Effect of Nutrition on Reproductive Performance of Postparturient Dairy Cows in the Tropics: A Review

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Abstract

In tropical countries such as Thailand, dairy cows particularly raised in small-holder farms are confronted by a problem of improper nutritional management and its consequences, which may lead to impair their production, health and fertility. This review attempted to summarize some nutritional factors influencing reproductive performance especially during postparturient period. The small-scale farmers have a limited skill on feed and feeding management for their cows during periparturient period or more specifically transition period. Negative energy balance during the transition period is more evident; in addition, fatty liver, as a consequence of negative energy balance, is also frequently observed in Thai dairy cows kept by small-holder farms. Cows with severe negative energy balance accumulate greater amount of triacylglycerol in the liver and have poor postpartum reproductive performance. Dairy cows fed with a high rumen degradable protein have an increase in blood urea nitrogen, which has been proven to reduce fertility. Hypocalcemia also impairs postpartum reproductive performance. Selenium and vitamin E also play important roles in maintaining reproductive efficiency in dairy cows. In order to optimize productivity of dairy cows, farmers should pay attention to optimize body condition score at calving, to properly prepare the rumen function and to offer a good quality and balanced diet to the cows. However, preventive measures to prevent adverse effects of nutritional mismanagement on reproduction in periparturient dairy cows should be concerned.

Keywords: cow, negative energy balance, nutrition, reproductive performance

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Introduction

Small-holder dairy farmers in tropical countries such as Thailand are not well-trained for nutritional management. Therefore, it is quite common that problems diagnosed in the farm seem to associate with feed and feeding mismanagement. One of the major problems related to nutritional management in periparturient dairy cows is negative energy balance (NEB), which is an inevitable phenomenon that dairy cows are usually unable to consume enough energy from the feed to meet their energy demand for lactation. The resulting NEB leads the cows to a higher risk of metabolic diseases, infections, suboptimal milk yield and infertility. Evidence exists that dairy cows with NEB have a poor reproductive performance such as anoestrus (Staples et al., 1990). Lyimo et al., 2004 studied postpartum reproductive performance of crossbred dairy cattle raised in small-holder farms in Tanzania, and suggested that the most likely influencing factor contributing to the delay in the resumption of postpartum ovarian activity was the change in the nutrition level. A cross-sectional study of reproductive performance of small-holder dairy cows in Tanzania by Swai et al., 2005 revealed that poor nutrition, mineral deficiency, high levels of dystocia and retained placenta might interact as management causes of long calving intervals. Lanyasunya et al. (2005) also reported animals with low body weight had low conception rate and long calving interval. These researchers also concluded that poor nutrition contributed to the poor reproductive performance of dairy cows on small-holder farms. In Thailand, dairy cows raised in small-holder farms could be suffered from NEB during periparturient period (Rukkwamsuk et al., 2004). Furthermore, the cows might be overfed with a high amount of rumen degradable proteins, which may affect reproductive performance of the cows. In addition, minerals and vitamins might also be imbalanced, which may also link to impairment of fertility. Therefore, this review attempted to summarize nutritional factors influencing reproductive performance especially during periparturient period.

Negative energy balance and postparturient reproductive performance

It has been known that negative energy balance (NEB) is an inevitable phenomenon in dairy cows during periparturient period. In general, periparturient dairy cows are not well adapted to increase their feed intake to cope with the increasing demand of energy for their requirement of milk production, resulting in a NEB. In order to maintain their milk production, dairy cows have to compensate the energy deficit by increasing fat mobilization. During the NEB period, dairy cows have to confront a high concentration of non-esterified fatty acids or NEFA. These fatty acids are transported to several organs, particularly to the liver, where these fatty acids are oxidized to generate energy or to ketone bodies and are re-esterified to triacylglycerols. In case that liver could not excrete triacylglycerols as a very low density lipoprotein to the blood, accumulation of triacylglycerols could result in fatty liver. The NEB and its consequences lead the periparturient dairy to be more susceptible to metabolic disorders, infections and infertility. High blood concentrations of NEFA impair postpartum ovarian functions. Jackson et al. (2011) reported that dairy cows with high NEFA concentrations at one week after calving showed a delayed onset of luteal activity. The NEB and fatty liver have been reported both in commercial farms and in small-holder farms (Rukkwamsuk et al., 2004; Rukkwamsuk et al., 2006; Rukkwamsuk, 2010). When postparturient dairy cows are arbitrarily divided into mild (liver triacylglycerol concentrations lower than 50 mg/g wet weight), moderate (between 50 and 100 mg/g) and severe (greater than 100 mg/g) (Gaal et al., 1983), around 54.1% of postparturient dairy cows sampled from this farm developed fatty liver (Rukkwamsuk et al., 2004). This study also reported that cows with severe fatty liver required longer times to reduce triacylglycerol accumulation in the liver. This result may impair gluconeogenic capacity of liver with high TAG levels (Rukkwamsuk et al., 1999). Accumulation of triacylglycerol in the liver is positively correlated with the number of days from calving to first ovulation (Rukkwamsuk et al., 1999).

In a field study in Thailand, average days from calving to first estrus was 72±65 days, which was longer than a normal range of 30-50 days (Rukkwamsuk et al., 2010). However, some cows in that study showed their estrus during expected period. Pregnancy rates of these studied cows were 28.6%, 11.1%, and 12.0% for first, second, and third artificial inseminations, which was relatively low. Grimard et al. (2006) reported that first service conception ranged from 38% to 50% depending on lactation number. Suboptimal milk yields, longer days from calving to first estrus and lower first service conception rate in this study could be due to some consequences of NEB during periparturient period. Although determination of NEFA as an indicator of NEB is not practical in the field, body condition scoring (BCS) is widely used to estimate levels of fat mobilization. The BCS ranges from 1 (too thin) to 5 (too fat). Rukkwamsuk et al. (2006) reported that BCS of cows at 1 week prepartum was 3.08±0.08, which was lower than the expected BCS of 3.5 for close-up dry cows (Ferguson et al., 1994). The changes of BCS during periparturient period were positively correlated with serum concentrations of NEFA at 2 weeks postpartum (Rukkwamsuk et al., 2006).

In practices, dairy cows with severe NEB and fatty liver postpartum experienced more postpartum problems (Van Dijk et al., 1989), such as a high occurrence of milk fever (Andrews et al., 1991; Rukkwamsuk et al., 2007), ketosis (Gröhn et al., 1983; Lean et al., 1994; Rukkwamsuk et al., 2007), and displaced abomasums (Muylle et al., 1990; Rukkwamsuk et al., 2007). There has been evidence that fatty liver cows have a delayed or impaired specific immunoreactivity against tetanus toxoid (Wentink et al., 1997). Therefore, it is likely that fatty liver impairs the defense mechanism of the cows. Taking together, some metabolic diseases possibly due to the consequences of NEB and fatty liver may...
Urea nitrogen and fertility

It is well known that daily intake of high protein increases milk production in dairy cows (Grings et al., 1991). However, at the same time, dairy cows fed high dietary protein increase blood urea nitrogen (BUN) concentration, which is associated with reduced reproductive performance (Canfield et al., 1990) possibly due to alteration of intrauterine environment (Elrod and Butler, 1993; Elrod et al., 1993). It is also documented that dairy cows fed high dietary protein also have low plasma progesterone concentrations (Sonderman and Larson, 1989). There might be some links between high protein, particularly rumen degradable protein, and fertility in dairy cattle. Ferguson et al. (1993) reported that blood urea nitrogen concentrations greater than 20 mg/dl were associated with lowered conception rates in dairy cows, and the magnitude of the association was likely to be related to the underlying reproductive performance between herds. At present, milk urea nitrogen (MUN), instead of BUN, could be used as an indicator of urea status in dairy cows and is more practical in the field (Roseler et al., 1993). Variation of MUN concentrations in different milk fractions collected during milking is small (Carlsson and Bergstrom, 1994). It is not only small variation between milk fractions, the variation in MUN between cows fed the same diet is also low. Thus, MUN is a practical and reliable indicator for protein metabolism in dairy cattle.

Urea nitrogen concentrations in bulk tank milk have been used to predict protein supply (Refsdal et al., 1985; Ropstad et al., 1989) and fertility differences between herds (Ropstad and Refsdal, 1987). Elrod and Butler (1993) reported that heifers fed high rumen degradable protein increase BUN concentrations and decrease uterine pH and pregnancy rate. In addition, according to Elrod et al. (1993), cows fed excess amount of protein increase BUN concentration as well as decrease uterine pH. Excess rumen degradable protein has a deleterious effect on embryonic development in lactating cows (Blanchard et al., 1990), but not in nonlactating cows (Garcia-Bojalil et al., 1994). In Thai dairy herds, farmers sometimes feed their cows with high urea levels in the diet and provide insufficient sources of dietary energy. This may result in increased concentrations of urea nitrogen in the body fluid and possibly impair fertility of the cows (Butler et al., 1996). However, data concerning the concentrations of BUN or MUN and postpartum fertility are not well documented in Thailand, and therefore further research or investigation is required.

Minerals and vitamins and reproductive disorders

In animals, macro-minerals such as calcium are needed in relatively large amounts, whereas trace minerals such as selenium are required in very small amounts. Adequate amounts of all of the indicated minerals are essential in the diet, and insufficient supplementation in the diet could have adverse effects on health, production and especially reproduction. The major function of calcium involves muscle contraction. In dairy cows, hypocalcemia usually occurs during periparturient period and clinical signs are usually developed when blood calcium concentrations are lower than 4 mg/dl (Wilde, 2006). Dairy cows under hypocalcemic condition have reduced motility of abomasum and strength of contraction (Daniel, 1983), resulting in decreased feed intake. Reduction of dry matter intake due to hypocalcemia during periparturient period enhances NEB of the cows. Hypocalcemia prolongs calving duration and has a detrimental effect on placenta expulsion and uterine involution, which finally impair postpartum fertility in the cows.

Micronutrients and reproduction in farm animals are reviewed by Smith and Akinbamijo (2000). Selenium is an anti-oxidant that works in conjunction with Vitamin E to prevent and repair cellular damage in the body. Selenium and/or Vitamin E deficiency has been shown to impair immune response. In addition, selenium is associated with thyroid hormone that regulates metabolism, reproduction, circulation and muscle function. Selenium could be transferred through the placenta and milk; therefore, selenium status of the cows will directly affect the health of their calves. Selenium deficiency is associated with delayed conception rate and cystic ovaries in dairy cows (Corah and Ives, 1991; Kommisrud et al., 2005). In a field investigation (data not published) of 94 dairy cows from 17 small-holder farms in Nakhon-Pathom, Thailand, average serum selenium concentrations were 86.0±6.8 (mean± SEM), 89.0±7.2, 88.4±7.8 and 91.4±5.5 ng/ml for lactation number 1, 2, 3 and greater than 3, respectively, which were in a normal range. However, mean serum selenium concentrations varied among farms, meaning that individual farm management affected serum selenium concentrations in dairy cows raised in small-holder farms. Further research is required to investigate the link between selenium status and infertility in small-holder farms with low versus normal blood concentrations of selenium. Vitamin E supplementation on the health and fertility of dairy cows was reviewed by Allison and Laven (2000). A potential mechanism is that vitamin E helps the cow improve ability to respond to oxidative stress. It is possible that the primary effect of vitamin E on retained placenta is through its effect on the activity of leukocytes. In tropical countries where feed quality is a constraint, it may be possible that the dairy cows raised in small-holder farms may be fed vitamin E deficient diet, which is one of potential risk factors of retained placenta. This will finally affect reproductive performance of dairy cows.

Conclusion

Negative energy balance and its consequences are directly or indirectly associated with fertility in postparturient dairy cows. Dairy cows with severe NEB are prone to suffer from other metabolic disorders or infections. Feeding high rumen degradable protein to the cows will result in high blood urea nitrogen concentration, which may relate to reproductive performance. Selenium and vitamin E are closely linked to retained placenta, which is
directly associated with postpartum infertility. Therefore, dairy farmers should pay more attention to offer a good quality and balanced diet to the cows in order to prevent adverse effects of nutritional mismanagement on reproduction particularly during periparturient period.

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