

Nutritional Causes of Infertility in Dairy Cows

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Introduction

Infertility is a term which includes all reasons for cows not conceiving after breeding. Infertility results in either culling of the cow or increased calving interval which reduces overall production efficiency. Repeat breedings or anestrus are the most common signs of infertility. Causes of repeat breedings may include bull infertility, improper semen handling, poor estrus detection, a nutritional imbalance, incorrect timing of insemination, or a decreased fertility level in the cow.¹

Nutritional imbalances are just one cause of infertility in dairy cattle, however, often more than one nutrient may be involved or other non-nutritional factors are partially to blame. These facts make it difficult to evaluate the effect of a single nutrient on infertility.

Research previously indicated that nutrient requirements for high milk production was greater than that required for reproduction, (therefore cows fed for high milk production would receive adequate nutrients for reproduction). More recent research indicates slight deficiencies or imbalances of either major or minor nutrients may decrease fertility in apparently normal, cycling dairy cows.² This paper will summarize the information available in the current literature about nutritional factors involved with infertility in dairy cows.

Energy

The most common nutritional cause of infertility is inadequate energy in the diet. It has been suggested that weight is a greater determinant of when heifers reach puberty than their age. Energy level of the diet is certainly a factor here. It deter-

mines what an animal will weigh at a given age.

Clinical signs of an energy deficiency in heifers would be a delay in the onset of puberty, heifers with inactive ovaries and a small and thin body condition.³ The condition can be treated simply by providing the animals a balanced diet higher in energy resulting in adequate skeletal growth and appropriate body condition.

Experiments show that animals gaining weight had a higher conception rate than those losing weight.² For optimum fertility heifers should be gaining weight for 30 days before and after breeding.³ In six heifers on 62 percent and 100 percent of Morrison's TDN allowance, plasma luteinizing hormone (LH) and progesterone levels were studied. A progressive increase in LH from the first to the third estrous cycle on low energy intake was noted along with a concurrent decrease in plasma progesterone levels. This indicates that ovarian inactivity in situations of restricted energy intake is due to a reduced ability of ovarian tissue to respond to LH rather than reduced circulating levels of LH.³

It is recommended that heifers be kept on a ration that provides gains of 1.5 pounds per day. Holstein and Brown Swiss heifers should exhibit estrus before 12 months of age and weigh 750 pounds before breeding. Ayrshire, Guernsey and Jersey heifers should weigh about 660 pounds at breeding.

Energy deficiency in cows may also cause inactive ovaries, lowered conception rate, and reduced progesterone production by the corpus luteum. Abortion may result in cases of severe energy deprivation. High producing dairy cows are known to be in a negative energy balance during early lactation as they are not able to consume enough feed to meet the increased nutrient requirements of elevated milk production. This causes weight loss to occur frequently this is at the time the cow is expected to conceive. Among high producing

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dairy cows, those with the highest negative energy balance had the longest anestrus periods. Thus, negative energy balance, resulting in weight loss and its associated stress, has been suggested as a possible cause of infertility.³

Subnormal progesterone levels in energy-deficient cows are primarily a result of decreased corpus luteum (CL) function. Energy-deficient cows with low progesterone levels are probably at a higher risk for premature luteolysis than cows with normal progesterone levels and a positive energy balance. Apparently the presence of a CL does not guarantee that adequate hormone levels are present for conception and pregnancy.¹

Conception rates are higher in cows gaining weight at the time of service than those losing weight. In 814 cows with a net weight gain in the 30-90 day postpartum period, a 64 percent conception rate was achieved compared to only 46 percent in 358 cows losing weight during this period. The animal with the largest problem of weight loss is the high producing two-year-old that is using nutrients for growth as well as for maintenance and production. In a New Zealand study 85 percent of anestrus two-year-olds had inactive ovaries at 60 days postpartum compared to only 47 percent of 808 cows at four years of age.³

For optimal reproduction performance cows must be in good physical condition at calving. Cows with inadequate energy intake and poor body condition have delayed return to estrus, decreased conception rates, and extended calving intervals. Excessively fat cows are predisposed to the fat cow syndrome. As mentioned earlier it is almost impossible to prevent high producing cows from losing weight at peak lactation. However, they should be fed high quality forages free choice, receive a balanced grain ration, and challenge feeding is also recommended. Total mixed rations and computerized feeding systems are other management tools that may be used to provide a more balanced ration in adequate amounts to the high producing dairy cow.

Short-term protein deficiencies can be met by body reserves, while prolonged inadequate protein intake reduces reproductive efficiency.

Adequate dietary protein is required by dairy cattle for the following reasons. 1) Heifers fed a diet deficient in protein may show delayed onset of puberty while cows with protein deficient diets may have an increase in the number of days open. 2) Adequate protein is necessary for normal development of the fetus and proper functioning of the reproductive organs. 3) In lactating cows,

protein deficiency may result in decreased appetite and is shown to result in emaciation and low milk production. While signs of energy and protein deficiency are similar, it is generally felt that an energy deficiency has a much larger scale effect on reproduction than a protein deficiency.

Elevated dietary protein levels can also have a negative effect on reproduction. In an Oregon study of 45 high producing cows, highest fertility rate was achieved when the ration contained 12.7 percent crude protein. An increase in the dietary protein level had a negative effect on reproductive parameters.³ Jordan and Swanson reported that dietary protein levels of 19.3 percent had a negative effect on days open and services per conception.⁴ See table 1 below.^a It has been speculated that the excess protein may have caused cellular damage to body tissues, producing sub-optimal uterine and ovarian environments for reproduction.²

The effect of urea on fertility in dairy cattle is inconclusive even though it is frequently incriminated as a cause of lowered fertility. In a Purdue study urea was fed in a blended ration for several lactations. The cows with the highest urea intake had an increased incidence of abortion at first pregnancy, increased incidence of retained placenta at second calving, and increased calving intervals. There was a decrease in ovarian cysts and gestation length when compared with controls. Therefore, heifers should not receive more than 30-40 grams of urea per day during the first gestation to avoid abortions.^{2,3} For lactating dairy cows, the total ration should contain between 14-18 percent protein depending on the level of production.¹ Feeding excess or insufficient dietary protein may impair reproductive efficiency.

Table 1
Effect of Dietary Protein on Reproduction

Item	Dietary Protein (% of Dry Matter)		
	12.7	16.3	19.3
Days to first ovulation	18	28	16
Days to first estrus	36	45	27
Services/Conception	1.47	1.87	2.47
Days open	69	96	106

^aFrom Jordan ER, Swanson LV: Effect of crude protein on reproductive efficiency, serum total protein and albumin in the high producing dairy cow. *J. Dairy Sci* 62:58-63, 1979.

Roughage

Reports from Israel indicate that low roughage diets may be involved in poor postpartum reproductive performance. Roughage intake below 30 percent of the total ration dry matter appears to decrease reproductive performance in high producing dairy cows.²

Vitamins

The vitamin requirements of dairy cattle are generally met by a combination of rumen and tissue synthesis and natural feeds. Commercial concentrates and minerals frequently contain supplemental vitamins. The probability of a vitamin deficiency causing an infertility problem in dairy cattle is therefore greatly reduced. Each of the following vitamins plays a role in the reproductive process and if not fed in adequate amounts can give rise to specific reproductive problems.

Vitamin A deficiency may result in such clinical signs as delayed onset of puberty, abortion, birth of blind, weak calves, keratinization and degeneration of the placenta, retained placenta and metritis. Vitamin A deficient cows have normal estrous cycles, ovulate, conceive and have normal early fetal development.^{2,3} Vitamin A deficiency could develop in cattle fed forages damaged by weather, overheated in processing or storage, or maintained in storage for a long period of time. Vitamin A deficiency could go unnoticed for months if adequate amounts have been stored in the liver.

Both lactating and dry cows require 1500 IU of vitamin A activity per pound of ration dry matter. This includes Beta-carotene as well as vitamin A. 1 mg of Beta-carotene is equal to 400 IU of vitamin A. Vitamin A supplementation for dairy cows is 30,000-50,000 IU daily.³ Weaver states that oversupplementation of vitamin A may impair metabolism of Beta-carotene and should be avoided.²

Studies in Germany indicate Beta-carotene may influence conception rate independent of vitamin A. Heifers were fed diets free of Beta-carotene but supplemented with vitamin A. Other heifers were fed the same ration containing vitamin A plus 0.3 mg/kg body weight of Beta-carotene. Services per conception were 2.0 for heifers fed the Beta-carotene free ration and 1.42 for heifers supplemented with Beta-carotene. Heifers not fed Beta-carotene had retarded ovulation and CL

development and had cystic degeneration of the ovaries.²

In another study by Folman et al. the number of services per conception did not differ between Beta-carotene supplemented and nonsupplemented groups.⁵

In a third study, Lotthammer showed a 31 percent increase in embryonic mortality and a 12.5 percent increase in early abortion of dairy cows not supplemented with Beta-carotene compared to those supplemented with Beta-carotene.⁶

Vitamin D deficiency decreases fertility by suppressing signs of estrus and delaying onset of estrus.

The effect of 43,000 IU of vitamin D₃ daily on postpartum reproductive performance was studied in 58 cows receiving 100 or 200 gm of calcium and 80-100 gm phosphorus. First estrus and conception occurred 12 and 35 days earlier, respectively, in the groups receiving vitamin D supplementation compared to the controls who received none.³ In a study by Ward et al. vitamin D supplementation of 300,000 IU/cow/week was shown to decrease the time from parturition to first ovulation by six days over unsupplemented cows.⁶

For lactating cows the vitamin D requirement is 320 IU per kg of dry matter in the diet. Vitamin D supplementation is recommended at 1000 to 1200 IU per kg of dry matter intake daily.²

There is no evidence that vitamin E deficiency alone is detrimental to reproductive performance in dairy cattle. However, a combination vitamin E and selenium deficiency has been associated with increased incidence of retained placenta.⁷

Minerals

Infertility in dairy cattle is frequently attributed to mineral imbalances. A large number of interrelationships exist between minerals which make it difficult to determine the influence of a specific mineral on fertility. Several minerals appear to be more important than others to reproduction, they will be discussed below.

A clinical sign of calcium deficiency is anestrus due to impaired ovarian function, delayed uterine involution and retained placenta. In one study the uterus of cows fed 200 gm calcium and 43,000 IU vitamin D involuted to normal 8 days sooner than cows fed 100 gm calcium and 43,000 IU vitamin D.³ Regulation of calcium intake is important to prevent clinical hypocalcemia. There is also an increased incidence of retained placenta, metritis, and dystocia in cows with hypocalcemia. Since

calcium is involved in muscle contraction it is not surprising that hypocalcemia would reduce the strength of uterine contractions increasing the incidence of dystocia and retained placenta. Uterine tone is also decreased and there is delayed uterine involution in cows deficient in dietary calcium.

First service conception rate of normal cows was 42 percent, but it was only 30 percent in 297 cows with retained placenta. Services per conception increased from 2.7 to 3.4 in cows having a retained placenta.^{3,7}

Calcium fed to dry cows should be restricted to 60-100 gm daily to prevent hypocalcemia. High levels of calcium, approximately 200 gm daily during early lactation along with supplemental vitamin D may accelerate uterine involution and the return to estrus.¹

Phosphorus is the mineral most frequently associated with infertility in dairy cattle. It should be remembered, however, that diets deficient in phosphorus are frequently deficient in energy and protein.

A moderate deficiency may be associated with repeat breeding while severe deficiency can delay the onset of puberty and postpartum estrus due to inactive ovaries.³ In a study of 27 heifers on a phosphorus deficient diet, the blood phosphorus level was 3.9 mg/dl compared to 6.6 mg/dl in 26 heifers receiving phosphorus supplementation. The number of services per conception declined from 2.8 to 1.3 with phosphorus supplementation in this group of heifers.³ In another study, Morrow reported phosphorus deficient heifers required 3.7 services per conception, while heifers fed adequate phosphorus levels required 1.3 services per conception.⁸

Clinically, phosphorus deficiency has been associated with cystic ovaries. Other causes that have been suggested include high levels of concentrate feeding, feeds high in manganese, plant estrogens, and Beta-carotene deficiency. The cause of cystic ovarian disease is unknown, however, hormonal imbalance rather than nutrition appears to be the cause.

The phosphorus level in the diet for the high producing dairy cow should be at least 0.4 percent of the total dry matter and 0.26 percent of the total dry matter intake for the dry cow.³ Excessive phosphorus levels, those greater than 40 gm daily, may increase the incidence of hypocalcemia and the downer cow syndrome and decrease milk yield.¹

Iodine has its effect on infertility by its action on the thyroid gland. Lowered thyroid function

appears to impair ovarian activity, resulting in anestrus or irregular estrus and decreased conception rates.^{2,3,9} Iodine toxicity can result in abortions.³

Estrus detection and fertility improved in cattle supplemented with iodine, compared with controls in iodine deficient areas.³ Iodine deficiency is related to retained placenta which increases the chance of metritis and pyometra.

In iodine deficient areas 0.01 percent potassium iodide in the salt is recommended to meet the minimum requirements for animals. The dietary iodine intake for high producing cows should be limited to 50 mg daily.¹ Incidence of retained placenta due to dietary iodine deficiency should be low with the feeding of iodized salts and mineral premixes.

The effect of copper deficiency is unclear. The most common clinical sign associated with copper deficiency has been a high incidence of early embryonic or prenatal mortality.⁹ Increased incidence of retained placenta, delayed estrus, and infertility has also been associated with inadequate copper in the diet. However, copper deficient cows may also appear normal and fertile.⁹ Other studies report no benefit from copper supplementation.³ Molybdenum and sulfur may complex with copper and decrease the availability resulting in copper deficiencies despite adequate dietary copper levels.

Copper in the ration should be 10 ppm of total dry matter intake in high producing dairy cows.²

The clinical signs of selenium deficiency include increased incidence of metritis, ovarian cysts, decreased conception rate, increased retained placenta and muscular dystrophy. In a trial at Ohio State University, the incidence of retained placenta was reduced 38 percent when selenium was increased from 0.23 to 0.92 mg daily during the last three weeks of gestation.¹⁰ In a second trial the incidence was decreased from 51.2 to 8.8 percent by injection of 50 mg selenium and 680 IU vitamin E 20 days prepartum.¹¹ See table 2 below.

Table 2

Incidence of Retained Placenta in Relationship to Selenium Supplementation^b

Trial	Control	Selenium
Trial 1		
Number of cows	26	15
Placental retention (%)	38	0
Trial 2		
Number of cows	80	113
Placental retention (%)	51.2	8.8

Prevention of retained placenta was achieved by feeding 0.1 ppm selenium daily during the dry period.³ However, researchers in Maryland and West Virginia found supplemental selenium to be ineffective in decreasing the incidence of retained placenta.¹¹ Diets should contain 0.1 to 0.2 ppm of ration dry matter of selenium daily.²

Ration dry matter should be 1.0 to 1.6 percent potassium to meet the demands of production.² Excess potassium, 5 percent of the diet, has been shown to delay puberty and ovulation. Prepartum cows should be limited to 0.8 percent potassium and 0.1 to 0.2 percent sodium to control udder edema.²

Only severe dietary deficiency of manganese will result in depression of reproductive performance. Anestrus, infertility, and silent estrus are the clinical signs seen in cases of manganese deficiency. Reported conception rates of 35 to 40 percent are not unusual.⁹ High producing cows should receive 40 ppm manganese of the total dry matter intake.³ Abortions and cystic ovaries are frequent on farms feeding high manganese feeds.⁹ Since corn silage has a low manganese content it should be remembered that there is a possibility of reproductive failure due to manganese deficiency in herds whose diet contains a high percentage of corn silage.

The most common indication of cobalt deficiency is a marked reduction in conception rate.⁹ Other clinical signs associated with cobalt deficiency are a delayed onset of puberty and return to estrus postpartum. Involution of the uterus requires three to nine weeks longer in cobalt deficient cows.⁹ The dietary level of cobalt for high producing cows should be 0.10 ppm of the total daily dry matter intake.³

Reduced fertility is the only reported reproductive effect in the female whose diet is deficient in zinc. Cows given a zinc supplement had a 28 percent higher conception rate than controls.⁹ High producing cows should be fed a diet containing 40 ppm of zinc of the total daily dry matter intake.³

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^bFrom Conrad HR, Moxon AI: Role of Selenium in Prevention of Reproduction Problems in Dairy Cows. *Proc. Cornell Nutr. Conf.*:57-62, 1978.

Conclusion

The current literature contains many studies correlating nutritional imbalances with decreased fertility. This indicates that nutrition is an important factor in fertility problems of dairy cattle. It should be remembered that frequently more than one nutrient is involved as well as other reproductive management factors. Table 3 in the appendix lists known nutritional causes of infertility in dairy cattle and makes a convenient reference.

In order to prevent problems of decreased fertility due to nutrition the following guidelines are suggested.

1. Rations should be balanced for energy, protein, vitamins and minerals to meet nutrient requirements using laboratory analysis of the total diet.
2. Attention should be given to the diets of heifers and dry cows to prevent future reproductive and metabolic diseases.
3. Use of challenge feeding to prepare cows for the extreme change in nutrient requirements involved with parturition and early lactation.

Table 4 in the appendix lists the suggested nutrient requirements of dairy cows and can be utilized when formulating a ration or interpreting a ration analysis in cases of suspected nutrient imbalances in the diet.

While nutritional causes of infertility do occur, other causes should also be considered to prevent incrimination of nutrition when cases of poor reproductive management or other causes of reproductive inefficiency may be involved.

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WHY THERE ARE NO SEEING EYE CATS