, %</td>
<td>5</td>
<td>6.4 ± .2</td>
<td>6.1 ± .2</td>
<td>Time*</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>4.7 ± .2</td>
<td>4.8 ± .2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>5.0 ± .2</td>
<td>5.2 ± .2</td>
<td></td>
</tr>
<tr>
<td>Ash, %</td>
<td>5</td>
<td>.91 ± .01</td>
<td>.88 ± .02</td>
<td>Time*</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>.77 ± .01</td>
<td>.79 ± .01</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>.88 ± .01</td>
<td>.91 ± .01</td>
<td></td>
</tr>
</tbody>
</table>

1Values represent the least square means ± SEM for sows fed either corn oil (Control, n = 18) or 1% CLA-60 (CLA, n = 17), initially (d 5), 7 d post treatment (d 12) and then at the end of lactation (d 20).

2Statistical significance examined differences for the effects of diet, time, parity, and the interactions. * Indicates significant differences detected at $P < .01$ and ** denotes significant differences detected at $P < .05$.

The lactating sow limits the growth potential of the nursing litter by both limiting total milk production (Boyd et al., 1995) and also by the pattern of nutrients secreted in milk relative to the nutrient needs of the piglet (Auldist et al., 1997). Previous studies have examined the manipulation of sow milk composition through the supplementation of lactating sow diets with dietary fat to increase the milk fat content and therefore increasing the energy intake of piglets. Recent studies (Averette et al., 1999; Tilton et al., 1999; and van den Brand et al., 2000) that were conducted in lean genotype lactating sows fed high fat diets (> 10 %) resulted in increased milk fat content and piglet growth rates compared to sows fed a starch-based diet. However, Auldist et al. (1997) observed maximum growth rates of piglets when the diet supplied approximately 45% more lysine relative to energy than provided in sow’s milk.

The dietary inclusion of CLA reduced sow milk fat content by 36% (Table 2) and the reduction in fat content resulted in lower total solids, but did not alter milk protein or ash content (Table 2). The reduction in milk fat content to dietary CLA supplements has also been observed in other studies conducted in sows (Poulos et al., 2000), dairy cows (Chouinard et al., 1999) and humans (Masters et al., 1999). Sow milk fat content was also reduced by feeding trans-18:1 fatty acids (Petterson and Opstvedt, 1991). CLA also has biological affects in growing animals. CLA fed to growing pigs (Ostrowska et al., 1999) and rodents (West et al., 1998) have altered body composition. Ostrowska et al. (1999) demonstrated in pigs fed CLA that the alterations in body composition were confined only to decreased lipid accretion with no changes in muscle growth.

Milk fat depression is believed to occur by either a shortage of precursors for milk fat synthesis or by a direct inhibition of milk fat synthesis (Griinari et al., 1997). The specific mechanism of how CLA reduces milk fat content and total yield has not been clearly established. Dairy cows appear to have a greater reduction in milk fat content (50%, Chouinard et al., 1999) compared to the 36% reduction found in sows in the present study. These differences could be explained by differences in the response by species. but also the source of fatty acids utilized for milk fat
The reduction in milk fat content without altering protein content increased the supply of amino acids relative to energy content for the piglets. However, litter size, average piglet weight (data not presented), and litter weights (Figure 1) were not different in sows fed CLA. Feeding sows trans- 18:1 fatty acids reduced milk fat content, but did not alter piglet performance (Petterson and Opstvedt, 1991). However, the study did not attempt to alter animal performance and no information was provided regarding nutrient adequacy of the lactation diet. Feeding CLA to female rats (Chin et al., 1994) during gestation and lactation resulted in no differences in litter size or pup weight at birth, but by day 10 of lactation the mean pup weight was increased in animals that were fed .5% CLA. No differences in rat milk protein concentration were observed, but the effects on milk fat concentration were not reported. These data suggest that nutrients from the milk of lactating animals fed CLA was utilized more efficiently for neonatal growth; although the total yield of milk nutrients was not estimated in studies with rodents or swine.

Sow body reserves (sow weight and back fat losses, Table 1) and feed intake (Figure 2) were not altered by dietary CLA. No information is available on body reserves of dairy cows fed CLA, because of the short duration of the studies. However, reductions in total milk energy output without changes in ADFI should result in a more positive energy balance in cows receiving CLA (Chouinard et al., 1999), which is consistent with milk fat depressed cows gaining body weight. We would expect that the reduced energy costs of lactation would result in reductions in sow ADFI or in less catabolism of sow body reserves, of which neither was observed. These data suggest that for sows, the total energy costs of milk output were not altered by CLA.

Several explanations could account for the failure to increase litter growth rates through alterations in sow milk composition that more closely meets the nutrient profile of piglets. Although milk fat and presumably milk energy content was lower with dietary CLA; total milk nutrient output and thus supply of other nutrients (i.e. amino acids) was not increased enough to accommodate increased piglet growth rates. Auldist et al., (1997) estimated that 4.2 g lysine/Mcal GE was necessary to maximize piglet weight gains compared to control sows in the present study providing an estimated 3.6 g lysine/Mcal GE. The 36% reduction in milk fat content only increased the estimated supply of lysine/Mcal GE by approximately 6%. Therefore, the reductions in milk fat content may not have been adequate enough to improve litter performance. However, piglets could have utilized milk nutrients from sows fed CLA more efficiently by altering the composition of their weight gain.

Implications
Dietary CLA altered the pattern of milk nutrients more similar to that found to maximize piglet growth in artificial rearing studies, but did not result in greater piglet performance. Furthermore, sow feed intake or the catabolism of body reserves were not altered by CLA. This suggests that total sow milk output and therefore total nutrient supply to the piglets were not enhanced even though the energy costs of lactation should have been reduced. Although not efficacious in improving piglet growth, CLA could be beneficial in heat stress environments, because of the potential reductions in the energy costs of lactation.

References


[1] Pig Improvement Company, Franklin, KY