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METABOLIC PROFILE OF POST-CALVING CROSSBRED DAIRY COWS UNDER DIFFERENT PRODUCTION SYSTEMS IN A TROPICAL ENVIRONMENT

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ABSTRACT

Common levels of blood metabolites of post-calving crossbred dairy cows under different production systems in Batangas and Laguna, Philippines were determined to deduce the general health and nutritional status of the animals. Thirty-six apparently healthy Holstein Friesian x Sahiwal post-calving cows were selected using purposive sampling. Blood samples were collected via the coccygeal vein and were analyzed for non-esterified fatty acids (NEFA), beta-hydroxybutyrate (BHBA), glucose, cholesterol, blood urea nitrogen (BUN), calcium (Ca), phosphorus (P), potassium (K) and magnesium (Mg). Mean NEFA, BHBA, cholesterol and P concentrations in the blood and NEFA-to-cholesterol ratio were within the normal range. Mean glucose and BUN concentrations, on the other hand, were higher than the maximum range while macro minerals Ca, K and Mg were lower than the minimum normal levels. Only mean NEFA concentrations from the intensive and semi-intensive production systems were significantly different (P<0.05). Mean concentrations of BHBA, glucose, cholesterol, BUN, Ca, P, K and Mg and NEFA-to-cholesterol ratio had no significant differences among the three production systems. Therefore, apparently healthy crossbred post-calving dairy cows from Batangas and Laguna did not experience negative energy balance but had macro mineral (Ca, K and Mg) deficiency when compared with reference standards in temperate countries.

Keywords: lactating cows, metabolite, negative energy balance, post-calving

INTRODUCTION

The dairy industry of the Philippines is still in its developing stage compared to other tropical countries. The main concern of Filipino dairy farmers, aside from the high cost of stocks, is the adaptability of dairy cattle in the Philippine environment which greatly affects production performance. Most of the dairy animals in the country are crossbreds, taking advantage of the higher milk production of the temperate breed and the resistance to heat and parasites of the zebu breed. However, peak productivity cannot be obtained with breed alone, especially during the transition period wherein 75% of all diseases usually

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occurs which includes displaced abomasum, milk fever, retained placenta, metritis, mastitis, and ketosis. The transition period covers three weeks before to three weeks after calving wherein the animal shifts from a pregnant, non-lactating state to a non-pregnant, lactating state and is considered as the most stressful period experienced by the cow during its lactation (Lager and Jordan, 2012). Rosatto *et al*. (2001) stated that this is the period in which severe metabolic changes are experienced by the animal challenging it to maintain a homeostatic balance to compensate for the high nutrient demands of milk production. Proper management and nutrition must be provided to allow the animals to reach their optimum productive capability (Knowlton and Nelson, 2003). Between the two, nutrition significantly affects milk production of dairy cows. In the Philippines, dairy farmers are not very particular on the amount of nutrients provided to their animals given the quality and quantity of roughage available. Hence, metabolic profiling could be used as one of the tools to assist farmers in determining disease risks due to nutritional deficiencies in the farm. Metabolic profiling is a series of analytical tests to determine levels of metabolites such as non-esterified fatty acids (NEFA) and beta-hydroxybutyrate (BHBA), to name a few, in animals which is especially useful during the transition period (Van Saun, 2016b). The levels of these metabolites could be used to determine whether a herd is at risk of nutritional and metabolic diseases or for disease diagnostic (DairyCo, 2012). In other countries, specifically in the temperate regions, metabolic profiling is used as part of a multidisciplinary approach in monitoring health of dairy herds (Whitaker *et al.*, 1999). However, limited researches had been conducted in tropical environments, such as in the Philippines, and in comparing the use of the metabolic profile of dairy cattle from smallholder and commercial farms and in different production systems, to help improve animal performance. This study was conducted to determine the level of blood metabolites of post-calving crossbred dairy cows in Batangas and Laguna, Philippines under extensive, intensive and semi-intensive production systems.

MATERIALS AND METHODS

The study was conducted from June 2015 to August 2016 at smallholder and commercial dairy farms in Batangas and Laguna, Philippines. A total of 36 apparently healthy Holstein Friesian crossed with Sahiwal (HF x SH) post-calving cows (8 to 15 days after calving) with an average weight of 366.23 ± 44.90 kg on their first to second parity were selected using purposive sampling. There was no intervention in the management practices implemented in the farms. Body condition scores (Jones and Heinrichs, 2004) were noted during blood collection and only cows with a BCS of 2.50 or better and are physically healthy were included in the study.

The animals were restrained in chutes during blood collection wherein approximately 4 mL of blood was collected from each animal using a yellow top vacutainer tubes via the coccygeal or tail vein at approximately the same time each day, 2 to 5 hours after the first feeding in the morning, as recommended by Hoff and Duffield (2013). The serum samples were spun and separated within one hour after collection and frozen at 0 °C until needed for analysis. Serum samples were analyzed for NEFA, BHBA, glucose, cholesterol, blood urea nitrogen (BUN), calcium (Ca), phosphorus (P), potassium (K) and magnesium (Mg) using Rayto Semi-automatic Chemistry Analyzer at the National Dairy Authority Central Office in Quezon City, Philippines. The chemistry analyzer works by measuring the characteristic light absorbance of the serum sample and use it in determining the amount of analyte calculated through specific pre-calibrated quantitative equations. Blood serum metabolites concentration data obtained from the farms were compared with the existing reference values used in temperate countries using descriptive analysis. Analysis of Variance (ANOVA), on the other hand, was used to determine differences in levels of metabolites in the different production systems after which, means were subjected to Least Significant Differences (LSD) test if differences were significant.

RESULTS AND DISCUSSION

The mean metabolite concentrations obtained from post-calving dairy cows are presented in Table 1. Mean values were compared to standards used by dairy farms in temperate countries.

The mean NEFA blood levels obtained from post-calving cows were all within the normal range for all production systems. NEFA is a good indicator of negative energy balance (NEB) (Oetzel, 2003) especially during near calving wherein the dairy cows will shift from a pregnant state to a lactating state thereby mobilizing NEFA from the adipose tissues due to the decrease in dry matter intake (DMI) during the last week before calving (Adewuyi, 2005). NEFA concentrations from the intensive and semi-intensive production systems were significantly different ($P<0.05$) but not with animals from the extensive production system versus the former two production systems. It is difficult to interpret and evaluate NEFA concentrations of milking cows since it is expected that these animals experience NEB after calving (Oetzel, 2003). Therefore, NEFA testing is ideally performed on pre-calving animals with samples obtained within one week of giving birth (Duffield and LeBlanc, 2009). It should be noted, however, that cows with elevated pre- or post-calving NEFA concentrations are not implicitly meant to experience postpartum diseases (Van Saun, 2010).

BHBA blood levels from the different production systems were within the normal range. Beta-hydroxybutyrate is another metabolite which, together with NEFA, is a good reflection of the energy status of transition cows. Concentrations of BHBA becomes greatly elevated following calving which predisposes the cows to postpartum diseases such as left displaced abomasum, metritis and ketosis (Van Saun, 2010) due to NEB (Hoff and Duffield, 2013). Therefore, it is best to use BHBA analysis on post-calving cows within the first month after calving, especially in the first two weeks. According to Oetzel (2003), subclinical ketosis is usually experienced by 15% of early lactation cows which is ideally not more than 10%. There were only 6.67%, 10% and 9.1% for animals in the extensive, intensive and semi-intensive production systems, respectively, that had elevated concentrations of BHBA. This was calculated by dividing the number of animals with BHBA levels below the minimum range with the total number of animals tested and multiplied with 100. However, a higher reference value for post-calving BHBA level was mentioned by DairyCo (2012) at 0.4 to 1.2 mmol/Li. Using this reference value, 100% of the cows from the extensive, intensive and semi-intensive production systems were within the normal range. When compared, the mean levels of BHBA from the three production systems were not significantly different. Cows have different clinical response to elevated BHBA concentrations and not all cows with elevated NEFA would also have elevated BHBA concentrations (Van Saun, 2010).

Table 1. Mean metabolite concentrations of post-calving dairy cows from Batangas and Laguna, Philippines.

Metabolite mmol/Li	Normal Range mmol/Li	Production System			P- value
		Extensive	Intensive	Semi-intensive	
No. of head		15	10	11	
NEFA					
Mean ± SD		0.39 ± 0.15[ab]	0.31 ± 0.08[b]	0.52 ± 0.21[a]	0.0147
Range	0.01 – 0.52[1]	0.10 - 0.60	0.19 - 0.42	0.18 - 0.91	
BHBA					
Mean ± SD[ns]		0.41 ± 0.26	0.63 ± 0.26	0.59 ± 0.21	0.0770
Range	0.16 – 0.85[1]	0.05 - 1.00	0.22 - 1.16	0.32 - 1.12	
Glucose					
Mean ± SD[ns]		4.77 ± 0.93	4.97 ± 0.77	4.64 ± 0.77	0.6628
Range	2.33 – 3.77[1]	3.54 - 6.83	3.51 - 5.95	3.28 - 5.66	
Cholesterol					
Mean ± SD[ns]		1.99 ± 0.57	2.10 ± 0.89	1.98 ± 0.62	0.9060
Range	1.63 – 6.55[1]	0.75 - 2.91	1.07 - 3.72	0.72 - 2.79	
NEFA-to-Cholesterol Ratio[ns]	0.03 – 0.40[1]				
Mean ± SD[ns]		0.22 ± 0.16	0.18 ± 0.10	0.28 ± 0.14	0.2119
BUN					
Mean ± SD[ns]		12.55± 8.85	9.45 ± 4.28	9.66 ± 5.62	0.4500
Range	3.36 – 5.93[2]	0 - 31.34	2.25 –17.07	0.45 - 20.37	
Calcium					
Mean ± SD[ns]		1.58 ± 0.56	1.71 ± 0.61	1.32 ± 0.35	0.2245
Range	2.17 – 2.74[1]	0.89 – 3.10	0.95 - 2.85	0.56 – 1.85	
Phosphorus					
Mean ± SD[ns]		1.56 ± 0.41	1.61 ± 0.17	1.57 ± 0.50	0.9508
Range	1.45 – 2.58[1]	1.21 - 2.98	1.36 - 1.87	1.15 - 2.99	
Potassium					
Mean ± SD[ns]		3.50 ± 0.92	3.55 ± 0.84	3.50 ± 0.85	0.9859
Range	3.80 – 5.20[1]	1.61 - 5.51	1.59 - 4.45	1.99 - 4.52	
Magnesium					
Mean ± SD[ns]		0.67 ± 0.32	0.59 ± 0.31	0.62 ± 0.25	0.8121
Range	0.82 – 1.43[1]	0.10 - 1.50	0.15 - 0.97	0.26 - 1.09	

[abc]Means with same superscripts are not significantly different ($P < 0.05$)
[ns] Not significant ($P > 0.05$)
[1]Penn State Extension, 2006.
[2]Lager and Jordan, 2012.
Note: Conversion factors used were based on Smith and Sherman. 2009.

Mean levels of blood glucose from the three production systems were higher than the normal range which could mean that the animals were not experiencing NEB. No significant differences were also found in the mean glucose concentrations of the cows among the production systems. However, according to Duffield and LeBlanc (2009) and Messman (2005), glucose levels in the blood of dairy cows is difficult to measure because glucose concentrations are under tight homeostatic control by the animal. Hence, it is more reliable to depend on BHBA levels to measure the energy status of transition cows.

The mean blood cholesterol concentrations of the cows were within the normal range for all production systems. Cholesterol level in the blood is a good indicator of the liver function of dairy animals. Increasing cholesterol level in the blood is seen as an improvement in the energy balance of dairy cows (Cavestany *et al*., 2005). Level of serum cholesterol concentration in the blood of healthy transition cows has been linked with DMI most likely because ruminants utilize circulating triglyceride-rich lipoproteins from the intestines (Sepúlveda-Varas *et al*., 2015). NEFA-to-cholesterol ratio is also used to indicate liver function and hepatic lipidosis. Ratios greater than 0.3 for post-calving animals were predictive of postpartum disease (Van Saun, 2016a). The post-calving cows have NEFA-to-cholesterol ratios less than 0.3 for the three production systems which indicate that the animals were not predisposed to any postpartum diseases. When compared between production systems, no significant differences were found in the mean cholesterol levels. The same result was also observed in the NEFA-to-cholesterol ratio wherein there were no significant differences among the different production systems.

BUN concentrations were higher than the maximum range for all production systems. High BUN may be due to high dietary crude protein intake, especially rumen degradable protein (RDP), and/or low dietary non-fiber carbohydrate (Oetzel, 2003). According to Sepúlveda-Varas *et al*. (2015), many dairy cows are fed with diets high in protein to maximize their milk production. Increased urea levels in the blood are consistent with excess intake of protein and abnormal urea levels observed in an abnormal herd is not related to specific diseases conditions (Hoff and Duffield, 2013). Blood urea nitrogen is a means of measuring the levels of dietary protein and nitrogen utilization efficiency by the animal. Monitoring the levels of urea in the blood or milk can guarantee that RDP and rumen undegradable proteins (RUP) are coordinated with starch degradability for improvement of rumen microbial protein synthesis since any imbalance in protein and carbohydrate degradability can lead to poor animal health and production (Lager and Jordan, 2012). The means of BUN concentration of each production system were also compared wherein no significant differences were found.

The mean Ca levels were below the normal range for the three production systems. When compared, there were no significant differences in the mean blood Ca levels from cows in the different production systems. According to Van Saun (2016a), pre- or post-calving animals with serum total Ca less than 2.0 mmol/Li, such as the results obtained from the study, were four times more likely to experience postpartum diseases, such as hypocalcemia or milk fever. The trend nowadays in feeding periparturient cows is towards maximizing milk yield. Hence, it is difficult to maintain a very low level of Ca intake of pre-calving animals due to the increase in DMI or feeding of alfalfa for dry cows (Kamiya *et al*., 2005).

Phosphorus (P) blood concentrations were within the normal range for all production systems. According to Horst (1986), absorption of P is directly related to the amount of P in the diet and plasma P concentration. The increase in P level after calving may be a reflection of the bone resorbing Ca and P to meet the requirements of milk production (Cavestany *et al*., 2005). Level of P in the blood from the different production systems was also compared wherein no significant differences were observed.

The mean potassium (K) levels for the post-calving cows are all slightly below the minimum range for the three production systems. According to Harrison *et al*. (2011), there is a negative retention of K for early lactation cows (< 75 days in milk) and that the amount of K excreted is directly related to the animal's K intake. Early lactation cows were usually in negative K balance due to the greater excretion and secretion of K in urine and milk, respectively. Heat-stressed cows are also prone to K deficiency due to losses via sweat (Sanchez, 2000). No significant differences were found in the mean K blood levels of post-calving cows from the different production systems.

All post-calving cows from the three production systems were below the normal range of magnesium (Mg) blood levels. According to Blowey (1999), Mg absorption is not very efficient wherein only 17% of consumed Mg is absorbed from the gut while the rest is excreted in the feces. The decrease in Mg level in the last week before calving could be related to the decrease in Ca level during parturition (Cavestany *et al*., 2005). The mean Mg levels in the blood of the cows from the different production systems were compared and no significant differences were found.

In conclusion, apparently healthy crossbred post-calving dairy cows from Batangas and Laguna did not experience NEB but had macro mineral (Ca, K and Mg) deficiency when compared with reference standards used in temperate countries. Metabolic profiling could be used to determine the nutritional status and diagnose risks to/and occurrence of diseases of dairy cows, especially during the transition period. Additional studies using more apparently healthy animals from different areas of the Philippines may be performed in order to establish normal metabolite values which can be used as the reference standard in tropical countries.

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