Nutritional Challenges of Lactating Dairy Cattle in a Tropical Climate

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ABSTRACT: Nutrition is frequently cited as the primary challenge for milk production in the tropics. The quality of tropical forages is typically low and forage production is uneven distributed throughout the year due to rainfall patterns. The higher fiber and lignin concentrations common to tropical result in lower than desired supplies of nutrient and energy limiting milk production and decreasing reproduction efficiency. To compensate, concentrates are frequently fed to improve nutrient balance. However, concentrate availability is limited in some areas and most concentrates are expensive compared with forage may limit or prevent their use by smaller producers. Utilization of improved grass varieties with lower lignin and fiber concentrations and higher digestibility would improve nutrient intake and supply which would support improved milk production. Legumes adapted to the tropics for grazing or as harvested forage often stimulate higher intake providing additional metabolizable energy and protein in support of higher milk production. Forage quality issues are compounded by heat stress which alters nutrient intake and metabolism of the dairy cow further limiting milk production and reproductive efficiency. Physical modification of the environment is an effective means of reducing the heat load of the cow. Providing supplemental forage to the animals under shade can improve intake and yield of milk and components. As the genetic potential for milk production increases, dry matter intake increases producing additional metabolic heat. Adjusting the composition of diets fed to compensate for decreased intake is necessary to maintain ruminal function and nutrient balance to support milk production and reproduction. Producer adoption of improved practices to address these challenges is also influenced by factors unrelated to actual nutrition such as cash flow, labor availability and facility or equipment requirements and must be considered when promoting new technologies for specific regions.

Keywords: Dairy production, nutrition, heat stress, forage

INTRODUCTION

Dairy products are recognized as a nutritious source of protein, minerals and vitamins, especially for growing children. Because of their nutrient value, many countries are working to promote dairy production and increase the availability of dairy products locally. As disposable income increases, people are consuming a greater proportion of calories and protein from meat and milk increasing demand. To meet the demand of projected population in 2020, annual milk production in Asia needs to increase at the rate of 3.2% per year relative to production in 1993 (Devendra, 2007). In addition to food production, dairy operations provide jobs and a steady income for families. As families generate income from the sale of milk, they are able to purchase supplies that in turn support the local economy.

There are numerous challenges to dairy production in the tropics. Nutrition is frequently cited as the primary challenge because the quality of tropical forages is typically lower than required to support moderate levels of milk production and production is unevenly distributed throughout the year related to demand. Compared with other regions of the world, concentrate feeds used to provide additional nutrients to support higher levels of milk production and improve reproduction efficiency are expensive and their availability is limited in some regions. These challenges are compounded by heat stress which alters nutrient intake and metabolism of the dairy cow further limiting milk production and reproductive efficiency, especially in herds managed for higher milk yield.

FORAGE QUALITY

Forages common to the tropics are characterized by relatively high concentrations of neutral detergent fiber (NDF) and lignin. Lignin limits fiber digestibility resulting in lower energy availability compared with forages grown in temperature regions (Aminah and Chen, 1989). Evitayani et al. (2004) evaluated the chemical composition and digestibility of seven tropical grasses and five legumes (Table 1). The grasses had higher concentrations of NDF and lower concentrations of crude protein (CP) and ether extract (EE) compared with legumes. Dry matter digestibility (DMD) and CP digestibility (CPD) were highest for legumes compared with grasses, but low relative compared with most temperate forages. The average metabolizable energy (ME) content of these grasses and legumes as calculated using 24 h gas production was 7.6 and 7.3 MJ/kg DM, respectively. These ME values are low and are not sufficient to support moderate milk yields without supplementation. Within the grass and legume varieties evaluated there was considerable variation in the chemical composition, nutrient digestibility and ME concentrations of individual species. Identification of forages with higher digestibility and ME concentrations that are adapted to the soils and climatic conditions is essential for improving nutrition of the dairy cow in order to support higher yields of milk, fat and protein.

Table 1. Chemical composition and in vitro digestibility of select tropical grasses and legumes.1

Species	CP	EE	NDF	ADL	DMD	CPD	ME
Grasses	-------------	% of DM	-------------		----- % -----		MJ/kg
A. gayanus	6.6	2.7	59.3	5.9	49.9	51.9	6.4
A. compressus	10.6	3.9	58.0	6.9	56.2	56.7	6.4
B. decumbens	12.8	2.9	57.8	5.4	56.2	57.2	6.8
C. plectostachyus	16.2	3.2	57.2	6.7	62.2	64.4	9.3
P. maximum	15.1	2.7	62.7	3.6	56.1	55.6	7.9
P. purpuphopides	15.2	2.7	66.2	3.7	54.2	54.5	8.0
P. purpureum	14.4	2.7	66.2	3.7	56.3	62.7	8.5
Legumes							
C. mucunoides	18.3	3.4	55.6	6.8	59.1	65.2	7.1
C. pubescens	18.9	2.8	51.1	4.7	60.8	68.6	6.5
G. maculate	17.5	3.8	40.7	6.5	66.8	65.7	6.8
L. leucocephala	29.1	4.6	24.4	4.9	71.8	70.5	8.3
P. phaseloides	23.2	4.3	46.3	5.4	69.7	72.0	7.9

1Adapted from Evitayani et al., 2004.

Higher dietary NDF concentrations also limit dry matter intake (DMI) of the lactating dairy cow (Mertens, 1985), especially when diets are based on grass which has a slower passage rate compared with legumes. Forages with lower NDF concentrations that are more digestible could improve DMI and support improved nutrition supporting higher production and reproduction efficiency. One approach to improve forage quality and animal performance is to provide improved fertilization and use intensive grazing management. Danes et al. (2013) used crossbred Holstein x Jersey cows grazing pastures based on 70% elephantgrass and 30% Napier grass fertilized with 50 kg of N/ha after each grazing cycle to evaluate the effect of increasing the protein concentration of the concentrate fed from 8.7 to 18.1% of DM. Concentrate was fed at the rate of 1 kg/3 kg milk based on daily milk yield at the beginning of the 10 wk trial. The DMI from pasture averaged 15.9 kg/d and the average chemical composition of the pasture was 18.5% CP, 58.7% NDF and 75.9% in vitro DM digestibility. Pastures were rotationally grazed based on canopy height and cows were offered a new pasture each day and each cycled averaged 28 d. Animals with lower nutrient requirements grazed the pastures to remove additional herbage. No differences were observed in yield of milk, fat or protein (average19.2 kg/d, 661 and 625g/d, respectively. In regions where fertilize is available, this could be an economical alternative to supplemental protein.

Another approach for improving nutrition is to feed supplemental higher quality forages. Nyambati et al. (2003) reported increased DMI when either mucuna or lablab hay was fed along with Napier grass to lactating cows. The DMI of Napier grass did not differ across treatments and the increase in DMI was due to the additional intake of the legume hay. These authors also reported increased DMD which they attributed to improved protein intake from the legumes. The protein content of the grass was low (6.84% of DM) which could limit ruminal fermentation. The additional protein from the legume hay provided additional rumen degradable protein that stimulated greater fiber fermentation by the ruminal microbes. There are many legume species that have been investigated for use in the tropics. One of the challenges for growing legumes in the tropics is the low soil fertility that reduces longevity or required additional inputs to improve soil fertility (Aminah and Chen, 1989). Identifying species suited to the soils and climatic conditions of a particular area is important for adoption by local producers.

SUPPLEMENTATION

To compensate for the lower forage quality, supplemental concentrates are often fed to provide additional nutrients to support higher milk yield and improve reproductive efficiency. Aguilar-Pérez et al. (2009) used suckling crossbred cows calving during the rainy or dry season and grazing stargrass irrigated pastures were fed supplemental concentrate at the rate of 0 or 0.9% of body weight (BW), total intake of DM, CP, and energy increased for cows fed concentrate. The improvements in total energy intake not only supported improved milk yield (7.8 compared with 11.1 kg/d for control and supplemented cows, respectively), but the 90 day in milk pregnancy rate was higher for control and supplemented cows (22% versus 47%, respectively). Aguilar-Pérez et al. (2009) reported that based on the price of milk and concentrate at the time of the trial, a positive return was realized for feeding the supplement at 0.5% of BW.

Another approach is to supplement the diet with higher quality forage. Nyambati et al. (2003) offered cows fed a base diet of Napier grass and supplemented with either mucuna or lablab hay or a commercial dairy concentrate. Improvements in total DMI and yield of milk and components were reported for feeding supplemental legumes along with the Napier grass, but highest total DMI and yield of milk and components was observed for cows fed the supplemental concentrate. These results suggest that improvements can be achieved by supplementing a low quality grass with higher quality legume hay which can be grown by the producers when concentrates are too expensive to purchase or not readily available.

HEAT STRESS

Heat stress results from the inability of the dairy cows to maintain homeothermy as the high temperature and humidity prevents the cows from dissipating body heat (West, 1999). Cows under heat stress have reduced milk yield and reproductive efficiency and greater health problems compared with cows maintained in a thermoneutral environment (West, 1999; Kadzere et al., 2002). Genetic selection for higher milk yield results in greater metabolic heat production as the cows must consume additional nutrients to support higher milk yield which compounds the problem (West, 1999). Methods used to reduce the negative impact of heat stress include: genetic selection for greater heat tolerance, adoption of heat abatement systems or structures, and dietary changes to provide improved nutrition and reduce heat stress.

Boonkum et al. (2011) reported that the effects of heat stress on Thai Holstein cross-bred cows increases greatly with parity and was greater for cows with higher percentage of Holstein genetics (≥93.7%. Holstein) as the temperature humidity index (THI) exceeded 80. The authors stated that Thai cattle were rarely fed to their genetic potential which would not generate as much metabolic heat production as those managed for higher milk yield which mediated the decline in milk yield. As producers breed for higher production, they will need to incorporate measures to alleviate heat stress to realize full benefit from the improved genetics.

Evaporative cooling systems are commonly used in developed countries to reduce heat stress, but these systems have a high initial cost for installing the system and relative high operating cost. Shade is often used to provide protection from solar radiation. In temperate climates, cows provided shade had reduced body temperature and higher milk yield compared to cows grazing pastures without shade (Kendell et al., 2006). These researchers reported that grazing behavior changed as cows with access to shade were not grazing during the midafternoon whereas cows without access to shade continued to graze. Total time grazing was not different among cows with and without access to shade. Granzin (2006) reported results of a trial in which cows were moved to a feeding pad equipped with shade and sprinklers when the THI ≥ 72 and were offered 0 or 3 kg DM/d of lucerne hay. Cows moved to the shaded feedpad with sprinklers with or without supplemental lucerne hay had lower body temperatures compared with those that remained on pasture. Yield of milk, fat and protein was highest for cows provided shade and sprinkler and fed 3 kg/d lucerne hay. The differences in yield were greatest when THI ≥ 82 compared with both cows that remained on pasture and those with access to shade and sprinklers without supplemental lucerne hay. Proving shade can reduce heat stress cows, but feeding supplement forage supports improved nutrient intake and maintains higher milk and component yield.

For higher producing herds, additional nutritional modifications are recommended to reduce the negative effects of heat stress and maintain or support higher milk yield (Staples, 2007). Diets should be formulated to maintain adequate dietary fiber concentrations to minimize ruminal acidosis. Concentrations of sodium, potassium and magnesium should be increased to compensate for increase losses from increased respiration, drooling, and sweeting. Dietary protein concentrations are typically increased to compensate for lower DMI and less rumen degradable protein is fed because of slower ruminal turnover. Some producers also feed supplemental B vitamin supplements as ruminal synthesis may not be adequate under heat stress conditions, especially for early lactation cows and high producing cows. The goal of these modifications is to maintain ruminal fermentation and increase nutrient density to compensate for reduced DMI that normally accompanies heat stress. Additional details of these modifications were previously described in greater detail by West (1999), Kadzere et al. (2002), and Staples (2007).

NUTRITIONAL TECHNOLOGY

Several technologies have been examined for improving ruminant nutrition including: ammonia-urea treatment of low quality forages and crop residues, feeding urea-molasses-multinutrient blocks, urea supplementation, enzyme treatment of forages and feedstuffs, forage fertilization, particle size reduction, etc. (Owen et al., 2012). While evidence supporting the potential of each of these technologies was presented to producers when introduced, the authors noted that adoption by small dairy producers are frequently lower than expected because of non-nutritional reasons including: additional cash required to purchase inputs, additional labor required to implement the technology, poor economic return for using technology, lack of facilities or equipment, or other issue. Larger facilities may be able to adopt these technologies as cash flow, labor, and other factors are not as limiting. It is also important to recognize the current limitation of some new technologies. For example much progress has been made identifying fibrolytic enzymes that can enhance fiber digestibity, but there is considerable variability among research trials with only 20% of trials summarized observing improvements in milk production compared with control diets (Adesogan et al., 2013).

CONCLUSIONS

Nutrition of dairy cows in tropical climates is challenging given the lower quality of grasses and legumes grown and cost and availability of concentrates. These challenges are compounded by heat stress conditions that further limit intake and alter nutrient metabolism. The adoption of higher quality grasses supplemented with legumes can improve the quality of native forages to provide improved nutrition in support of improved milk yield. Provision of shade and supplemental forage when cows are not grazing reduces heat stress and provides additional nutrients that can maintain milk yield as heat stress increases. Many improvements in the nutrition of dairy cows have been identified that could be implemented to improve the nutrition of lactating dairy cows and increase milk yield. As summarized by Owen et al. (2012), it is often difficult to determine which technologies will be adopted by dairy producers as other factors often influence adoption. Thus careful consideration should be given to the potential for successful implementation of technologies introduced to producers as well as the science behind them before introduction.

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