# Influences of Fatty Acid Supplementation on Reproduction of Grazing Beef Cows

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## Introduction

Interest in the area of supplementing fatty acids to the grazing beef cow has increased since researchers began reporting improvements in reproductive processes of cows fed supplemental lipids. Lipid supplements have been touted as a nutraceuticals (Williams and Stanko, 2000) acting to influence a variety of physiological processes (Hess et al., 2005; 2008). Provision of supplemental lipid to the grazing beef cow, however, must be limited in order to avoid negative effects imposed by high amounts of dietary fat (Palmquist, 1994; Hess et al., 2008). The objective of this paper is to discuss provision of supplemental fat and reproductive responses by beef cows consuming lipid supplements.

## Supplementation Considerations

Supplementing the grazing beef cow's diet with lipid increases the energy density of the animal's diet because fatty acids yield more energy than other organic nutrients metabolized by the animal. Energy values reported in the NRC (1982) are at least 2 times greater for lipid feedstuffs than cereal grains. From a scientific viewpoint, it is difficult to attribute responses to supplemental lipids unless a control group of cattle is fed a low-fat supplement balanced to maintain plane of nutrition at a level comparable to that of cattle fed a lipid supplement. Thus, researchers often formulate lipid supplements to deliver the same quantity of energy as control treatments to avoid confounding experimental outcomes associated with changing the animal's nutritional status (DelCurto et al., 2000; Hess et al., 2008).

Feeding programs designed to supplement the grazing beef cow's diet with fatty acids should be developed with the goal of improving sustainability of the production system. It is important to ensure that utilization of other dietary components is not affected greatly when lipid supplements are included in the diet. Total amount of energy available to the animal is one criterion used to determine the optimal level of supplemental lipid that can be included in the grazing beef cow's diet. The two most important factors to consider in this regard are diet digestibility and intake because these two items combined represent digestible energy intake. Collective results summarized in a review by Hess et al. (2008) indicated that supplemental lipid should be 3% of diet dry matter or less if the goal is to maximize use of forage-based diets.

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Substitution of forage consumption with intake of supplemental lipid occurred with lipid additions greater than 2% of diet dry matter and digestible energy did not increase if supplemental lipid exceeded 4% of dry matter intake.

Forage intake was not affected by feeding supplemental fat at 1.5 to 1.74% of diet dry matter (Brokaw et al., 2000; 2001). Supplementing corn oil to steers grazing fescue pasture at 2 to 3 times those dietary levels, however, decreased forage intake and total digestibility energy intake, and reduced total intake reflected forage dry matter substitution rates greater than 1 (Pavan et al., 2007). A similar higher level of dietary fat from supplementing dried distillers grains resulted in a forage substitution rate of 0.5 for heifers grazing bromegrass pastures (MacDonald et al., 2007). However, providing a comparable level of fat as dried distillers grains by supplementing corn oil did not affect forage intake. Digestible energy for diets with supplemental fat may be comparable or greater than the cereal-based supplements if one accounts for greater energy value of fatty acids disappearing from the small intestine (Scholljegerdes et al., 2004). Additionally, deleterious effects of supplementary lipid on utilization dietary forage may be avoided by rendering the supplemental fat inert in the rumen (Hightshoe et al., 1991a).

## Fatty Acid Supply

Quantifying fatty acids actually reaching the duodenum for absorption is critical for determining fatty acid status of the animal (Merchen et al., 1997) because dietary lipids transformed in the rumen (60%) and lipids synthesized by ruminal microorganisms (35%) constitute 95% of total lipids reaching the duodenum (Jenkins, 1994). Dietary lipids are modified extensively as they undergo biohydrogenation in the rumen. Complete biohydrogenation of dietary fat resulted in a substantial increase in duodenal flow of stearic acid (Hess et al., 2008). Cattle consuming supplemental fat also experience an increase in flow of unsaturated fatty acids to the duodenum because biohydrogenation in the rumen does not always go to completion. Even with ruminal biohydrogenation of linoleic acid equivalent to 92.8%, Scholljegerdes et al. (2004) noted that cattle fed grass hay plus high-linoleate safflower seeds had nearly 3 times more linoleic acid flowing to the duodenum than cattle fed a corn-based control supplement. Likewise, duodenal flow of eicosapentaenoic acid was approximately 11% of eicosapentaenoic acid intake and docosahexaenoic acid was not detected in duodenal digesta of cattle fed restricted amounts of forage and a fishmeal-based supplement (Hess et al., 2007). This latter response may explain why Burns et al. (2003) did not detect an increase in endometrial content of docosahexaenoic acid in beef cows fed fishmeal. Nevertheless, the potential to manipulate fatty acids available to the animal is possible despite extensive ruminal biohydrogenation of dietary fatty acids.

## Nutritional Manipulation to Influence Reproduction

Dietary manipulations designed to enhance reproduction of beef cows have often focused on the net effect of increased energy status. Ovarian follicular growth was stimulated by adding lipid to the diet to improve cow energy balance (Lucy et al., 1992).

Moreover, increasing the range beef cow's energy status by supplementing lipid resulted in more cows exhibiting estrus at 30 to 90 days postpartum and more cows pregnant during the first 95 days of the breeding season (Espinoza et al., 1995). However, Lucy et al. (1992) noted that the benefits of dietary lipid may not be totally attributable to caloric value because lipid containing diets were formulated to deliver the same quantity of energy as control treatments in several other studies. For example, increased plasma cholesterol in beef cows fed calcium salts of palm oil (Megalac®) versus an isocaloric control supplement was accompanied by decreased serum estradiol, enhanced follicle growth, increased lutenizing hormone, and by a greater concentration of progesterone during the luteal phase of the first postpartum estrous cycle (Hightshoe et al., 1991b). In another study, Thomas et al. (1997) demonstrated that consumption of soybean oil stimulated a greater rate of ovarian follicular growth in beef cows than an isocaloric control, tallow, or fish oil supplements. Subsequent reviews (Staples et al., 1998; Williams and Stanko, 2000) have attributed many positive reproductive responses to the high linoleic acid content of the supplementary lipids. In a summary of data from the two studies in which high-linoleate safflower seeds were fed to primiparous beef cows 53 or 55 d prepartum (Lammoglia et al., 1999a,b), Bellows (1999) noted that the proportion of pregnancy increased from 56% for the 89 control cows to 70% for 179 cows fed supplemental lipid. Thus, manipulating the cow's diet to increase the amount of linoleic acid available for metabolism seemed to impart physiological responses that were separate than the energy value of supplemental lipid.

## Enhancing Linoleic Acid Status to Influence Reproduction of Beef Cows

Because linoleic acid was touted as the causative agent for many of the aforementioned beneficial responses, and we had noted increased linoleic acid in plasma of reproducing beef cattle fed supplemental lipids (Whitney et al., 2000; Alexander et al., 2002), a series of studies was conducted to investigate the influence of supplementing fat high in linoleic acid on reproductive responses in beef cows. Extensive details of our experimental results were described in a previous review (Hess et al., 2005). It was concluded that supplementing cracked high-linoleate safflower seeds decreased first service pregnancy per AI (Hess, 2003) because fewer cows had functional corpus luteum (Scholljegerdes et al., 2009), which may be the related to an increase in prostaglandin $F_{2\alpha}$ (**$PGF_{2\alpha}$**; Grant et al., 2005) or perturbations in the insulin-like growth factor-I (**IGF-I)** system (Scholljegerdes et al., 2009). Subsequent $\chi^2$ analysis of data from experiments in which young beef cows were fed cracked high-linoleate safflower seeds during early lactation revealed that the proportion pregnant was reduced ($P$ = 0.06) from 93.6% for cows (n = 47) fed control diets to 80.4% for cows (n = 45) fed high-linoleate safflower seeds. Using ruminal biohydrogenation values reported by Scholljegerdes et al. (2004), Hess et al. (2008) suggested that increasing intestinal supply of linoleic acid by 16 to 18 g/d during the first 60 to 90 days postpartum exerted deleterious effects on reproduction. Scholljegerdes et al. (2007) reported that primiparous cows fed high-linoleate safflower seeds for the first 33 d postpartum displayed increased concentrations of linoleic acid in the oviduct but not in other uterine tissues. A trend for greater concentrations of linolenic acid in plasma was consistent with greater concentrations of linolenic acid in endometrial tissues of cows fed high-linoleate safflower seeds. Despite an increase in plasma concentration of eicosapentaenoic acid for cows fed high-linoleate safflower seeds, concentration of eicosapentaenoic acid in uterine tissues was not affected by diet. Intercaruncular concentration of eicosapentaenoic acid was negatively correlated with serum concentrations of $PGF_{2\alpha}$ metabolite on d 33 postpartum. Hess et al. (2008) speculated that desaturation and elongation of linolenic acid to eicosapentaenoic acid in uterine tissues was greater cows fed control, resulting in reduced $PGF_{2\alpha}$ synthesis in bovine endometrium (Burns et al., 2003).

Recent observations from experiments conducted with calcium salts rich in linoleic acid (Megalac E®) are not consistent with observations described above. For example, Lopes et al. (2007) noted that pregnancy to timed AI increased from 45.6% to 56.5% if Nellore cows were fed 100 grams of Megalac E from the beginning of estrous synchronization through 30 days after breeding. Based on personal communications with representatives from ARM & HAMMER® Animal Nutrition, intestinal supply of linoleic acid was increased approximately 35 grams/day for cows fed Megalac E. It is hypothesized that the discrepancy between our previous observations and those reported by Lopes et al. (2007) is attributable to cows fed Megalac E having twice as much linoleic acid available at the small intestine as cows fed high-linoleate safflower seeds.

The experiment described by Moriel et al. (2009) was designed to test the abovementioned hypothesis. Primiparous (n = 45) and multiparous (n = 57) lactating beef cows (initial BW = 519) were synchronized (CO-Synch protocol) with an intravaginal progesterone device + i.m. injection of 100 µg of GnRH on day 0. At this time cows were randomly assigned to one of two dietary treatments (each age group served as a block): Control groups were hand-fed a beet pulp-based supplement at 1.77 $kg \cdot cow^{-1} \cdot d^{-1}$ whereas fat-supplemented cows were offered a beet pulp-based hand-fed supplement containing rumen-inert fat (1.36 kg/d), formulated to deliver Megalac-R® at 250 $g \cdot cow^{-1} \cdot d^{-1}$ (estimated to provide between 34 to 41 g/d of linoleic acid). Supplements were formulated to provide equal quantities of protein and energy. Cows had free access to bromegrass hay (% of DM: 66.5% NDF, 43.9% ADF, 0.97% N, 50.0% in vitro dry matter digestibility) throughout the synchronizing period (day 0 until the day of insemination). On day 7 of the synchronization, the intravaginal progesterone device was removed and 25 mg of $PGF_{2\alpha}$ was administered i.m. Sixty six hours later a 100 µg i.m. injection of GnRH was administrated, cows were inseminated and transported to native pasture (% of DM: 53.8% NDF, 30.1% ADF, 2% N, 59.0% in vitro dry matter digestibility) where they remained on their respective dietary treatments for 30 days. Blood samples were obtained 30 days after breeding for pregnancy diagnosis. Data were analyzed as randomized complete block design. Body weight gain did not differ (P = 0.54) between treatments. First AI pregnancy was not affected (P = 0.84) by dietary treatments, with Control cows having 50.9% pregnant and cows fed supplemental lipid having 47.2% pregnant.

Provision of supplemental lipid to increase intestinal supply of linoleic acid notwithstanding, $\chi^2$ analysis of 324 individual observations from literature reports using

170 beef cows fed lipid revealed an equivocal effect on pregnancy rates (Hess et al., 2005). This result was reaffirmed by Martin et al. (2005) who reported that pregnancy rate was not affected by feeding whole corn germ to cows for approximately 45 d postpartum. Therefore, unless cow energy balance is improved, lipid supplementation during the postpartum should not be recommended as a nutritional strategy to improve pregnancy rates of beef cows. Lipid supplementation should only be utilized if cost-effective lipid sources are available (Funston, 2004).

## Conclusions

Supplementing fat to reproducing beef females can be an effective strategy to increase energy density of the animal's diet. Optimal levels of fat in the diet depend on goals set for the production unit. Limiting supplemental fat to 2% of dietary dry matter will help prevent negative associative effects for grazing beef cows. However, deleterious effects on forage utilization often noted with supplementary lipid may be avoided by rendering the supplemental fat inert in the rumen. Energy density of the grazing cow's diet is not expected to increase if supplemental lipid exceeds 4% of dry matter. Extensive ruminal biohydrogenation of dietary 18-carbon unsaturated fatty acids does not preclude the ability to alter unsaturated fatty acid status of ruminants fed fat supplements. Effects on reproductive processes in beef cattle fed fat have been attributed to changes in unsaturated fatty acid status rather than energy per se. Although a variety of positive physiological responses are induced when supplemental lipid is used as an isocaloric replacement for another source of supplemental energy, cow pregnancy rate will not be improved when the dietary replacement occurs during the postpartum period. Thus, supplementing the postparturm beef cow's diet with lipid should only practiced if the supplement is more cost-effective than other sources of supplemental energy.

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# SESSION NOTES