# Effect of Dietary fat on Reproduction in Cattle

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**Abstract**

Feeding supplemental fat to dairy cows no longer has energy density as a primary consideration in the ration. Essential fatty acids, notably linoleic (omega-6) and linolenic (omega-3) acids have direct effects on physiological processes such as cellular membrane integrity, hormonal pathways, and immune function. Clearly, they are important to uterine health, and that is accompanied by earlier ovulations PP and more cycles during the voluntary waiting period. decline in fertility and there is increasing evidence to assume that reduced oocyte and embryo quality are two major players in this "disappointing fertility syndrome" nutrition has the potency to alter the micro-environment of the oocyte and the embryo, making it more hostile to optimal fertilization and pre implantation embryonic growth .Data reviewed shows that supplementation with different sources of lipids and fatty acids improve reproductive performance of the female ruminant. However, it is important to consider that the optimum response will be achieved when under nutrition status of the female is not extremely severed. A nutrient balance (protein: energy) in the ration consumed by the animal is fundamental to obtain maximum benefit from supplementation with fat, The feeding of additional energy in the form of fat reduces the cow's negative energy status so that she returns to oestrus earlier after calving and therefore conceives sooner.

Cows fed fat produce or secrete more progesterone, a hormone necessary for the implantation and nutrition of the newly formed embryo. Specific individual long chain fatty acids found in some fats inhibit the production or release of prostaglandin by the uterus. This prevents the regression of the corpus luteum (CL) on the ovary so that the newly formed embryo survives. Based on the experiments done at this time, it appears that dietary fats may increase the size and the life span of the CL. The larger size of the dominant follicle in fat-supplemented cows may result in a larger CL. More CL cells produce more progesterone. Greater progesterone should improve implantation and nutrition of the embryo. In addition, certain fatty acids such as linoleic acid and those found in fish may partially suppress secretion of Prostaglandin by the uterus at the time of conception so that the CL is not regressed and embryo survival is potentially enhanced.

**Keywords:** Essential fatty acid; Fertility; Nutrient-balance; Embryonic growth; Oestrous; Micro-environment.

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## Introduction

Nutrition has an important impact on the reproductive performance of cattle. Energy is the major nutrient required by adult cattle and inadequate energy intake has a detrimental impact on reproductive activity of the female bovine. Cows under negative energy balance have extended periods of an ovulation. Postpartum anoestrus, as well as infertility, is magnified by losses of body condition during the early postpartum period. Resumption of ovulatory cycles is associated with energy balance, and the underlying mechanisms seem to be associated with metabolic signals and regulatory hormones primarily insulin and insulin-like growth factor-1(IGF-1), which link nutritional status with gonadotropin secretion, re-coupling of the growth hormone-IGF system, and follicle maturation and ovulation.

Feeding diets that promote increases in plasma glucose and insulin may improve the metabolic and endocrine status of cows in early lactation. Nevertheless, feeding excess of starch to promote increase in insulin and glucose might suppress intake of early lactating dairy cows, thereby pre including benefits to cyclicity. Feeding behaviour of dairy cows during the transition period, particularly a decline in feed intake before calving is associated with risk of postpartum uterine disease. Because metritis and more chronic forms of uterine diseases have profound negative effects on pregnancy in dairy cows, providing adequate bulk space and an environment to maximize feed intake might potentially improve fertility of dairy cows. Specific nutrients and dietary ingredients have been implicated on reproduction in cattle.

Addition of moderate amounts of supplemental fat to the diet improves energy intake, modulates PGF2□$\alpha$ secretion by the uterus, affects ovarian dynamics, enhances luteal function and embryo quality, and has moderate positive effects on fertility. More specifically, some fatty acids (FA) might impact fertilization rate and embryo quality in dairy cows. Early research confirmed that nutrition played an important role in reproduction. This fact sheet presents some of the available research information relating nutrition to reproduction in dairy cows and it provides a basis from which to evaluate potential contribution of nutritional factors to impaired reproductive performance in field situation. However, two facts about the relationship between nutrition and reproduction must be kept in mind Nutrition is only one possible cause of reproductive problems. Other possibilities should not be neglected. Some, like poor oestrous detection and poor sanitation and hygiene at calving, should be ruled out before looking for a nutritional cause for breeding problems in herds where obvious nutritional problems are not apparent.

Relatively little information is known regarding to the complex interaction between nutrition and reproduction. Often the best recommendation that can be made is to feed a ration that is balanced for energy estimate of feed intakes are required. Metabolic hormone secretion documented effects of supplemental lipids on metabolic hormones have been mixed. The consumption of polyunsaturated plant oils has been shown to increase serum insulin and GH concentrations in both dairy and beef cows However, it is reported [1]that no differences in serum concentrations of glucose, NEFA, GH, IGF-I, insulin, or IGF-I binding proteins in primiparous beef heifers supplemented with high linoleic or high oleic safflower seeds. Bellows *et al* (2001) also found no differences in concentrations of IGF-I, glucose, or NEFA after feeding primiparous beef heifers sunflower seeds for 68 day before calving compared to a control diet without added fat.[1] It was also reported that plasma NEFA is nearly always elevated in cows fed supplemental fat and blood glucose concentrations generally are not changed under conditions of supplemental fat.

### *What are dietary fat*

Fats consist of a wide group of compounds that are generally soluble in organic solvents and generally insoluble in water. Fats are triglycerides, triesters of glycerol and any of several fatty acids. Fats may be either solid or liquid at room temperature, depending on their structure and composition. Although the words "oils", "fats", and "lipids" are all used to refer to fats."Lipids" is used to refer to both liquid and solid fats, along with other related substances,

*Types of fat*

Saturated and unsaturated are the types of fat. Unsaturated fats are sub-classified into the monounsaturated and polyunsaturated fat, polyunsaturated fat mostly found in nuts, seeds, fish, algae, leafy greens, Whole food sources are always best, as processing and heating may damage polyunsaturated fat.

*Reproductive problems associated with dietary fat*

Under nutrition inhibits oestrous behaviour by reducing responsiveness of the central nervous system to estradiol by reducing the estrogens receptor$\alpha$ content in brain ( Hileman *et al*, 1999). Cows with low BCS at 65 d postpartum are more likely to be anovular. (Santos *et al*, 2008) Prolonged postpartum anovulation or anoestrus extend the period from calving to first AI and reduces fertility during the first postpartum service.

*Nutrition in fertility and Postpartum uterine health*

*Nutritional factor*

Over conditioning at the time of calving has been related to a higher incidence of infections in some studies, since over conditioned cows may exhibit poor uterine muscle tone, fatigue earlier during the calving process, and experience a higher incidence of difficult births. On the other hand, severely under conditioned cows appear to be more susceptible to infection than cows in proper condition. Monitor body condition in late lactation so that cattle calve with body condition scores between 3+ to 4- on a scale of 1 to 5. Calcium is important for proper uterine smooth muscle contraction. Low levels of blood calcium may contribute to retained placenta resulting in uterine infection. Low calcium may also delay uterine involution maintenance of healthy uterine tissue. Other nutritional factors may be indirectly related to maintaining uterine health, so feeding a balanced dry cow ration is critical. Adequate tissue levels of proper vitamins and minerals must be present prior to calving and throughout the postpartum period.

*Postpartum uterine health*

Before parturition the uterine lumen is sterile and if bacterial invasion occurs, there is usually resorption of the foetus or abortion.During parturition, the physical barriers of the cervix, vagina and vulva are compromised providing the sum for bacteria to ascend the genital tract from the environment as well as the animal's skin and faeces. Indeed, bacterial contamination of the uterine lumen is almost ubiquitous in cattle and notably greater than in other mammals including ruminants such as sheep. The reasons for the species differences are not clear, as sheep and cattle inhabit similar environments and the progress of uterine involution is similar . Surprisingly, the level of hygiene of the environment during and immediately after parturition appears to have little effect on the qualitative or quantitative uterine bacterial flora.[2]Percent animals with uterine bacteria Day postpartum.Proportion of uteri contaminated with bacteria during the first 60 days postpartum drawn from the data.[2] However, the functional capacity of neutrophils is reduced after parturition in many cattle and this may predispose to the establishment of uterine disease. Later, macrophages are likely to be important in the uterine immune response. In addition, an early ovulation and formation of a corpus luteum after calving (<19 days versus >3days) increased the risk for prolonged luteal cycles before service in dairy cattle.Metritis is a severe inflammatory condition to postpartum period.

*Effect of uterine health on fertility*

Infection causes damage to the uterine tissues and features of endometrial damage such as increased inflammation in the stratum compactum are associated with poor reproductive performance.[1] Endometritis causes infertility at the time the uterine infection is present and sub fertility even after successful resolution of the disease. In typical studies the conception rate is about 20% lower for cows with endometritis, the median calving to conception interval 30 days longer and there are 3% more animals culled for failure to conceive (Borsberry and Dobson, 1989; LeBlanc *et al*, 2002). Furthermore, cows with a purulent cervical discharge have lower submission rates (McDougall, 2001). As well as the effects on fertility, uterine infection is associated with lower milk yields particularly if associated with retained placenta.

*Nutritional manipulation to increase energy intake strategy to increase energy intake*

The extent and duration of postpartum negative energy balance is influenced by genetic potentiality for milk production, dietary energy density and dry matter intake. Nutritional management strategies can be employed to minimize the extent and duration of negative energy balance. In view of the fact that dry matter intake during the early lactation period goes down, increasing energy density of the ration is the only available option to improve energy intake, which can be achieved through supplementation of grains or fat. Diets containing high levels of grain may cause metabolic disturbances, such as rumen acidosis, and may ultimately result in low milk and milk fat production. To avoid these problems, fat can be added to increase the energy density of the diet. Fat supplementation also has other potential benefits, such as increased absorption of fat-soluble nutrients and reduced dustiness of feed. In addition, feeding fat to dairy cows generally improves fertility.

*Dietary supplementation of fat*

Vegetable oils as such are not recommended for ruminants because the unsaturated fatty acids are toxic to rumen bacteria, especially to fibre degrading bacteria. Unsaturated fat supplementation reduces fibre digestion, thereby defeating the major objective of increasing the availability of energy. Therefore, the supplementation of fat for dairy cows is achieved by means of bypass fats, which pass the rumen without any degradation. Rumen bypass fats can be either rumen-protected or rumen-stable fats. These are inert in the rumen and are digested in the lower GI tract; hence they are not harmful to rumen bacteria.

*Rumen-stable and rumen-protected fats*

The protected fats are mostly either calcium salts of long-chain fatty acids or saturated fats. Protection does not mean stability; usually protection depends on the conditions of the rumen and its $p^H$. Rumen-protected calcium-soap or calcium salts of long-chain fatty acids were developed to improve milk production. Being a chemical reaction product, they have many disadvantages. Because of the pungent soap taste, there is usually poor acceptance of the feed. A further disadvantage is that larger amounts of feed concentrate, low $p^H$ values in feed and in the rumen, impair the stability of calcium soaps resulting in the release of the unsaturated fatty acids. These unsaturated fatty acids may negatively influence milk fat formation and may also disturb ruminal digestion, as described earlier. Recent development in fat supplementation for dairy cows is rumen-stable fats, which are fractionated triglycerides, rich in saturated fatty acids, mainly palmitic acid. Rumen-stable fats are stable at various $p^H$ conditions. Their fatty acids are largely saturated so that they pass through the rumen almost unchanged. As a result, the fats reach the small intestine where they are broken down by enzymes and, subsequently, utilised by the body as an efficient source of energy. Animals, during the 2 week period before calving for cows that went on to develop puerperal metritis, and Quimby *et al* (2001), with feedlot steers, indicated that reduced feeding behavior can be used to detect animal morbidity approximately 4.1 days earlier than identification by pen riders. This work provides clear evidence that reduced feeding time and DMI during the period before calving increases the risk of cows being diagnosed with metritis after calving. However, whether a reduction in intake and feeding time before calving is a cause of metritis, or an effect of something else going on during the prepartum period, is not known. Cows that developed postpartum metritis also engaged in fewer aggressive interactions at the feed bunk during the week prior to calving and avoided the feed bunk during period when competition for feed was highest. Nutritional efforts to minimize the extent and duration of NEB may improve reproductive performance. The first and most important factor that affects energy intake in dairy cows is feed availability.[3] Therefore, dairy cows should have continual access to a high quality, palatable diet to assure maximum DMI. However, DMI is limited during late gestation and early lactation, which can compromise total energy intake and reproductive performance. Several nutritional management strategies have been proposed to increase energy intake during early lactation. Feeding high quality forages, increasing the concentrate: forage ratio, or adding supplemental fat to diets are some of the most common ways to improve energy intake in cows.

A number of studies have demonstrated the importance of insulin as a signal mediating the effects of acute changes in nutrient intake on reproductive parameters in dairy cattle. In early postpartum dairy cattle under NEB, reduced expression of hepatic growth hormone receptor 1A (GHR-1A) is thought to be responsible for the lower concentrations of IGF-I in plasma of cows . Because IGF-I is an important hormonal signal that influences reproductive events such as stimulation of cell mitogenesis, hormonal production, and embryo development, among other functions; increasing concentrations of IGF-I early postpartum are important for early resumption of cyclicity and establishment of pregnancy. It is interesting to note that insulin mediates the expression of GHR-1A in dairy cows[4] which results in increased concentrations of IGF-I in plasma. Because IGF-I and insulin are important for reproduction in cattle, feeding diets that promote greater insulin concentrations should benefit fertility.

*Resumption of postpartum cyclicity*

The onset of lactation creates an enormous drain of nutrients in high producing dairy cows; which, in many cases, antagonizes the resumption of ovulatory cycles. During early postpartum, reproduction is deferred in favour of individual survival. Therefore, in the case of the dairy cow, lactation becomes a priority to the detriment of reproductive functions. During periods of energy restriction, oxidizable fuels consumed in the diet are prioritized toward essential processes such as cell maintenance, circulation, and neural activity . Homeorhetic controls in early lactation assure that body tissue, primarily adipose stores, will be mobilized in support of milk production. Therefore, the early lactation dairy cow that is unable to consume enough energy-yielding nutrients to meet the needs of production and maintenance, will sustain high yields of milk and milk components at the expense of body tissues. This poses a problem to reproduction, as delayed ovulation has been linked repeatedly with energy status.[4] Energy deprivation reduces the frequency of pulses of luteinizing hormone (LH); thereby impairing follicle maturation and ovulation. Furthermore, under nutrition inhibits oestrous behaviour by reducing responsiveness of the central nervous system to estradiol by reducing the estrogens receptor $\alpha$ content in the brain. Generally, the first postpartum ovulation in dairy cattle occurs 10 to 14 d after the NEB.[4]

Severe weight and BCS losses caused by inadequate feeding or illnesses are associated with anovulation and anoestrus in dairy cattle. In fact, cows with low BCS at 65 d postpartum are more likely to be anovular which compromises reproductive performance at first postpartum insemination. Prolonged postpartum anovulation or anoestrus extends the period from calving to first AI and reduces fertility during the first postpartum service. In fact, anovular cows not only have reduced oestrous detection and conception rates, but also have compromised embryo survival . On the other hand, an early return to cyclicity is important in reared to early conception. The timing of the first postpartum ovulation determines and limits the number of oestrous cycles occurring prior to the beginning of the insemination period. Typically, in most dairy herds, fewer than 20 % of cows should be anovulatory by 60 d postpartum. Oestrous expression, conception rate, and embryo survival improved when cows were cycling prior to an oestrous synchronization program for first postpartum insemination. Resumption of ovarian activity in high producing dairy cows is determined by energy status of the animal. Therefore, feeding management that minimizes loss of body condition during the early postpartum period and incidence of metabolic disorders during early lactation should increase the number of cows experiencing a first ovulation during the first 4 to 6 wk postpartum.

*Fat and its importance in reproduction*

Fat to dairy cattle usually improved the risk for pregnancy, although responses have not been consistent . When fat feeding improved production and increased body weight loss, primiparous cows experienced reduced pregnancy risk at first AI; although pregnancy to AI was extremely high in the unsuplemented cows. However, Ferguson *et al* (1990) observed a 2.2 fold increased risk of pregnancy at first AI and all AI in lactating cows fed 0.5 kg/d of fat, which tended (P = 0.08) to enhance the proportion of pregnant cows at the end of the study (93 vs. 86.2 %).[5] In grazing cows, supplementation with 0.35 kg of FA improved the risk of pregnancy after the first postpartum AI; although a similar proportion of cows were pregnant at the end of the study.[6] Feeding calcium salts of long chain fatty acids (Ca-LCFA) of palm oil improved pregnancy of dairy cows , although the authors did not report statistical significance. On the other hand, others did not observe improvements in fertility of dairy cows supplemented with Ca-LCFA or oilseeds ; which might be attributed to increased milk yield and body weight losses. Because the benefits of feeding fat may originate specific FA , others have evaluated whether feeding FA differing in the degree of saturation might influence fertility of cows. The essential FA of the n-6 and n-3 families are available in much smaller supply to ruminants than non ruminants because of microbial bio-hydrogenation of FA in the rumen [7]suggesting that their supplementation may benefit reproduction.

Three recent studies explored the role of n-6 and n-3 FA supplementation to lactating dairy cows on risk of pregnancy after the first postpartum AI; When cows were fed 0.75 kg of fat from flaxseed, a source rich in C18:3 n-3, or sunflower seed, a source rich in C18:2 n-6; pregnancy tended (P = 0.07) to be greater for cows fed n-3 FA. However, a similar response was not observed by others when cows were fed flaxseed as the source of n-3 FA. Similarly, feeding n-3 FA from fish oil as Ca-LCFA did not improve risk of pregnancy in high producing, lactating dairy cows when compared with a source rich in saturated FA [7] or with Ca-LCFA of palm oil evaluated the effect of feeding cows pre- and postpartum Ca-LCFA of either mostly saturated and monounsaturated FA or a blend of C18:2 n-6 and trans-octadecenoic FA. He observed that cows fed unsaturated FA had 1.5 times greater risk of pregnancy either at 27 or 41 d after AI compared with cows fed mostly saturated FA.

Improvements in pregnancy risk when cows were fed C18:2 n-6 and trans-octadecenoic FA were supported by improved fertilization and embryo quality in non-superovulated lactating dairy cows.[8]Because n-3 FA can suppress uterine secretion of PGF2$\alpha$,[9,10] it is thought that they have the potential to improve embryonic survival in cattle.[9] In 3 of 5 experiments, feeding n-3 FA either as flaxseed rich in C18:3 n-3 or fish oil rich in eicosapentanoic acid (EPA) and docosahexanoic acid (DHA) reduced pregnancy losses in lactating dairy cows after the first postpartum AI. On the other hand, when n-6 FA were fed as Ca-LCFA, pregnancy losses were similar to those observed for cows fed Ca-LCFA of palm oil . Collectively, these data suggest that feeding fat to dairy cows generally improves fertility and responses are observed when the energy density of the ration increased with fat feeding. Also, these data suggest that fertility responses to fat feeding are altered according to the type of FA supplemented in the diet. Feeding n-3 FA from oilseeds has improved pregnancy risk in some, but not all studies; however feeding n-3 FA as Ca-LCFA containing fish oils does not seem to influence risk of pregnancy. On the other hand, feeding Ca-LCFA rich in n-6 and transoctadecenoic FA improved pregnancy in lactating dairy cows. Although feeding n-3 FA has not consistently improved pregnancy risk, it has reduced pregnancy losses in dairy cows.

*Action of EFA*

Polyunsaturated fatty acids (PUFA) are precursors to cholesterol, which is an antecedent to steroid hormones. The corpus luteum (CL) uses cholesterol to make progesterone (P4), and P4 is itself a precursor to estradiol (E), but it is also an inhibitor of Estrogens secretion. Linoleic acid (along with its elongated product, eicosapentanoic acid) is a proven inhibitor of cyclooxygenase in endometrial tissues (Haag, 2001). Consequently, endometrial secretion of the prostaglandin (PG) PGF2$\alpha$ from the uterus can be suppressed. This action might also be aided by the effect fat has in repressing E17$\beta$ secretion ; thereby reducing PGF2$\alpha$ secretion and decreasing the sensitivity of the CL to PGF2$\alpha$. This helps prolong the life and functionality of the CL and allows it to increase P4 concentrations. Higher pre-breeding concentrations of P4 have a positive impact on conception rates, discussed subsequently

*Cholesterol-progesterone concentrations*

Dietary fat supplementation increases circulating concentrations of cholesterol and progesterone and the lifespan of induced corpora lutea (**CL**) in cattle. Cholesterol serves as a precursor for the synthesis of progesterone by ovarian luteal cells. Progesterone prepares the uterus for implantation of the embryo and also helps maintain pregnancy. Increased concentrations of plasma progesterone have been associated with improved conception rates of lactating ruminants.Increased concentrations of cholesterol from fat supplementation may lead to an increase in progesterone synthesis or reduced rate of clearance from the blood [11], primary follicles exposed to adverse conditions associated with the metabolically challenging period of NEB early postpartum may be less capable of producing adequate amounts of estrogens and progesterone (after ovulation). Moreover, such follicles would be doomed to contain an inferior oocyte, which will then ovulate approximately 60-80 days postpartum. Early embryonic death is a major cause of reproductive failure in dairy cows. There are four major factors impinging on embryo quality in the specific case of high producing dairy cows: gamete quality, corpus luteum quality combined with the circulating progesterone concentration, uterine involution, and nutrition. However, only those that are related to NEB

*LH secretion and Follicular development*

Secretion of LH from the pituitary and follicular growth in cattle are regulated partially by the energy status of the animal. Energy provided by fat supplementation increases LH secretion in animals deficient in energy. A mechanism independent from energy by which dietary fatty acids affect LH secretion has not been established.[9] In some studies, LH dynamics were stimulated by fat supplementation but were unchanged or decreased in others . The mechanism by which supplemental fat would stimulate LH release is not known unless a glucose-sparing effect occurs at the mammary gland, providing greater glucose to signal the hypothalamic-pituitary control system to secrete more LH. Similarly, fat supplementation may increase glucose production through increased propionate production. This increase in glucose may have a positive effect on LH release.

Supplemental fat stimulated programmed growth of a preovulatory follicle, increased total number of follicles, and increased the size of preovulatory follicles.[9] Increased size of preovulatory follicles may be due in part to increased concentrations of plasma LH, which stimulates the latter stage of follicular growth. The ovulation of larger follicles may result in the formation of larger corpora lutea with increased steroidogenic capacity and result in greater progesterone production, which has been associated with higher conception rates.

*Prostaglandin synthesis*

Prostaglandins play an important role in restablishing oestrous cycles both immediately after parturition and thereafter, until conception occurs. Prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) is responsible for uterine involution after parturition. Greater postpartum $PGF_{2\alpha}$ concentration is associated with faster uterine involution. The uterus releases $PGF_{2\alpha}$ during each oestrous cycle to regress each new CL if the cow is not pregnant and initiate a new oestrous cycle. During the period of CL regression, concentrations of $PGF_{2\alpha}$ and progesterone are inversely related. If the cow conceives, release of $PGF_{2\alpha}$ from the uterus is prevented in order to preserve the CL and maintain pregnancy. Prostaglandin is important for uterine involution after parturition, but increased production and release after conception may lead to luteolysis and increased embryonic mortality.

Linoleic acid is substrate for the syntheses of $PGF_{2\alpha}$. Linoleic acid can be desaturated and elongated to form arachidonic acid, which is a precursor for $PGF_{2\alpha}$. Regulatory enzymes for this conversion, include $\delta_6$-desaturase and cyclooxygenase. Linoleic acid can inhibit $PGF_{2\alpha}$ synthesis by competitive inhibition with these key enzymes.[3] In contrast, Grant *et al* (2003) found that supplementing beef cows postpartum with high-linoleate safflower seed increased PGF-metabolite from 25 to 80 d postpartum and tended to decrease first-service conception rates. Filley *et al* (2000) also demonstrated that feeding calcium salts of palm oil increased plasma linoleic acid and PGF-metabolite in beef heifers. Arachidonic, and two fatty acids found in fishmeal, eicosapentaenoic (EPA) and docosahexanoic (DHA), have been shown to inhibit cyclooxygenase activity as well .[9] Heifers with low-luteal phase progesterone supplemented with fishmeal had lower PGF-metabolite concentrations after an oxytocin challenge. However, fishmeal had no effect in heifers with high-luteal phase progesterone. Linolenic acid was also present in the endometrial $PGF_{2\alpha}$ synthesis inhibitor isolated.[12]Linolenic acid has also been shown to be a strong inhibitor of $PGF_{2\alpha}$ synthesis. The amount and probably type of particular fatty acids reaching the target tissues likely influence whether $PGF_{2\alpha}$ synthesis is stimulated or inhibited. It has also been suggested that reductions in intrafollicularand serum[13] concentrations of estradiol associated with fat supplementation may play a role in modulating luteal responsiveness to prostaglandin.

*Dietary PUFA and Oocyte maturation*

Reproductive Effects of Dietary Fat Ovarian Follicle Development A variety of fat sources have influenced the size and number of ovarian follicles. Normally follicle development progresses through stages of recruitment, selection, and dominance during each oestrous cycle .[12] In the initial days of the oestrous cycle, a group of follicles grow up from which a single follicle (called the dominant follicle) continues to grow while the others undergo atresia. At approximately day 10 to 11 of the cycle, this dominant follicle regresses, and this process of recruitment and selection reoccurs. A second dominant follicle arises and ovulates. This is the normal 216 [12] sequence for cows having a two follicular wave oestrous cycle. Three consecutive dominant follicles would arise if cows experienced a three wave oestrous cycle. As follicles are recruited and grow in diameter, they increase from a detectable size of 3 mm up to about 15 to 18 mm before regressing or ovulating. Several studies involving either dairy or beef cows have reported that fat supplementation increased the number of follicles of different class sizes. An increase in the number of smaller follicles may reflect a greater pool of follicles available for subsequent development. A greater number of larger follicles may indicate an altered selection process. In addition to the increased numbers of follicles due to fat supplementation, the size of the dominant follicle has commonly been increased. Larger follicles usually occur under conditions of low concentrations of progesterone and high estradiol 17-β.

As will be discussed later, this hormonal profile is just the opposite of what is seen typically when fat is supplemented. The impact of larger ovarian follicles due to the feeding of supplemental fat on conception rate has not been defined. If a follicle becomes too large (> 25 mm), it can become cystic and fail to ovulate.

Only one study reported greater occurrence of cystic follicles when fat was fed (Salfer *et al*, 1995). The size of a healthy follicle may have no relationship to the amount of estradiol it secretes or to the secretion of progesterone by the subsequent CL formed. The mechanism by which dietary fats stimulate ovarian activity has yet to be determined. Mechanisms by Which Fats May Improve Fertility Several hypotheses have been proposed regarding the mechanism(s) by which fat supplementation improves reproductive performance. These include 1) an amelioration of a negative ES thus leading to an earlier return to oestrus postpartum and therefore improved fertility, 2) an increase in progesterone production/ secretion favourable to improved fertility, and 3) a stimulation or inhibition of PGF2$\alpha$ production/release which influences the persistence of the CL.

*Early postpartum study*

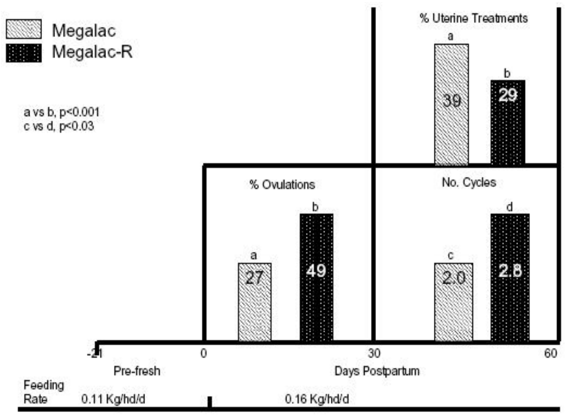
*Importance of EFA early postpartum*

Research at The University of Arizona has centered on evaluating the role of EFA in the early PP interval. Since EFA are precursors for steroids and PG, they should be related to re-initiation of cyclicity PP. Data in Figure 4 confirm that EFA directly affects postpartum reproductive events. Holstein cows were fed 0.11 kg/hd/d of Megalac® (Arm & Hammer Animal Nutrition, Princeton, NJ) 21 d prepartum, then received 0.16 kg/hd/d of Megalac® or Megalac®-R through the voluntary waiting period. Megalac®-R contains 4.5 fold the amount of linoleic acid and 23.5 fold the amount of linolenic acid compared to Megalac®. Those extra fats in Megalac®-R doubled the incidence of ovulations by 30 DIM, contributed to almost 1 additional cycle by 60 DIM, and markedly improved uterine health by 60 DIM compared to cows fed Megalac® (Figure 4). All of those physiological responses have been reported to reduce services per conception and days open in previous studies. A point to consider here: many people are extending voluntary waiting periods with timed A.I. programs. If uterine health and cyclicity are hastened by feeding EFA, then timed A.I. should occur earlier postpartum to capitalize upon the physiological advantage of cows being ready for breeding earlier

Figure 4. Reproductive events in dairy cows fed Megalac® or Megalac®-R from 3 wk prepartum through the voluntary waiting period. The percent of ovulations observed during the first 30 DIM; the number of estrual cycles during the first 60 DIM; and the percent uterine treatments prior to 60 DIM are portrayed Research at The University of Arizona has centered on evaluating the role of EFA in the early PP interval

*Role of EFA in maternal recognition of pregnancy*

Pregnancy recognition in the bovine occurs between d 15 and 18 post-oestrus with the conceptus maintaining the CL of pregnancy. Not unexpectedly, then, it is estimated that 40 % of embryonic death loss occurs during d 8-17 post-oestrus and could largely be a result of inability to maintain the CL. This is accomplished through the production of interferon-tau (INF) which inhibits the ability of the uterine endometrium to produce pulsatile PGF2$\alpha$ which is responsible for the degradation of luteal tissue.[12]There is evidence indicating that the length of the conceptus is directly related to the production capacity of INF.[14] Of equal importance is the observation that inclusion of n-3 fats in the diet via fish oil or Ca-LCFA increases the length of the conceptus, likely improving the ability to synthesize INF and enhancing postpartum and more cycles during the voluntary waiting period. These events lead to improved fertility earlier in the postpartum interval because they reduce services per conception and days open.




*Effect of omega-3 fatty acid on male reproduction*

Prostaglandins may also play an important role in male reproduction, as there are several effects of PG on sperm motility and quality.[15] Arachidonic acid and, subsequent production of PG and leukotrienes, may also be involved in mediating the stimulatory actions of luteinising hormone on testicular steroid synthesis.

No published studies have specifically examined the effects of n-3 supplementation on male fertility and semen quality in sheep and cattle. In non-ruminant studies, total sperm number.[16] and sperm motility was improved when boars were supplemented with fish oil. In addition, total sperm count and sperm motility were negatively related to serum concentrations of n-6 in a study in humans . Semen quality may be improved when the concentration of PUFA in sperm membranes is increased following supplementation with long-chain n-3.[15] However, PUFA are also associated with increased oxidative stress, which can reduce semen quality.[15] so several mechanisms need to be considered when examining the overall effects.

*Optimum level of fat*

As stated, the amount of supplemental fat needed to elicit a positive or, in some cases, a negative effect on reproductive function is largely unknown and titration studies are needed in all situations in which supplemental fat has been fed. Dose-response studies indicate that the amount of added plant oil necessary to maximize positive ovarian effects is not less than 4%, 3% added dietary fat (DM basis) has often positively influenced the reproductive status of the dairy cow. Lower levels of added dietary fat (2%) have also been shown to elicit a positive reproductive response.[17] and, in studies with fishmeal, less than 1% added fat produced a positive reproductive response[17] , indicating that both the amount and types of fatty acids are important. Feeding large quantities of fat (>5% of total DMI) has not been recommended due to potential negative effects on fiber digestibility and reduction in DMI (Coppock and Wilks, 1991).

*Disorder fat cow syndrome*

Excess energy (concentrates, corn silage, some hays) fed during the dry period may cause obese cows near calving time. These "too fat" cows are more susceptible to a number of other metabolic problems (milk fever, ketosis, displaced abomasums , retained placenta, metritis),and the chance of dying is more likely .It is not uncommon in some operations for overweight Holstein cows to weight 1,600 to 2,000 pounds, which frequently creates problems. Feeding strategy is recommended to restore lost body condition during late lactation. Not only will this practice help avoid severely overweight cows, but feed conversion into body tissue is more efficient during late lactation, compared to the dry period.

*Fatty liver*

Fatty liver syndrome is the accumulation of fat within the cow's liver. Fatty liver occurs as a result of the cow breaking down too much fat for the liver to process properly. Fat mobilisation occurs as a result of negative energy balance. The broken down far is then converted back to fat in the liver to prevent them becoming toxic. Thus the liver becomes fat when the cow is losing condition, the more loss in condition the more fat in the liver. Fatty liver can develop within 24 hours of an animal going off feed. This is typically around calving time. Once it is deposited in the liver, the concentration of fat in the liver does not fall until the cow gets into positive energy balance, which can be over ten weeks after calving, particularly if the fatty liver is severe. Fat cows (Body Condition Score > 3.5)

*Infertility*

Caused by nutritional problems include of that may be too fat or too thin. Causes other than nutrition must be considered when obvious nutritional problems are lacking. Cow body condition evaluation is important because extremely thin or too-fat cow's reproductive efficiency is considerably reduced. The too-fat cows have more problems post-calving (retained placentas, metritis , cystic ovaries) while the too-thin cows usually have breeding problems due to prolonged time lapse before resuming normal heat cycles (30-40 days post-calving).Maintain and record body condition scores which rate 1 as too thin and 5 as too fat. Lactating cows, at peak production, should not drop below 2.5 and should be dried off at 3.5, and maintain this score throughout the dry period.

## Conclusion

Feeding supplemental fat to dairy cows no longer has energy density as a primary consideration in the ration. Essential fatty acids, notably linoleic (omega-6) and linolenic (omega-3) acids have direct effects on physiological processes such as cellular membrane integrity, hormonal pathways, and immune function. Clearly, they are important to uterine health, and that is accompanied by earlier ovulations PP and more cycles during the voluntary waiting period. decline in fertility and there is increasing evidence to assume that reduced oocyte and embryo quality are two major players in this "disappointing fertility syndrome" nutrition has the potency to alter the micro-environment of the oocyte and the embryo, making it more hostile to optimal fertilization and pre implantation embryonic growth. Data reviewed shows that supplementation with different sources of lipids and fatty acids improve reproductive performance of the female ruminant. However, it is important to consider that the optimum response will be achieved when under nutrition status of the female is not extremely severed. A nutrient balance (protein: energy) in the ration consumed by the animal is fundamental to obtain maximum benefit from supplementation with fat, The feeding of additional energy in the form of fat reduces the cow's negative energy status so that she returns to oestrus earlier after calving and therefore conceives sooner.

Cows fed fat produce or secrete more progesterone, a hormone necessary for the implantation and nutrition of the newly formed embryo. Specific individual long chain fatty acids found in some fats inhibit the production or release of prostaglandin by the uterus. This prevents the regression of the corpus luteum (CL) on the ovary so that the newly formed embryo survives. Based on the experiments done at this time, it appears that dietary fats may increase the size and the life span of the CL. The larger size of the dominant follicle in fat-supplemented cows may result in a larger CL. More CL cells produce more progesterone. Greater progesterone should improve implantation and nutrition of the embryo. In addition, certain fatty acids such as linoleic acid and those found in fish may partially suppress secretion of Prostaglandin by the uterus at the time of conception so that the CL is not regressed and embryo survival is potentially enhanced.

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