



## Evaluation of Energy Balance in Tropical and Temperate Crossbred Dairy Cows at Post-Partum Transition Stage: A Case Study

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### ABSTRACT

Objective of the present study was to assess the energy balance of tropical (Sahiwal x Jersey) and temperate (Friesian x Jersey) crossbred dairy cows in Sri Lanka using serum metabolic profile. The study consisted of tropical and temperate crossbred dairy cows which were at post-partum transition stage, and were from two medium-scale farms in low country dry zone, and mid country intermediate zone, respectively. Each cow was bled (0800 hours) on the day of data collection and serum metabolic profile was assessed. Milk production, body weight and body condition score (BCS) of cows were recorded whereas, dry matter, crude protein and metabolizable energy contents of the mixed rations fed to cows in both farms were analysed. Results revealed that, serum non-esterified fatty acids (NEFA), urea and calcium contents were significantly ( $P<0.05$ ) high, serum beta-hydroxybutyric acid (BHBA) content was significantly ( $P<0.05$ ) low in temperate crossbred cows compared to those of tropical crossbred cows at post-partum transition stage. The serum BHBA content ( $1.32\pm 0.11$  mmol/L) of tropical crossbred cows, and NEFA ( $0.62\pm 0.15$  mmol/L) and urea ( $30.09\pm 2.60$  mg/dL) content of temperate crossbred cows at post-partum transition stage exceeded the upper critical limit of the reference range proposed for the determination of NEB. The recorded inferior BCS of both tropical ( $2.9\pm 0.6$ ) and temperate ( $2.5\pm 0.2$ ) crossbred dairy cows further confirmed their poor energy balance under the present feeding system. It was concluded that, both tropical and temperate crossbred dairy cows at post-partum transition stage suffer from negative energy balance under the current feeding system in the two medium-scale farms studied. The BHBA level was suggested as more appropriate indicator to assess the energy balance in dairy cows, managed under free-stall system. Adoption of energy-dense feeding programs and overcoming energy deficiency are suggested to optimize the productivity of dairy cattle in low-country, dry-zone and mid-country intermediate-zone.

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## INTRODUCTION

Fifty-six percent of Sri Lankan cattle population is found in the dry-zone. They are either tropical crossbred or non-descriptive cattle. Large proportion (75%) of the genetically improved cattle (i.e. pure temperate or their crosses) is managed in the mid country and up country farms. Crossbred cows managed in these regions play a significant role in domestic dairy industry (Ibrahim *et al.*, 1999). Despite great genetic potential for milk production, productivity of crossbred cows currently lies below 10 L/cow/day in both dry zone and mid country areas (Subasinghe and Abeygunawardena, 2011). Appropriate 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. Investigation of serum metabolic profile is a novel technique used to assess nutritional status of dairy cows in developed countries (Shapiro and Lusi, 2015). A precise nutritional assessment in dairy cows could be made by combining blood metabolic profile and body condition score (BCS) and nutritive value of feed (Kida, 2003).

Period between three weeks pre-partum and three weeks post-partum (transition period) is considered as a critical period in the sense of nutritional demand and disease susceptibility in dairy cows (Bell, 1995; Drackley, 1999; Leblanc, 2010). Negative energy balance (NEB) caused by severe increment in nutrient demand for milk production coupled with greater decrease (i.e. about 30%) in dry matter intake (DMI) is the biggest challenge faced by transition cows (Goff and Horst, 1997). Calving stress and endocrine changes that occur during early stages of the lactation are two main reasons for the reduction of DMI (Leblanc, 2010). Hence, nutritional assessment of dairy cows at transition stage is beneficial to propose better feeding strategy which ensures successful subsequent lactation yield. Such assessment has never been carried out in Sri Lanka. Therefore, the present study was designed to

assess the energy balance using serum metabolic profile in temperate and tropical crossbred dairy cows at post-partum transition stage in two selected dairy cattle farms each in mid country intermediate zone (MCIZ), and low country dry zone (LCDZ) of Sri Lanka.

## MATERIALS AND METHODS

### Experimental Sites and Animals

The sampling protocol suggested by PennState University Extension (2017) was followed. Fifteen tropical crossbred (Sahiwal x Jersey) dairy cows managed in a LCDZ farm (Haifah farm, Walikanda, 7°53'N and 81°09'E) and 15 temperate crossbred (Friesian x Jersey) dairy cows managed in a MCIZ farm (Sri Lak farm, Nawalapitiya, 7°04'N and 80°56'E) were selected for the study. All 30 cows were multiparous and were at post-partum transition stage. They were fed ad-libitum with a mixed ration twice a day after morning and evening milking. Table 1 presents the details of animals and feeds used in the study.

### Data collection:

On the day of data collection, morning and evening milk production, body weight and body condition score (1-5 scale as described by Ferguson *et al.*, 1994) of cows were recorded.

Representative ration samples (i.e. 500g) were collected from both morning and evening meals on the previous day of blood sample collection, and stored at -20°C. They were allowed to thaw at room temperature, dried at 105°C and ground using a hammer mill to pass through a 0.5mm sieve (Glen Creston Ltd., United Kingdom). Morning and evening feed samples were then mixed to form composite samples, and stored in clean, labeled bottles until analyzed for dry matter (AOAC 934.01), crude protein (AOAC 984.13), and gross energy content (using a bomb calorimeter; Model No: A1435DDEE, Parr Instruments, Illinois, USA).

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

	Tropical crossbred cows	Temperate crossbred cows
<u>Ration composition (g/kg Dry matter)</u>		
- Grass ( <i>Panicum maximum</i> )	568.3	435.5
- Coconut cake	-	208.9
- Maize ( <i>Zea mays</i> ) grain powder	6.6	-
- Dhal dust	194.8	120.7
- Rice polish	183.0	210.0
- Beer pulp	-	11.5
- Molasses	32.5	-
- Mineral mixture	-	6.6
- Salt	-	6.6
- Di-calcium phosphate	14.8	-
<u>Nutritive value</u>		
- DM (%)	32.6	35.3
- CP (%)	10.5	13.4
- ME (MJ/kg DM)	8.1	8.3
<u>Nutrient requirement*</u>		
- CP (kg/cow/day)	1.2	1.2
- ME (MJ/cow/day)	98.0	94.4
Milk production (L/cow/day)	8.5	10.5

\* Nutrient requirements were estimated considering respective body weight (Table 3) and production of tropical and temperate crossbred cows as recommended by National Research Council (2001).

### Analysis of Blood Metabolic Profile:

Blood samples were drawn through jugular vein or coccygeal vein of each cow, into blood collecting tubes without EDTA, at 0800 hours, on the day of data collection. They were allowed to clot at room temperature for 3 hours before centrifuging at 2000 X g for 10 minutes. Serum was then separated and stored at -20°C until metabolic profile was determined. The serum non-esterified fatty acids (NEFA), beta-hydroxybutyric acid (BHBA), urea, albumin, calcium and phosphorous contents 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:

Pooled t-test was performed to compare serum metabolic profiles of tropical and temperate crossbred dairy cows at post-partum transition period using version 9.2 of SAS software (SAS Institute Inc., 2003). 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 as given in Table 2.

**Table 2: Reference range of serum metabolites of temperate and tropical crossbred dairy cows for identification of status of negative energy balance**

Metabolite	Critical limits for tropical crossbred cows		Critical limits for temperate crossbred cows	
	Lower limit	Upper limit	Lower limit	Upper limit
NEFA (mmol/L)	0.01	0.52 <sup>1</sup>	0.01	0.52 <sup>1</sup>
BHBA (mmol/L)	0.22	1.18 <sup>2</sup>	0.30	1.50 <sup>1</sup>
Albumin (g/dL)	2.70	4.70 <sup>3</sup>	2.80	3.90 <sup>4</sup>
Urea (mg/dL)	5.00	27.00 <sup>3</sup>	5.00	27.00 <sup>3</sup>
Ca (mg/L)	6.56	10.44 <sup>2</sup>	7.00	11.00 <sup>5</sup>
P (mg/L)	4.50	8.00 <sup>1</sup>	4.30	8.00 <sup>3</sup>

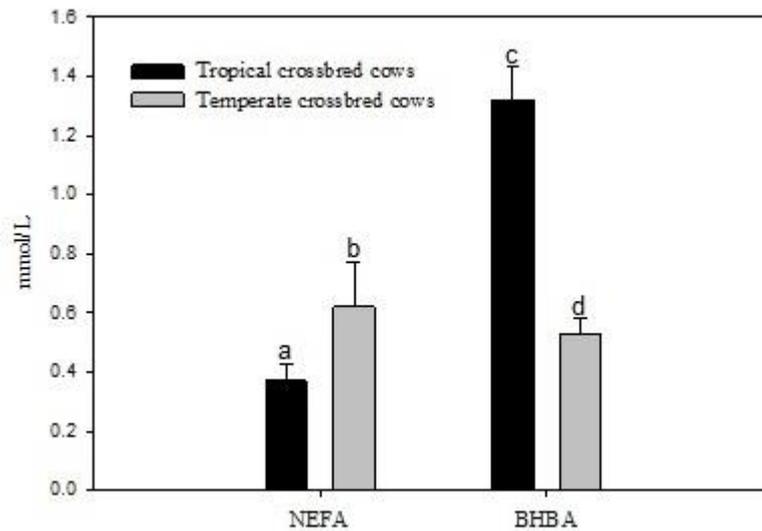
<sup>1</sup> PennState Extension, 2017; <sup>2</sup> Quiroz-Rocha *et al.*, 2009; <sup>3</sup> Lager and Jordan, 2012; <sup>4</sup> Kahn and Line, 2011; <sup>5</sup> Puls, 1989.

## RESULTS AND DISCUSSION

Serum NEFA, albumin, urea, calcium and phosphorous contents of tropical crossbred dairy cows were found to be within the respective reference ranges. However, their serum BHBA content was greater than the upper critical limit of the reference range (Figures 1 - 3). The temperate crossbred cows recorded serum BHBA, albumin, calcium and phosphorous contents within the respective reference range while serum NEFA and urea contents exceeded the upper critical limit of respective reference ranges.

Although the nutrient demand of dairy cows for milk production is enhanced intensely with the onset of lactation, the DMI increases slowly causing them to mobilize body reserves (Reist *et al.*, 2002). Hence, triacylglycerols of the adipose tissues are mobilized as NEFA to meet the energy demand particularly during their post-partum transition stage. Elevated levels of serum NEFA indicates NEB in dairy cows at transition period (Chilliard *et al.*, 2000). A similar situation was observed only among the temperate crossbred cows at post-partum transition stage in the present study (Figure 1). Therefore, the findings provide evidence that the temperate crossbred cows experience NEB during the post-partum transition stage under the present management in the MCIZ. Additionally, the serum NEFA content of temperate crossbred cows at post-partum transition stage was

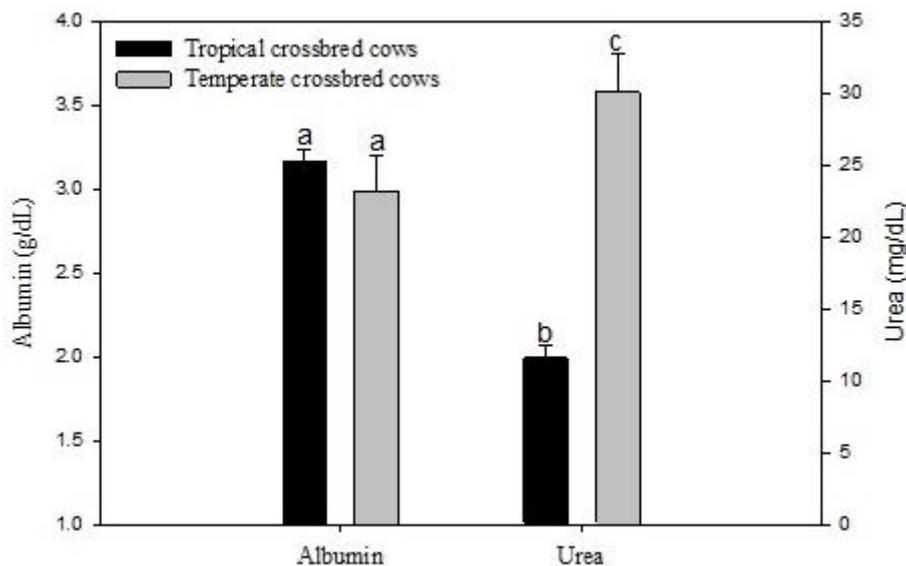
significantly ( $P < 0.05$ ) greater than that of tropical crossbred cows. Contrary, the serum BHBA content of temperate crossbred cows at post-partum transition stage was significantly ( $P < 0.05$ ) lower than that of tropical crossbred cows. Tropical and temperate crossbred cows of the present study were managed in free-stall and tie-stall systems, respectively. Therefore, it is obvious that the tropical cows were more active compared to temperate crossbred cows. Muscle activity of active animals leads to a comparatively high blood flow to muscles and uptake of NEFA as an energy source for 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 into ketone bodies such as BHBA and acetoacetate due to lack of oxaloacetate, when animals experience NEB (McDonald *et al.*, 2011). Hence, active cows oxidize more serum NEFA and record greater serum BHBA than their counterparts when experience NEB. Adewuyi *et al.*, (2006) also reported that walking activity cause to decrease the serum NEFA content. Therefore, despite the low level of NEFA (Figure 1) the tropical crossbred cows also experience NEB during the post-partum transition stage under the current free-stall management in the LCDZ. Further, the findings suggest that the level of BHBA is a better indicator than NEFA to assess the state of energy balance of cows managed under free-stall system.



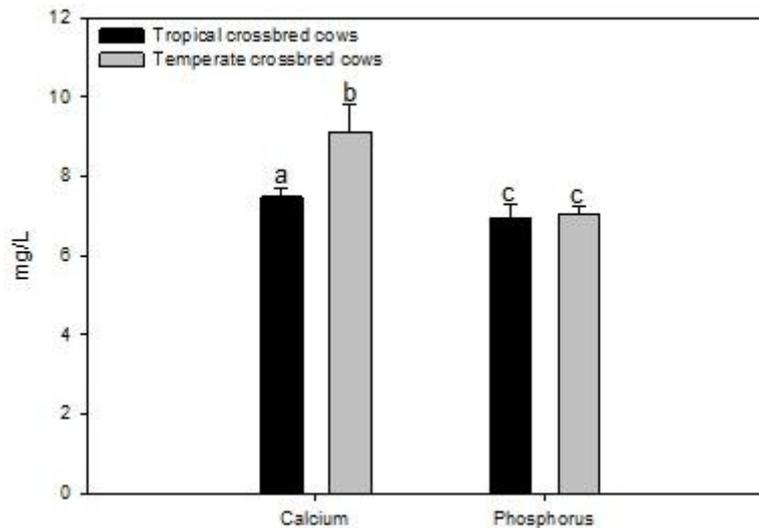
**Figure 1: Serum NEFA and BHBA contents of tropical and temperate crossbred dairy cows at post-partum transition stage**

Serum calcium and urea contents of tropical crossbred cows were significantly ( $P < 0.05$ ) lower than those of temperate crossbred cows at the post-partum transition stage (Figures 2 and 3). Garcia et al. (2017) and Sosa et al. (2010) have also reported greater serum calcium and urea contents in high producing cows than in low producing cows.

The present study recorded high milk production in temperate crossbred cows (10.5 L/cow/day) compared to tropical crossbred cows (8.5 L/cow/day). Priscaru (2014) confirmed that there is a variation in the serum calcium content among different breeds (Fleckvieh, Pinzgauer, Black Spotted Romanian) of cattle.



**Figure 2: Serum albumin and urea contents of tropical and temperate crossbred dairy cows at post-partum transition stage**



**Figure 3: Serum calcium and phosphorus contents of tropical and temperate crossbred dairy cows at post-partum transition stage**

Hence, it can be suggested that owing to the differences in yield and genetic makeup, the serum calcium content between tropical and temperate crossbred dairy cows at post-partum transition stage varies. Hammond (1997) reported that dairy cow rations with adequate protein with less dietary energy increased serum urea content due to inefficient utilization of ammonia production 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 of energy deficient diet.

Though the BCS of tropical crossbred cows at post-partum transition stage was significantly ( $P < 0.05$ ) greater than that of their counterparts, both groups reported BSC below 3.0 (Table 3) which is a reflection of poor nutritional status of post-partum dairy cows. Further, lower body condition at calving may indicate poor productive and reproductive performances in the subsequent lactation (Roche *et al.*, 2009). Thus, the productive and reproductive performance of tropical and temperate crossbred dairy cows will be greatly lower than their genetic potential under the

present management of the two respective farms in LCDZ and MCIZ.

The CP and ME requirements for tropical and temperate cows with 408.6 kg and 356.5 kg body weight (Table 3) producing 8.5 L/day and 10.5 L/day of milk (Table 1), respectively were estimated according to recommendations of NRC (2001). As presented in Table 1, composition of the rations offered for dairy cows in the present meets the respective nutritional requirements despite that both groups of cows experienced NEB during post-partum transition. Therefore, regardless of nutritive value of the rations, low nutrient intake may have created energy deficiency in both tropical and temperate crossbred dairy cows studied. Several studies reported that the DMI of dairy cows at transition was retarded by multiple stresses caused by numerous metabolic and endocrine changes occurs during the period (Zamet *et al.*, 1979; Lean *et al.*, 1994; Mendelez, 2008; Gross *et al.*, 2013). Therefore, as reported by Rabelo *et al.* (2003), feeding the crossbred transition cows with energy dense rations will result more energy intake and thereby high milk production in the subsequent lactation.

**Table 3: Body weight and body condition score (BCS) of tropical and temperate crossbred dairy cows at post-partum transition stage**

Parameter	Tropical crossbred cows <sup>†</sup>	Temperate crossbred cows <sup>†</sup>
Body weight (kg)	408.4 ± 6.5 <sup>a</sup>	356.5 ± 13.3 <sup>b</sup>
BCS	2.9 ± 0.6 <sup>a</sup>	2.5 ± 0.2 <sup>b</sup>

<sup>†</sup>, Mean±SE

Means followed by different superscripts within a row are significantly different ( $P < 0.05$ ).

## CONCLUSIONS

It can be concluded that both tropical and temperate crossbred dairy cows at post-partum transition stage suffer from NEB under the tie-stall and free-stall feeding systems currently practiced in LCDZ and MCIZ, respectively. The level of serum BHBA is an appropriate indicator to assess the state of energy balance of dairy cows, managed under free-stall system. Poor DMI could be suggested as one of the main causes for the NEB status in both tropical and temperate crossbred dairy cows in LCDZ and MCIZ. Thus, the condition could be overcome by feeding the post-partum dairy cows with energy dense rations.

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