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Interaction Between Nutrition and Reproduction in Livestock

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Abstract

Nutrition is an integral component of livestock production industry that determines reproductive capacity, fertility, estrus cyclicity and production potential of an individual livestock. Lower energy intake leads to an increase in the length of anestrous period whereas and higher intake causes "fatty cow syndrome". Body condition score (BCS) helps in determination of energy status of an animal. Similarly higher level of protein in the feed lead to delayed return of normal ovarian function. Feeding high fat diets to cycling heifers and postpartum cows was found to increase progesterone production and enhance the lifespan of the corpus luteum. A negative dietary cation-anion difference (DCAD) prior to calving signifies decreased incidence of metabolic disorders postpartum and maintain reproductive integrity for future lactations.

Keywords: Nutrition; Cyclicity; Body condition score; Progesterone.

Introduction

Nutrition and proper management is essential to maintain health, reproduction and well-being of animal. Increase in productivity due to genetic enhancement provides continual pressure on management and husbandry practices. So, ration must be formulated in the way to meet the daily physiological demand of the animal nutrition plays an important role in young animals to determine the age at which they reach puberty. Under nutrition results in the loss of body weight and body condition, delays the onset of puberty, increases the post-partum interval to conception, interferes with normal ovarian cyclicity by decreasing gonadotropin secretion and increases infertility. At the time of pregnancy, pregnant female requires an adequate amount of calories to meet the nutritional demand of both mother and fetus. In the lack of nutrition, the fetus becomes weak, handicapped and abortion and other various metabolic and pathologic diseases can occur leading to reduced fertility (Sguizzato *et al*., 2020).

The various nutritional factors affecting fertility of an animal is mentioned below:

Energy

Energy balance is the most important nutritional factor related to poor reproductive function in animals (Randel,

1990). Lower energy intake during late gestation increases the length of anestrous after parturition and subsequently delays pregnancy. The effect of insufficient energy intake during later part of gestation cannot be overcomed by increasing energy intake postpartum. Cyclic heifers that have begun to have normal estrous cycles may stop cycling, if they are fed with energy deficient rations. Higher energy intake during late lactation and the dry period can cause "fatty cow syndrome" which reduces reproductive efficiency in the next lactation (Kim *et al*., 2010). Cows that are over-conditioned when they calve have a higher incidence of retained placenta, more uterine infections and more cystic ovaries. They also have a higher incidence of metabolic disorders and have a greater tendency to go off feed. All of these problems can result in poor reproductive performance (Elrod and Butler, 1993). Table 1 shows nutrients requirement of metabolisable energy (ME) in Megajoule (MJ) for maintenance of each cow according to body weight.

Body condition scores (BCS) can be used on both heifers and cows as an indication of the energy status, although primarily used on the lactating dairy herd. Cows with low BCS are more prone to metabolic problems and diseases, have decreased milk yield, lower conception rates and decreased efficiency of heat detection, compared to cows that are gaining weight and have higher body condition scores(Kellogg, 2010).

Table 1: Requirement of metabolisable energy (ME) in Megajoule (MJ) for maintenance of each cow according to body weight

BODY WEIGHT KILOGRAM (KG)	ENERGY REQUIREMENTS (MJ ME/DAY)
300	34.6
350	38.8
400	42.9
450	46.9
500	50.8
550	54.5

(Source: Requirements & Dairy, 2020a).

Protein

Feed containing higher level of protein or urea than the recommended proportion has been associated with decreased pregnancy rates in female dairy and beef cattle. It appears that exposure to high levels of ammonia or urea may impair maturation of oocyte and subsequent fertilization or maturation of developing embryos. However, supplying adequate energy for excretion of excess ammonia or urea may prevent decreases in fertility in dry cows or heifers (Laven and Drew, 1999). Nutrient's requirement of crude protein (CP) for maintenance of each cow according to body weight is shown in Table 2.

- ✓ High levels of blood urea may occur, which has a toxic effect on the sperm, the ova, and the developing embryo.
- ✓ The balance of hormones may be altered—progesterone levels are low when the blood contains high levels of urea (Law *et al*., 2009).
- ✓ In the early lactating cow, high levels of protein may exacerbate the negative energy balance and delay the return of normal ovarian function (Geppert, 2015).

Table 2: Requirement of crude protein (CP) for maintenance of each cow according to body weight.

BODY WEIGHT KILOGRAM (KG)	PROTEIN REQUIREMENTS (KG CP/DAY)
300	0.288
350	0.324
400	0.358
450	0.391
500	0.423
550	0.454

(Source: Requirements & Dairy, 2020b).

Fats

The impact of fats on reproduction in cattle is a focus of considerable research because fatty acids and cholesterol are substrates for hormone synthesis, increasing fat in the diet may increase levels of reproductive hormones (progesterone, prostaglandins) or fats may act directly on the reproductive axis(Rodney *et al*., 2015). High fat diets for cattle contain 5% to 8 % fat. Exceeding these dietary fat levels impairs rumen function. Early studies indicated that feeding high fat diets to cycling heifers and postpartum cows increased progesterone production and the lifespan of the corpus luteum (CL). Higher progesterone levels during the luteal phase generally result in improved fertility. Increasing dietary fat also results in increased follicular growth. More small and medium follicles are present in cows and heifers fed high fat diets. In addition, this increased follicular growth is often accompanied by increased estrogen and/or progesterone production leading to enhanced reproduction(Boerman, 2014).

Vitamins and Minerals

Table 3 shows the effect of vitamins and mineral imbalance in fertility and reproduction of livestock. Reproduction is one of the physiological processes in animals governed by minerals. Mineral deficiencies, imbalances and toxicity of certain mineral elements may cause reproductive disorders

as minerals play an important role in health and reproduction of the livestock(Ahuja and Parmar, 2017). An important concept surrounding macro-mineral balance is dietary cation-anion difference (DCAD). DCAD measures the level of cations i.e. sodium and potassium and anions i.e. Chlorine and sulfur (Martinez *et al*., 2018). The equation for calculating DCAD balance is:

(Sodium + potassium) – (chloride + sulfur) = DCAD in mEq/100g of ration dry matter

A negative DCAD prior to calving signifies decreased incidence of metabolic disorders postpartum and maintain reproductive integrity for future lactations.

Table 3: Effect of vitamins and mineral imbalance in fertility and reproduction of livestock

S.N.	Minerals	Effects
1	**Phosphorus**	Decreased fertility rate, feed intake, milk production, decreased ovarian activity, irregular estrous cycles, increased occurrence of cystic ovaries, delayed sexual maturity and low conception rates have been reported when phosphorus intakes are low (Steevens *et al*., 1971).
2	**Calcium**	Ratios (Ca:P) between 1.5:1 and 2.5:1 for lactating cows should not result in problems. Uterine involution may also be impaired giving rise to fertility problems(Martinez *et al*., 2016).
3	**Selenium**	Selenium is important for normal spermatogenesis and largely as a component of seleno-proteins phospholipid hydroperoxide glutathione peroxidase (PHGPx/GPX4) and Seleno-protein V. It serves as a powerful antioxidant protecting cells from oxidative stress. PHGPx also appears to be involved as a structural protein to provide normal sperm motility (Qazi *et al*., 2019).
4	**Zinc**	Zinc is known to be essential for proper sexual maturity, reproductive capacity, and more specifically, onset of estrus. Zinc has a critical role in the repair and maintenance of the uterine lining following parturition, speeding return to normal reproductive function and estrus(Hidiroglou, 1979). In bulls, a zinc deficiency results in poor semen quality and reduced testicular size and libido (Roy *et al*., 2013).
5	**Copper**	Reproductive problems that relate to copper deficiency manifest themselves in inhibited conception rate even though estrus may be normal. Symptoms of a copper deficiency include early embryonic death, resorption of embryo, increased retained placentas and necrosis of the placenta. Weak and silent heats have been reported. Dairy cows with higher serum copper levels had significantly less days to first service and fewer services per conception (Hefnawy and khaiat, 2015).
6	**Potassium**	Delayed onset of puberty, delayed ovulation, impaired corpus luteum (yellow body) development and increased incidence of anestrous in heifers are the outcome of feeding high levels of potassium (Fahar *et al*., 2018).
7	**Vitamin A**	It is well known to regulate the development, cellular growth and differentiation, and tissue function. Its metabolites affect ovarian follicular growth, uterine environments and oocyte maturation. Vitamin A is also required for maintaining healthy tissue in the reproductive tract. In deficient cattle, delayed sexual maturity, abortion, the birth of dead or weak calves, retained placenta and metritis have been reported (Kumar *et al*., 2010).
8	**Vitamin D**	Vitamin D is required for normal calcium and phosphorus metabolism. Animals with vitamin D deficiency symptoms have a stiff gait, labored breathing, weakness and possibly convulsions. Swollen knees and hocks can also occur. Bones may be soft (rickets) or be reabsorbed in older animals. Calves may be born dead, weak or deformed (Kumar *et al*., 2010).
9	**Vitamin E**	Vitamin E functions as an intra-cellular antioxidant scavenging for free reactive oxygen and lipid hydroperoxidases, and converting them to non-reactive forms, thus maintaining the integrity of membrane phospholipids against oxidative damage and peroxidation (Zubair, 2017).
10	**Iodine**	Iodine is not known to affect reproductive processes directly. However, a lack of iodine can depress thyroid function. Hypo or hyperthyroidism may reduce the secretion of gonadotrophic hormones (Hemken, 1970).
11	**Cobalt**	It causes lack of appetite, secondary failure of estrum and delayed onset of puberty in cattle (Kumar *et al*., 2011).

Conclusion

Nutrition is directly related to reproduction in the dairy cow and nutrient either in deficient amount or in higher amount has been shown to be capable of altering reproduction. The best recommendation at present is to provide a feeding program for dairy cows which is balanced for all nutrients and meets all known nutrient requirements.

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