Serum Metabolic Profile Based Assessment of Energy Balance in Tropical and Temperate Crossbred Dairy Cattle at Post-Partum Transition Stage

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Abstract

Objective of the present study was to evaluate the nutritional status of post-partum transition dairy cows in dry-zone and mid-country, through assessment of serum metabolic profile. Tropical and temperate crossbred dairy cows at post-partum transition stage (i.e. 3 weeks post-partum) managed at a medium-scale farm in dry-zone (n=15) and mid-country(n=15) were used for the study. Milk production, body weight and body condition score of cows were recorded. The forage concentrate mixed rations of the farms were analyzed for nutrient and energy contents. Cows were bled and serum was analyzed for non-esterified fatty acids (NEFA), beta-hydroxybutyrate (BHBA), urea, albumin, calcium and phosphorous contents. While serum NEFA, urea and calcium contents were significantly ($P<0.05$) greater, serum BHBA content was significantly ($P<0.05$) lower in temperate crossbred cows compared to tropical crossbred cows at post-partum transition stage. The serum BHBA content of tropical crossbred cows and NEFA and urea content of temperate crossbred cows at post-partum transition stage were exceeded the upper critical limit of the reference range suggested to determine the state of energy balance. In conclusion, both tropical and temperate dairy cows at post-partum transition stage suffer from negative energy balance under the current feeding system in studied farms in dry-zone and mid-country. The BHBA level is suggested as an appropriate indicator to assess the state of energy balance in dairy cows, managed under free-stall system. Adaptation of appropriate energy dense feeding programs focusing particularly overcoming energy imbalance are warrant to optimize the productivity in dairy cattle of mid-country and dry-zone.

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Introduction

Dry-zone house for 56% of domestic cattle population which comprised of tropical crossbred and non-descriptive cattle in Sri Lanka. Of the domestic cattle herd, 75% of the genetically improved cattle (i.e. temperate pure or their crosses) are managed in the mid-country (Ibrahim *et al.*, 1999). Therefore, both regions could play a significant role in the domestic dairy industry. Despite high genetic potential for milk production the productivity of both temperate and tropical crossbred dairy cows, still lies below 10 L/cow/day in dry-zone and mid-country. Maintenance of better nutritional status is one of the key factors leading to high productivity particularly in improved dairy cattle. Hence, assessment of nutritional status of dairy cows is of utmost importance in dairy cattle husbandry. Nutritional assessment through blood metabolic profile is one of the novel techniques used in developed countries (Shapiro and Lusis, 2015). Further, blood metabolic profile in combination with body condition score (BCS) of animals and nutritive value of feed could provide precise results in nutritional assessment of dairy cows (Kida, 2003).

Transition period (i.e. period from pregnant, non-lactating state to non-pregnant, lactating state) is critical in the sense of nutritional demand and disease susceptibility in dairy cows. The state of Negative energy balance (NEB) caused by drastic increase in nutrient demand for milk production while greater decrease in dry matter intake (i.e. about 30%) is the biggest challenge faced by transition cows. The dry matter intake (DMI) could be reduced due to calving stress and endocrine changes occur during parturition and beginning of lactation (Leblanc, 2010). Hence, nutritional assessment of dairy cows at transition stage is beneficial to propose better feeding strategy to make sure success of the subsequent lactation period. Such assessment has never been tried in Sri Lanka. Hence, the objective of this paper was to assess the nutritional status of temperate and tropical crossbred dairy cows in two selected farms in mid-country and dry zone of Sri Lanka through blood metabolic profile.

Materials and Methods

Selection of cows and field data collection

Tropical and temperate crossbred dairy cows at post-partum transition stage (i.e. 3 weeks post-partum) at medium-scale cattle farms in dry-zone (i.e. Haifah Farm, Valikanda, n=15) and mid-country (i.e. Sri Lanka Farm, Nawalapitiya, n=15), respectively were selected for the study. Cows of both farms were fed with forage concentrate mixed rations. Feed samples were drawn and calculated for nutrient and energy contents (Table 1). Milk production, body weight and body condition score (i.e. 1-5 scale) were also recorded.

Table 1: Ration composition, nutritive value, nutrient requirement and milk production of tropical and temperate crossbred dairy cows at post-partum transition stage

	Tropical crossbred cows	Temperate crossbred cows
Ration composition (g/kg Dry matter)		
- Grass	568.27	435.52
- Coconut Poonac	-	208.90
- Maize	6.64	-
- Dhal husk	194.83	120.71
- Rice polish	183.03	210.04
- Beer pulp	-	11.51
- Molasses	32.47	-
- Mineral mixture	-	6.64
- Salt	-	6.64
- Di-Calcium Phosphate	14.76	-
Nutritive value of ration*		
- DM (%)	32.57	35.33
- CP (%)	10.48	13.39
- ME (MJ/kg DM)	8.12	8.33
Nutrient requirement of cows*		
- CP (kg/cow/day)	1.19	1.20
- ME (MJ/cow/day)	98.00	94.43
Milk production (L/cow/day)	8.5	10.5

*, Computed.

Determination of serum metabolic profile

Each cow was bled through jugular or Coccygeal vein, into blood collecting tubes without EDTA. Blood samples were allowed to clot at room temperature for 3h before centrifugation at 2000 g for 10 minutes. Harvested serum was stored at -20°C until determine the serum metabolic profile. The content of serum non-esterified fatty acids (NEFA), beta-hydroxybutyrate (BHBA), urea, albumin, calcium and phosphorous were determined using Randox serum test kits (Randox Laboratory Limited, United Kingdom) and auto analyzer (i.e. 3000 Evolution® auto analyzer, Biochemical System International, Arezzo, Italy).

Data analysis

Data were subjected to statistical analysis using the version 9.2 of SAS software. Pooled t-test was performed to compare serum metabolic profiles of tropical and temperate crossbred dairy cows at post-partum transition periods. Further, means of metabolite contents were compared with respective upper and lower critical limits of the reference ranges proposed to assess the state of energy balance for tropical and temperate dairy cows. Mann-Whitney U test was performed to compare the BCS of the cows.

Results and Discussion

The reference ranges proposed for the serum metabolites of tropical and temperate crossbred dairy cows for determination of state of negative energy balance are presented in Table 1(Pennstate Extension, 2017; Quiroz-Rochaet et al., 2009; Lager and Jordan, 2002; Puls, 1989). The content of serum NEFA (0.37±0.06 mmol/L), albumin (3.16±0.07 g/dL), urea (11.55±0.74 mg/dL), calcium (7.48±0.22 mg/L) and phosphorous (6.95±0.33 mg/L) of the tropical crossbred cows were found to be within the respective reference range. Yet, the serum BHB Acontent (1.32±0.11 mmol/L) of the cows was greater than the upper critical limit of the reference range. Meanwhile, the temperate crossbred cows recorded serum BHBA (0.53±0.05 mmol/L), albumin (2.99±0.21 g/dL), calcium (9.11±0.45 mg/L) and phosphorous (7.04±0.19 mg/L) within the respective reference range. Both serum NEFA (0.62±0.15 mmol/L) and urea (30.09±2.60 mg/dL) contents of them exceeded the upper critical limit of the respective reference range (Table 2).

Table 2: Comparision of serum metabolic profile of tropical and temparate crossbred dairy cows at post-partum transition stage

Metabolite	Tropical crossbred cows				Temperate crossbred cows			
	Metabolite content			Reference range	Metabolite content			Reference range
NEFA (mmol/L)*	0.37	±	0.06	0.01-0.52	0.62	±	0.15	0.01-0.52
BHBA (mmol/L)*	1.32	±	0.11	0.22-1.18	0.53	±	0.05	0.30-1.50
Albumin (g/dL)	3.16	±	0.07	2.70-4.70	2.99	±	0.21	2.80-3.90
Urea (mg/dL)*	11.55	±	0.74	5.00-27.00	30.09	±	2.60	5.00-27.00
Ca (mg/L)*	7.48	±	0.22	6.56-10.44	9.11	±	0.45	7.00-11.00
P (mg/L)	6.95	±	0.33	4.50-8.00	7.04	±	0.19	4.30-8.00

**, Dairy cows at post-partum transition stage are significantly different (P<0.05).*

Although, the nutrient demand of cows for milk production is enhanced dramatically with the onset of lactation, the DMI increases slowly causing them to mobilize body reserves. Hence, triacylglycerols of the adipose tissues are mobilized as NEFA to meet the energy demands particularly during the post-partum transition stage in dairy cows. Elevated levels of serum NEFA indicates negative energy balance (NEB) in dairy cows at transition period (Chilliard *et al.*, 2000). Similar situation was observed in the present study only in the temperate crossbred cows at post-partum transition stage. Therefore, the findings provide evidence that the temperate crossbred cows experience NEB during the post-partum transition stage under the present management of the mid-country farm studied. Additionally, the serum NEFA content of the temperate crossbred cows at the post-partum transition stage was significantly *(P<0.05)* greater than that of tropical crossbred cows at the stage. Contrary, the serum BHBA content of temperate crossbred cows at post-partum transition stage was significantly *(P<0.05)* lower than that of tropical crossbred cows. Tropical and temperate crossbred cows of the present study were managed in free-stall and tie-stall systems, respectively. Therefore, it is obvious that the tropical cows were more active compared to the temperate crossbred cows. Muscle activity of active animals leads to greater blood flow to muscles and uptake of NEFA as an energy source of muscle tissues compared to less active animals. Hence, oxidation of NEFA for energy is more in active animals (van Hall, 2015). Yet, NEFA is partially oxidized and converted in to ketone bodies such as BHBA and acetoacetate due to lack of oxaloacetate when animals experience NEB. Hence, more active cows oxidize more serum NEFA and record greater serum BHBA when they experience NEB. Therefore, despite the low level of NEFAthe tropical crossbred cows also experience NEB during the post-partum transition stage under the current management in the dry-zone farm.

Serum calcium and urea contents of tropical crossbred cows were significantly *(P<0.05)* lower than that of temperate crossbred cows at the post-partum transition stage. Garcia *et al.* (2017) have also reported greater serum calcium and urea contents in high producing cows than low producing cows. The present study recorded greater milk production in temperate crossbred cows compared to tropical crossbred cows (i.e. 10.5 vs. 8.5 L/cow/day). There is evidence that the serum calcium content is affected by the breed of cattle as well. Hammond (1997) reported that dairy cow rations with adequate protein and with less dietary energy content increased serum urea content due to inefficient utilization of ammonia produced in the rumen. Thus, it can be argued that significantly *(P<0.05)*greater serum urea recorded (i.e. exceeding the upper critical limit of reference range)among the temperate crossbred cows is an indication of feeding them with poor energy diet.

Though, the body condition scores (BCS) of tropical crossbred cows (2.92±0.63) at post-partum transition stage was significantly *(P<0.05)* greater than that of their counterparts (2.50±0.18), both groups reported BSC below 3.0. Poor nutritional status of post-partum dairy cows is reflected by BCS below 3.0. Further, lower body condition at calving may indicate poor productive and reproductive performances in the subsequent lactation.

Dairy cow rations of tropical and temperate crossbred lactating dairy cows of the present study meet the respective nutritional requirements (Table 1). However, as proven before, both groups experienced NEB during their post-partum transition period. Therefore, regardless of nutritive value of rations, low nutrient intake may have created energy imbalance in both tropical and temperate crossbred dairy cows at post-partum transition stage. Hence, as proven by Rabelo *et al.* (2003), feeding the crossbred transition cows of the farms with energy dense rations will result more energy intake and thereby high milk production in the subsequent lactation.

It can be concluded that both tropical and temperate crossbred dairy cows at post-partum transition stage suffer from NEB under the current tie-stall and free-stall feeding systems of the studied farms in dry-zone and mid-country, respectively. The level of BHBA is suggested to be a better indicator to determine the state of energy balance of dairy cows, managed under free-stall system. Poor DMI may be one of the main causes for the state of NEB in both tropical and temperate crossbred dairy cows in dry-zone and mid-country which may be able to overcome by feeding post-partum dairy cows with energy dense rations.

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