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Research Article

Blood Metabolite Parameters during the Pregnancy and Lactation of Brahman Crossbred Cows Grazed under Oil Palm Plantation in Kalimantan, Indonesia

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Abstract | The effect of physiological status on blood chemistry parameters of grazing cows using the oil palm cattle integration system (OPCIS) has never been reported in tropical areas of Indonesia. This study aimed to assess the profile of the metabolic parameters at the different physiological statuses of Brahman crossbred (BX) cows grazed under the oil palm plantation. A total of 80 clinically healthy adult cows, comprising 40 pregnant and 40 lactating cows, were used in this study. Cows were grazed on oil palm plantations covering an area of 2,700 Ha for 90 days using a rotational grazing model. Clinical examinations were conducted after rotational grazing, followed by blood sampling from the jugular vein. The results showed that the pregnant animals had a higher level of triglycerides in comparison to the lactating ones ($P<0.05$), whereas the pregnant animals had lowered level of Ca, Mg, Na, K, Cl, glucose, globulin, and serum total protein than the lactating ones ($P<0.05$). There were no significant differences in serum P, albumin, blood urea nitrogen, and creatinine concentrations between the pregnant and lactating cows ($P>0.05$). It could be concluded that physiological status had a significant influence on some blood metabolic parameters of BX cows grazed under oil palm plantations. These findings might support the clinical diagnosis and formulation of preventive strategies for metabolic disorders in cattle raised in the OPCIS.

Keywords | Blood chemistry, Brahman crossbred cow, Oil palm, Grazing

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INTRODUCTION

Pregnancy and lactation that have the potential to cause metabolic changes (Iriadam, 2007), can affect the physiological status of animals. The changes that might occur are not only related to productivity but also metabolic disorders (Sobiech *et al*., 2008). According to LeBlanc (2002), pregnancy and lactation are critical periods for animals with a potential incidence of approximately 30–50% of metabolic disorders and infections. During pregnancy, all metabolic pathways are involved in the maintenance of fetal development (Bell *et al*., 2000) and animals can experience metabolic stress (Ceylan *et al*., 2009). During the lactation period, there is often a negative energy balance, which results in changes in the metabolic and hormonal profiles of the blood (Wathes *et al*., 2009). Therefore, blood chemistry parameters such as total protein (TP), glucose (GLU), triglycerides (TGs), creatinine (CREA), blood urea nitrogen (BUN), and electrolytes, are important indicators of metabolic activity in pregnant and lactating animals (Balicki *et al*., 2007; Karapehlivan *et al*., 2007). Apart from its physiological status, other factors such as breed (Balicki *et al*., 2007; Stojevic *et al*., 2008), management, and geography (Watanabe *et al*., 2013) are also known to influence blood metabolite parameters. Studies have shown that adding concentrate feed to animals that are openly grazed (extensive farming) has a highly significant effect on blood chemistry (Obese *et al*., 2018; Adjorlolo *et al*., 2019). Cows that are managed in extensive farming have different blood chemical parameter values compared to those in intensive farming (Radkowska and Herbut, 2014). Additionally, the blood chemistry levels of cattle that live freely in the open are also influenced by seasonal factors (Pambu-Gollah *et al*., 2000).

Currently, extensively cultivated beef cattle in tropical climates, such as Indonesia, are openly released on oil palm plantations, which is known as the oil palm cattle integration system (OPCIS). The application of this farming method could provide an opportunity to fulfill the nation's need for meat and land conservation (Gartina and Sukriya, 2019). Cattle fed on grass and plants that grow between oil palm trees; therefore, reducing weeds in oil palm plantations. In addition, cattle can also be given additional concentrates made from palm oil industrial waste. In contrast, cattle manure can be used as a fertilizer for oil palm plants and support soil conservation efforts. Information regarding the blood chemistry parameters of cows managed with the OPCIS is quite limited, although they have a critical meaning, such as examining nutritional status, health conditions, diagnosis of metabolic diseases, and overcoming diseases and metabolic disorders in cattle (Radostits *et al*., 2007; Puppel and Kuczyńska, 2016). The results of previous studies on female BX cows managed with OPCIS showed that blood chemistry parameters were significantly influenced by cattle age (Kristanto and Widiyono, 2021). To date, the effect of physiological status on blood chemistry parameters of 90-day grazing cows using the OPCIS in tropical areas of Indonesia for breeding purposes has never been reported. Therefore, this study aimed to assess the blood metabolite profile of adult female BX cattle managed extensively by OPCIS in the wet tropical region of Central Kalimantan, Indonesia, at different physiological statuses. The results of this study can be used to support the clinical diagnosis and formulation of preventive strategies for metabolic disorders in cattle that are grazed or raised on OPCIS.

MATERIALS AND METHODS

Ethical approval

The present study was approved by the Ethical Clearance Commission, Integrated Quality Testing and Testing Laboratory, Universitas Gadjah Mada, on December 14, 2018 (Certificate number: 00132/04/LPPT/XII/2018).

Place and time of the study

This study was conducted from January to March 2019 in an oil palm plantation located in Kotawaringin Barat, Central Kalimantan, Indonesia. The oil palm plantation used for this research was 2700 Ha in size, which was divided into 90 blocks. Each block consisted of 30 Ha. The altitude of the area ranges from 0 to50 m above sea level with temperatures ranging from 22.5°C to 32.73°C. This region has a type A climate (Schmid and Ferguson classification) and a wet/rainy season of 202 days that last longer than the dry season. Rainfall ranges from 3,000 mm/year.

Animals and the raising

A total of 80 clinically healthy Brahman crossbred (BX) adult cows, consisting of a pregnant group (40 cows within 7–9 months of gestation), and a lactating group (40 cows within 2–3 months postpartum) were used in this study. All animals were openly grazed on the oil palm plantation at the same location extensively for 3 months using a rotational grazing block model. Each grazing rotation consisted of 90 grazing blocks. Each block was 30 Ha in size and was filled with approximately 350 cattle for 1–2 days (Kristanto and Widiyono, 2021). Cows were grazed on pasture/forages/vegetation between oil palm plants and supplemented with concentrate twice daily in the morning and afternoon (approximately 3 kg/cow/day) consisting of oil palm cakes (42.5%), solid palm oil (20%), cassava dregs (17.5%), rice bran (10%), molasses (7.95%), salt (0.8%), Sel-Plex® (0.05%), and lime (1.2%). The concentrate contained 2.73% water, 9.09% crude protein, 9.09% crude fat, 15.58% crude fiber, 4055 kcal/kg gross energy, 8.20% ash, and 69.64% total digestible nutrients.

Collection, preparation, and analysis of samples

Clinical and physiological status examinations were performed at the end of the grazing rotation to determine the health status of the body and its physiological status. Only clinically healthy animals were included in the study. Blood samples (10 mL) were collected from the jugular vein using a BD Vacutainer tube (Becton Dickinson, USA) in the morning before feeding. The sera samples were separated by centrifugation at 2000 rpm for 10 min and stored at -20°C until analysis. Blood sera were analyzed spectrophotometrically using an autoanalyzer (Roche/Hitachi Cobas 6000 analyzer) (Kristanto and Widiyono, 2021). Blood chemistry tests included GLU, TG, BUN, CREA, TP, albumin (ALB), globulin (GLB), Ca (calcium), P (phosphorus), Mg (magnesium), Na (sodium), K (potassium), and Cl (chlorine) were carried out.

Statistical analysis

Statistical analysis of data was performed using Statistical Product and Service Solutions 16 with an error level of 0.05.

The influence of physiological status on blood metabolite values was analyzed using an independent samples t-test.

RESULTS AND DISCUSSION

Studies on the effect of physiological status (pregnant cows and lactating non-pregnant cows) to blood metabolite parameters of BX were performed on cows grazed extensively with OPCIS in Kotawaringin Barat Regency, Central Kalimantan, Indonesia. The results of the blood chemistry research are presented in Tables 1 and 2.

Table 1: Levels of glucose, triglycerides, blood urea nitrogen, creatinine, and serum protein of female Brahman crossbred cows at the different physiological statuses.

Parameter*	Serum level			Reference value
	Pregnant cows	Lactating cows	P value	
GLU (mg/dL)	41.4±14.1[a]	53.45±14.6[b]	0.0001	40-100[2]
TG (mg/dL)	37.52±16.5[a]	29.27±11.5[b]	0.012	0-14[1]
BUN (mg/dL)	22.59±4.76[a]	21.15±4.39[a]	0.164	6.0-27[1]
CREA (mg/dL)	1.85±0.35[a]	1.72±0.30[a]	0.096	1.0-2.0[1]
TP (g/dL)	8.07±0.86[a]	8.62±1.17[b]	0.019	5.7-8.1[1]
ALB (g/dL)	3.95±0.45[a]	4.17±0.57[a]	0.052	2.1-3.6[1]
GLB (g/dL)	4.12±0.54[a]	4.44±0.75[b]	0.03	2.9-4.9[1]

a, b: Mean values in the same rows with different superscripts are significantly different (P<0.05). *GLU: glucose, TG: triglyceride, BUN: blood urea nitrogen, CREA: creatinine, TP: total protein, ALB: albumin, GLB: globulin. [1]Radostits *et al.* (2007). [2]Latimer *et al.* (2011).

Table 2: Mineral and electrolyte levels of Brahman crossbred cows at different physiological statuses.

Parameter*	Serum level		P value	Reference value
	Pregnant cows	Lactating cows		
Ca (mmol/L)	2.24±0.25[a]	2.43±0.28[b]	0.001	2-2.85[2]
P (mg/dL)	8.49±1.56[a]	8.29±1.69[a]	0.584	5.6-8.0[2]
Mg (mg/dL)	2.17±0.4[a]	2.51±0.39[b]	0.0001	1.5-2.9[2]
Na (mmol/L)	147.2±11.5[a]	155.3±13.7[b]	0.006	132-152[1]
K (mmol/L)	4.94±0.73[a]	5.39±0.69[b]	0.006	3.9-5.8[1]
Cl (mmol/L)	99.55±9.45[a]	104.78±11.1[b]	0.027	95-110[1]

a, b: Mean values in the same rows with different superscripts are significantly different (P<0.05). *Ca: calcium, P: phosphorus, Mg: magnesium, Na: sodium, K: potassium, Cl: chlorine. [1]Radostits *et al.* (2007). [2]Latimer *et al.* (2011).

The results of statistical analysis showed that physiological status had an effect on the mean serum glucose level. Pregnant cows (7–9 months of gestation) had significantly lower serum glucose levels than lactating cows (P<0.05). These results are consistent with those reported by Teleb *et al.* (2014), Otomaru *et al.* (2015), and Mohammed *et al.* (2021), who stated that the glucose level in the prepartum/late gestation period tends to be lower than that in the lactation period. Additionally, cows generally have cases of ketosis in the third trimester; therefore, glucose concentrations are lower (Ashmawy, 2015). According to Soliman (2014), low serum glucose levels in the gestation period may occur due to the gluconeogenic effect of epinephrine and cortisol before parturition and possibly related to fetal development and glucose mobilization to the fetus. These results are in accordance with those reported by Antunovic *et al.* (2011) and Soliman (2014) on sheep and Waziri *et al.* (2010) on Sahelian goats; during pregnancy, serum glucose levels tend to be lower than that in non-pregnant periods. However, the overall blood glucose levels for BX cattle in OPCIS Central Kalimantan during all physiological periods were within the range of physiological reference values for adult cattle (Radostits *et al.*, 2007; Latimer *et al.*, 2011). Based on the results of the study, it is expected that by maintaining glucose levels until 13 weeks postpartum, fertility can be maintained (Sulieman *et al.*, 2017).

The TG concentration of the pregnant group was significantly higher than that of the lactation group (37.52% vs. 29.27%, P<0.05). Karapehlivan *et al.* (2007), Arfuso *et al.* (2016), and Djokovic *et al.* (2019) stated that TG concentrations were higher in the 3 weeks before parturition than during the lactation period from 1 to 30 days. Ashmawy (2015) reported that TG concentrations in pregnant buffaloes were higher than those in the lactation period. This might be due to increased energy requirements during lactation. According to Karapehlivan *et al.* (2007), TGs are used by the mammary glands to form milk fat, and their needs increase as the lactation period progresses. Furthermore, according to Meliani *et al.* (2011), the average TG concentrations in horses were the highest at the end of gestation period compared to that at the beginning of pregnancy. Hussein and Azab (1998), Eski *et al.* (2015), and Soares *et al.* (2018) reported that TG concentrations in pregnant goats were higher than those in the lactation period. This increase could be attributed to higher free fatty acid levels in pregnant than non-pregnant animals, which is due to increased cortisol levels as a result of stress induced by pregnancy. Overall, the average TG level in BX cows grazed on oil palm plantations was higher than the reference value (Radostits *et al.*, 2007; Latimer *et al.*, 2011). This difference may be related to the feed factor consumed by cattle grazing in this oil palm plantation. Sun *et al.* (2018) reported that the difference in the ratio of metabolizable glucose to metabolizable protein in the diet results in differences in cholesterol and TG levels in the blood.

BUN levels in cows managed with OPCIS were within the normal physiological range (Radostits *et al*., 2007; Latimer *et al*., 2011). BUN levels in the pregnant and lactating groups were comparable (22.59 ± 4.76 mg/dL vs. 21.15 ± 4.39 mg/dL), although there was a tendency to decrease in the lactating group (*P*>0.05). Celeska et al. (2015) reported no differences in BUN levels in prepartum and postpartum Frisian-Holland cows. Soares *et al*. (2018) also reported that BUN levels in lactating and pregnant goats were not significantly different. However, the results of this study on BX cows managed with OPCIS in Central Kalimantan showed that BUN levels in the pregnant cow group tended to be higher than those in cows in the lactation period. These results are as per the reports of Otomaru *et al*. (2015) and Djokovic *et al*. (2019), whostated that BUN levels in the prepartum/late pregnancy were higher than those during the lactation period. Likewise, Ashmawy (2015) reported that BUN levels in pregnant buffaloes were higher than those in the lactation period. High BUN levels during gestation and significantly decreased at the end of the lactation period were also found in sheep (Piccione *et al*., 2009). Increased levels of BUN in pregnant BX cows may indicate an increase in deamination or protein intake, as suggested by Hagawane *et al*. (2009) and Abd-El Naser *et al*. (2014). Piccione *et al*. (2009) suggested that high energy requirements during the gestation period may lead to an increase in thyroid hormone activity, which induces protein catabolism. Meanwhile, the lower levels of BUN in the lactation period may be related to the use of urea for protein/milk synthesis. Urea levels need to be kept low at 10–13 weeks postpartum to maintain fertility (Sulieman *et al*., 2017).

The mean CREA level in the serum of the pregnant and lactating cows was at the normal physiological level for cows, which was 1.0–2.0 mg/dL (Radostits *et al*., 2007). In the group of pregnant cows, the CREA level was 1.85 ±0.35 mg/dL and decreased slightly in the lactation period to 1.72 ±0.30 mg/dL (*P*>0.05). An increase in CREA during gestation, followed by a decrease during the lactation, was also reported in Shorthorn cows (Doornenbal *et al*., 1988). Physiological status has been reported to affect CREA levels, which are at a higher level in pregnancy than that during lactation (Patel *et al*., 2016). Furthermore, Soares *et al*. (2018) also reported that pregnant goats had higher CREA levels than those during lactation.

The results showed that serum TP levels were within the normal physiological range for cows (Radostits *et al*., 2007). The pregnant cows had a TP concentration of 8.07 ± 0.86 mg/dL, whereas the lactating ones had a significantly higher TP concentration 8.62 ± 1.17 mg/dL (*P*<0.05). These results are consistent with those of previous studies on dairy cows (Gianesella *et al*., 2018). A similar opinion was also conveyed by Mohammed *et al*. (2021) that the TP level was lower during pregnancy than during the lactation or non-pregnant period. Piccione *et al*. (2012) reported that TP levels at the end of the lactation period were higher than those at the end of the gestation period and the beginning of the lactation period. A similar finding was also found by Soares *et al*. (2018) in goats, in which the serum TP levels were higher in the early lactation period than in the pregnancy period. Mohamed (2014) reported that lactation had a significant effect on TP levels, particularly during the initial period. The feed factor is assumed to have played a role in changes in TP concentration, where the concentrate increased carbohydrate intake, increasing rumen microbial protein (Heck *et al*., 2009). An increase in TP levels is also associated with protein requirements for milk formation and immunoglobulin supply (Bremmer *et al*., 2000; Mohri *et al*., 2007). Based on the data on pregnant and lactating BX cows in this study, it can be seen that the increase in TP levels is closely related to the increase in ALB and GLB levels (Table 1). The levels of serum TP and ALB in BX cattle that were grazed extensively with OPCIS slightly above the normal physiological level for cattle (Radostits *et al*., 2007) and thus, which might indicate that the cows had good nutritional status. Herdt (2000) stated that serum TP values are used as indicators of animal nutritional status as they reflect feed intake and metabolism. Furthermore, Piao *et al*. (2015) emphasized that TP, ALB, and BUN are indicators of the adequacy of an animal's protein intake.

There was no significant difference between the mean concentration of serum ALB in the pregnant and the lactating group of BX cows, 3.95±0.45 vs. 4.17±0.57 mg/dL (*P*>0.05). This finding was as per the findings of several previous studies on beef cattle (Doornenbal *et al*., 1988), dairy cows (Piccione *et al*., 2012; Mohamed, 2014; Djokovic *et al*., 2019), sheep (Teleb *et al*., 2014), and goats (Soares *et al*., 2018), which showed that ALB concentrations were not affected by physiological status. However, the ALB level showed a slight increase from 3.95 mg/dL in pregnant cows to 4.17 mg/dL in lactating cows (*P*>0.05). These findings are similar to those reported by Otomaru *et al*. (2015) and Gianesella *et al*. (2018), who found that ALB concentration tends to be higher in the lactation period than in other physiological periods. The increase in ALB during lactation plays a role in the process of immunoglobulin extraction in colostrum and milk (Soliman, 2014). Overall, these levels were slightly above the upper limit of the reference value for cows (Radostits *et al*., 2007), which might indicate that the status of digestible crude protein in these two groups of animals raised under the OPCIS in Kalimantan Indonesia was quite good. According to Herdt (2000), long-term levels of ALB in circulation can be used as an indicator of digestible crude protein status.

The mean GLB levels of adult female BX cattle managed extensively with the OPCIS ranged from 4.12 to 4.44 mg/dL and were at the normal physiological level for cows (Radostits *et al*., 2007). The concentration of GLB in lactating cows was significantly higher than that in pregnant cows. The statistical analysis showed significant differences in the GLB of the pregnant and lactating groups (P<0.05). These results are consistent with those reported by Otto *et al*. (2000), Kida (2003), Mohamed (2014), and Gianesella *et al*. (2018), who found that the lactation period has a significant effect on GLB concentrations. This is also consistent with the results of studies in Tuj ewes, which showed an increase in GLB levels in the first 30 days post-partum/lactation (Karapehlivan *et al*., 2007) as well as with the results of a study in Holstein-Friesian cows (Kida, 2003). Moreover, the findings in Angoni cows in Mozambique showed that the highest levels of GLB in serum were found in lactating cows (Otto *et al*., 2000). Increased serum GLB concentration during early lactation in comparison to pregnancy has also been reported in goats (Soliman, 2014; Soares *et al*., 2018). In contrast to the above findings, Aziz and Mujalli (2008) found in dairy cows and Salem (2017) in small ruminants that the GLB concentration was lower during lactation than during the non-lactation period.

The concentration of Ca in female BX cattle in the lactation group was significantly higher than that in the pregnant cows (P<0.05). The presence of high serum Ca levels during the lactation period is consistent with the findings of Djokovic *et al*. (2014) in cows and Eski *et al*. (2015) in Angora goats; however, different from the results of Ate *et al*. (2009) on cattle in Nigeria and Mohammed *et al*. (2021) in crossbred dairy cows, which showed that Ca levels in the blood during pregnancy and lactation were not significantly different. Fadlalla *et al*. (2020) also reported that the concentration of Ca in dairy cows during different stages of physiological status was not significantly different; however, the level during prepartum and postpartum tended to be lowest when compared with the middle of lactation. Furthermore, P levels in the blood of BX cattle managed with OPCIS in Central Kalimantan did not show any significant changes in physiological status (P>0.05). These results areas per those of Kida (2003), Djokovic *et al*. (2019), and Mohammed *et al*. (2021), who reported no differences in P concentration in pregnant and lactating cows. In buffalo, Patel *et al*. (2016) also found that physiological status did not have a significant effect on P concentration. Similarly, studies on sheep and goats showed that P levels in the blood did not show any significant changes during pregnancy and lactation (Teleb *et al*., 2014; Soares *et al*., 2018). The results of this study indicated that the mean concentration of Ca in BX cow serum (2.24–2.43 mmol/L) was in the range of normal physiological values for cattle, 2–2.8 mmol/L, while the levels of P (8.29–8.49 mg/dL) were above the upper limit of the normal value for cattle, 5.6–8.2 mg/dL (Latimer *et al*., 2011). High serum P levels in this study are most likely related to the feed given, which are forage (grazing) and supplemented with concentrates that provide minerals at a fairly good level. Hadzimusic and Krnic (2012) stated that P levels are related to the P content in cattle feed.

The concentration of Mg in the lactating and pregnant groups were 2.51 mg/dL and 2.17 mg/dL, respectively. Based on the results of the study, it was shown that the mean concentration of blood serum Mg BX in all groups was within the normal range, 1.5–2.9 mg/dL (Latimer *et al*., 2011). This might indicate an adequate daily supply of Mg and good absorption of Mg in BX cattle, which are integrated into this oil palm plantation. As stated in the literature, the concentration of Mg in livestock blood is influenced by the Mg content of the feed or Mg intake and its absorption in the rumen (Djokovic *et al*., 2014). The results of the statistical analysis showed that physiological status had a significant effect on Mg levels in BX cows (P<0.05). Serum Mg levels in the lactation group were significantly higher than those in the pregnant group (P<0.05). These results are consistent with findings in crossbred dairy cows, Sahiwal and Holstein-Friesian cows and sheep, which show that Mg levels in lactating animals are higher than those in pregnant animals (Asif *et al*., 1996; Kida, 2003; Zaidan *et al*., 2015; Mohammed *et al*., 2021). The cause of the difference in Mg levels in BX cattle serum in this study is not known with certainty; however, it is likely related to differences in feed intake in some of these physiological statuses. Schonewille (2013) stated that the level of Mg in serum is closely related to the intake/content of Mg in the feed and its absorption in the digestive tract of cattle. A different report was put forward by Fadlalla *et al*. (2020) who stated that the concentration of Mg in the prepartum period was higher than that in the postpartum period and there tended to be no change during lactation.

The results of the statistical analysis showed that physiological status had a significant influence on Na concentrations. Serum Na levels in the pregnant cow group were 147.2±11.5mmol/L and increased significantly to the level of 155.3±13.7 mmol/L in the lactation group (P<0.05). The results of this study are consistent with the results of previous studies on Sahiwal cattle, which showed that serum Na levels in the lactation period were higher than those during the pregnancy period (Asif *et al*., 1996). Kupczynski and Drozdowska (2002) also reported that blood Na levels of Holstein Friesian cows aged 4–6 years in the gestation period ranged from 138 mmol/L and increased to the highest level in the 1-month postpartum period (lactation). The tendency for mean serum Na levels to be higher during the lactation period than during the pregnancy period was also found in Nigerian cattle (Ate *et al*., 2009) and Angora goats (Eski *et al*., 2015). This significant change in blood Na levels in female BX cows managed in oil palm plantations in Central Kalimantan may be related to aldosterone activity related to their physiological status. The Na levels in the blood can be associated with the activity of renin, aldosterone, and prostaglandins (Ozgo *et al*., 2008; Skrzypczak *et al*., 2014).

The results of the statistical analysis showed that the physiological status of BX cows had a significant effect on K concentrations. The K concentration in the pregnant group was at the lowest level (4.94 mmol/L) and was significantly different from that in lactating cows (5.39 mmol/L; $P<0.05$). These results are consistent with the report by Asif *et al*. (1996), who stated that the K concentrations of pregnant Sahiwal cows were significantly lower than those in lactating cows. The lowest K concentrations in pregnant cows were found during the dry period. Similarly, Kurpinska (2013) reported that the lowest K concentrations occurred 4 weeks before parturition. The same finding was also reported by Kurek and Stec (2005) that the lowest K concentrations of 2.5-4 year old cows were found in the 7-day prepartum gestation period and the highest was in the 7-day postpartum lactation period. A high concentration of K during the lactation period was also reported by Sattler and Fecteau (2001) at the first 3 months of lactation. However, overall serum levels of K in BX cattle managed extensively in oil palm plantations in Central Kalimantan during pregnant and lactating periods were in the physiological range of 3.9–5.8 mmol/L (Radostits *et al*., 2007).

BX beef cattle in Central Kalimantan, which were grazed in the oil palm plantation and given concentrate during the pregnancy and lactation periods, had serum Cl levels ranging from 99.55–107.30 mmol/L. These results might indicate that these beef cattle had normal serum Cl levels for beef cattle, which was 95–110 mmol/L (Radostits *et al*., 2007). Statistical analysis of serum Cl of BX cattle showed that physiological status had a significant effect on the serum Cl concentration of BX cows managed with OPCIS ($P<0.05$). Serum Cl concentrations in the pregnant group were significantly lower than those in the lactating cows ($P<0.05$). These results are as per the report of Dodamani *et al*. (2009), who stated that the Cl levels in cow serum decreased significantly during the gestation period until the 9th month. Moreover, Ozgo *et al*. (2008) and Skrzypczak *et al*. (2014) stated that the highest levels of serum Cl levels in Holstein Friesian cows were immediately after delivery. Furthermore, Grundwalt *et al*. (2005) confirmed that serum Cl levels were higher in beef cattle during the lactation period (105.0 mmol/L). The similarity in the tendency of lower Cl and Na levels in the pregnant group and higher in other physiological status (lactating group) in BX cows may indicate a relationship between Cl and Na regulation in the blood. This is in line with the statement of some researchers that Cl homeostasis is closely related to Na homeostasis (Ozgo *et al*., 2008; Batcherlder *et al*., 2007; Skrzypczak *et al*., 2014).

CONCLUSIONS AND RECOMMENDATIONS

The study results concluded that physiological status had a significant influence on some blood metabolic parameters of BX cows grazed under oil palm plantations. These findings might support the clinical diagnosis and formulation of preventive strategies for metabolic disorders in cattle that are raised in the OPCIS.

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NOVELTY STATEMENT

This study varies from others in several ways, including the method, the location, the length of the study, and the animals utilized. Furthermore, the oil palm cattle integration concept may only be created in just a few areas throughout the world. Studies related to metabolic profile in cattle that are influenced by factors of physiological status have been reported, but studies related to the effect of physiological status on blood chemistry parameters of 90-day grazing Brahman crossbred (BX) cattle using the OPCIS in tropical areas of Indonesia for breeding has never been reported. Therefore, this study aimed to assess the blood metabolite profile of adult female BX cattle managed extensively by OPCIS in the wet tropical region of Central Kalimantan, Indonesia, at different physiological statuses. The results of this study can be used to support the clinical diagnosis and formulation of preventive strategies for metabolic disorders in Brahman crossbred cattle that are grazed or raised on OPCIS.

AUTHOR'S CONTRIBUTION

DK was involved in collecting the sample, conception and design, data analysis and interpretation; IW was involved in drafting the manuscript or critically revising it for important intellectual content and gave final approval of the version to be published; SH was purely technical and provided writing assistance.

Conflict of interest

The authors have declared no conflict of interest.

REFERENCES

- Abd-El-Naser EM, Mohamed GAE, Elsayed HK (2014). Effect of lactation stages on some blood serum biochemical parameters and milk composition in dairy cows. Assiut. Vet. Med. J., 60: 83–88. https://doi.org/10.21608/avmj.2014.170968
- Adjorlolo L, Obese YF, Tecku P (2019). Blood metabolite concentration, milk yield, resumption of ovarian activity and conception in grazing dual purpose cows supplemented with concentrate during the post-partum period. Vet. Med. Sci., 5: 103–111. https://doi.org/10.1002/vms3.148
- Antunovic Z, Novoselec J, Sauerwein H, Speranda M, Vegara M, Pavic V (2011). Blood metabolic profile and some of hormones concentration in ewes during different physiological status. Bulg. J. Agric. Sci., 17: 687–695.
- Arfuso F, Fazio F, Levanti M, Rizzo M, Pietro SD, Giudice E, Piccione G (2016). Lipid and lipoprotein profile changes in dairy cows in response to late pregnancy and the early postpartum period. Arch. Anim. Breed., 59: 429–434. https://doi.org/10.5194/aab-59-429-2016
- Ashmawy NA (2015). Blood metabolic profile and certain hormones concentrations in Egyptian buffalo during different physiological states. Asian J. Anim. Vet. Adv., 10: 271–280. https://doi.org/10.3923/ajava.2015.271.280
- Asif M, Rahman ZU, Arif M, Haq IU, Javed I (1996). Trace element and electrolyte concentrations in different physiological states of Sahiwal cattle. J. Islamic Acad. Sci., 9: 125–128.
- Ate IU, Rekwot, PI, NokAJ, Tekdek LB (2009). Serum electrolyte values of cows during third trimester of pregnancy and early lactation in settled cattle herds in Zaria, Northern Nigeria. Afr. J. Biomed. Res., 12: 125–130.
- Aziz A, Mujalli A (2008). Studies on some serum constituents of dairy cows in Saudi Arabia. Sci. J. King Faisal Univ., 9: 1429.
- Balikci E, Yildiz A, Gurdogan F (2007). Blood metabolite concentrations during pregnancy and post-partum in Akkaraman ewes. Small Rumin. Res., 67: 247–251. https://doi.org/10.1016/j.smallrumres.2005.10.011
- Batcherlder, CA, Bertolini M, Mason JB, Moyer AL, Hoffert KA, Petkov SG, Famula TT, Angelos J, George LW, Anderson GB (2007). Perinatal physiology in cloned and normal calves: hematologic and biochemical profiles. Clo. Stem Cells, 9: 83–96. https://doi.org/10.1089/clo.2006.0038
- Bell A, Burhans WS, Overton TR (2000). Protein nutrition in late pregnancy, maternal protein reserves and lactation performance in dairy cows. Proc. Nutr. Soc., 59: 119–126. https://doi.org/10.1017/S0029665100000148
- Bremmer DR, Bertics SJ, Brsong SA, Grummer RR (2000). Changes in hepatic microsomal triglyceride transfer protein and triglyceride in periparturient dairy cattle. J. Vet. Sci., 83: 2252–2260. https://doi.org/10.3168/jds.S0022-0302(00)75109-5
- Celeska I, Janevski A, Dzadzovski I, Ulchar I, Kirovski D (2015). The Dynamics of Biochemical Parameters in Blood of Clinically Healthy Holstein Cows from Day 5 before to Day 60 after Calving. Mac. Vet. Rev., 38 (2): 189-193. https://doi.org/10.14432/j.macvetrev.2015.07.049
- Ceylan E, Tanritanir P, Dede D (2009). Changes in some macro-minerals and biochemical parameters in female healthy Siirt Hair goats before and after parturition. J. Anim. Vet. Adv., 8: 530–533.
- Djokovic R, Cincovic M, Ilic Z, Kurburic V, Andjelic B, Petrovic M, Lalic N, Jasovic B (2019). Relationships between contents of biochemical metabolites in blood and milk in dairy cows during transition and mid lactation. Int. J. Appl. Res. Vet. Med., 17.
- Djokovic RD, Kurcubic VS, Ilic ZZ (2014). Blood serum levels of macro and micronutrient in transition and full lactation cows. Bulg. J. Agric. Sci., 20: 715–720.
- Dodamani MS, Mohteshamuddin K, Awati SD, Tandle MK, Honnappag SS (2009). Evaluation of serum profile during various stages of gestation in crossbred Deoni cows. Vet. World, 2: 398–399.
- Doornenbal H, Tong AKW, Murray NL (1988). Reference values of blood parameters in beef cattle of different ages and stages of lactation. Can. J. Vet. Res., 52: 99–105.
- Eski F, Tasal I, Karsli MA, Sendag S, Uslu BA, Wagner H, Wehrend A (2015). Concentrations of NEFA, β-HBA, triglycerides, and certain blood metabolites in healthy colored Angora goats during the peripartum period. Turk. J. Vet. Anim. Sci., 39: 401–405. https://doi.org/10.3906/vet-1412-25
- Fadlalla IMT, Omer SA, Atta M (2020). Determination of some serum macroelement minerals levels at different lactation stages of dairy cows and their correlations. Sci. Afr., 8. https://doi.org/10.1016/j.sciaf.2020.e00351
- Gartina D, Sukriya RLL (2019). Tree Crop Estate Statistics of Indonesia 2018–2020. Secretariate of Directorate General of Estates, Directorate General of Estates, Ministry of Agriculture-Republic of Indonesia, Jakarta.
- Gianesella M, Perillo L, Fiore E, Giudice E, Zumbo A, Morgante M, Piccione G (2018). Transition period in healthy and diseased dairy cows: evaluation of metabolic modifications. Large Anim. Rev., 24: 107–101.
- Grundwalt EG, Guevara JC, Esteves OR, Vicente A, Rousselle H, Alcuten D, Aguerregaray D, Stasi CR (2005). Biochemical and haematological measurements in beef cattle in Mendoza plain rangelands (Argentina). Trop. Anim. Health Prod., 37: 527–540. https://doi.org/10.1007/s11250-005-2474-5
- Hadzimusic, Krnic J (2012). Values of calcium, phosphorus and magnesium concentrations in blood plasma of cows in dependence on the reproductive cycle and season. J. Fac. Vet. Med. Istanbul Univ., 38: 1–8.
- Hagawane SD, Shinde SB, Rajguru DN (2009). Haematological and blood biochemical profile in lactating buffaloes in and around Parbhani city. Vet. World, 2: 467–469.
- Heck JML, Van Valenberg HJF, Djikstra J, Van Hooijodonk ACM (2009). Seasonal variation in the Dutch bovine raw milk composition. J. Dairy Sci., 92: 4745–4755. https://doi.org/10.3168/jds.2009-2146
- Herdt TH (2000). Variability characteristics and test selection in herd-level nutritional and metabolic profile testing. Vet. Clin. N. Am-Food. A., 16: 387–403. https://doi.org/10.1016/S0749-0720(15)30111-0
- Hussein SA, Azab ME (1998). Plasma concentrations of lipids and lipoproteins in newborn kids and female Baladi goats during late pregnancy and the onset of lactation. Deutsche Tierärztliche Wochenschrift, 105: 6–9.
- Iriadam M (2007). Variation in certain haematological and biochemical parameters during the peri-partum period

in Kilis does. Small Rumin. Res., 73: 54–57. https://doi.org/10.1016/j.smallrumres.2006.11.001

- Karapehlivan M, Atakisi E, Atakisi O, Yucart R, Pancarci SM (2007). Blood biochemical parameters during the lactation and dry period in Tuj ewes. Small Rumin. Res., 73: 267–271. https://doi.org/10.1016/j.smallrumres.2006.12.006
- Kida K (2003). Relationships of metabolic profiles to milk production and feeding in dairy cows. J. Vet. Med. Sci., 65: 671–677. https://doi.org/10.1292/jvms.65.671
- Kristanto D, Widiyono I (2021). Effect of age on serum metabolites of female Brahman crossbred cattle raised in an integration system of cattle-oil palm plantation in Central Kalimantan. J. Indonesian Trop. Anim. Agric.. 4: 57–66. https://doi.org/10.14710/jitaa.46.1.57-66
- Kupczynski R, Drozdowska BD (2002). Values of selected biochemical parameters of cows' blood during their drying-off and the beginning of lactation. Electron. J. Polish Agric. Univ., 5: 01.
- Kurek L, Stec A (2005). The influence of the perinatal period and age on the levels of selected macroelements, indicators of parenchyma organs and level of free fatty acids. Ann. Univ. Mariae Curie-Skłodowska Lublin- Polonia. 60: 37–54.
- Kurpinska AK (2013). Identification of proteins with variable expression in plasma proteome of cows in the last month of pregnancy and in the first two months of lactation. PhD Dissertation. Poland. pp. 1–130.
- Latimer, KS, Duncan JR, Mahafrey EA, Phrasse KW (2011). Duncan and Prasse's Veterinary Laboratory Medicine: Clinical Pathology. 5th ed. Iowa: Iowa State Press.
- LeBlanc SJ, Duffield TF, Leslie KE, Bateman KG, Keefe GP, Walton JS, Johnson WH (2002). Defining and diagnosing postpartum clinical endometritis and its impact on reproductive performance in dairy cows. J. Dairy Sci., 85: 2223–2236. https://doi.org/10.3168/jds.S0022-0302(02)74302-6
- Meliani S, Benallou B, Halbouche M, Niar A, Naceri A (2011). Serum macrominerals, glucose and triglycerides in Arabian mares during different phases of reproduction cycle. Pak. Vet. J., 31: 291–294.
- Mohamed GAE (2014). Investigation of some enzymes level in blood and milk serum in two stages of milk yield dairy cows at Assiut City. Assiut. Vet. Med. J., 60: 142. https://doi.org/10.21608/avmj.2014.170982
- Mohammed SE, Ahmad FO, Frah, EAM, Elfaki I (2021). Determination of blood glucose, total protein, certain minerals, and triiodothyronine during late pregnancy and postpartum periods in crossbred dairy cows. Vet. Med. Int., Vol. 2021. ID 6610362. https://doi.org/10.1155/2021/6610362
- Mohri M, Sharifi K, Eidi S (2007). Hematology and serum biochemistry of Holstein dairy calves: agerelated changes and comparison with blood composition in adults. Res. Vet. Sci., 83: 30–39. https://doi.org/10.1016/j.rvsc.2006.10.017
- Obese FY, Dwumah K, Adjorlolo LK, Ayizanga RA (2018). Effects of feed supplementation on growth, blood parameters and reproductive performance in Sanga and Friesian-Sanga cows grazing natural pasture. Trop. Anim. Health Prod., 50: 1739–1746. https://doi.org/10.1007/s11250-018-1614-7
- Otomaru K, Shiga H, Kanome J, Yanagita K (2015). Blood biochemical values in Japanese Black breeding cows in Kagoshima Prefecture, Japan. J. Vet. Med. Sci., 77: 1021–1023. https://doi.org/10.1292/jvms.15-0001
- Otto F, Baggasse P, Bogin E, Harun M, Vilela F (2000). Biochemical blood profile of Angoni cattle in Mozambique. Isr. J. Vet. Med., 55: 1–9.
- Ozgo M, Skrzypczak WF, Michalek K, Lepczynski A, Herosimczyk A, Dratwa A (2008). Regulacja gospodarki wodno-elektrolitowej matki i noworodka. Monografi a Noworodek a środowisko", Problemy cieląt i krów. Wyd. UP, Wrocław. pp. 151–180.
- Pambu-Gollah, R, Cronje PB, Casey NH (2000). An evaluation of the use of blood metabolite concentrations as indicators of nutritional status in free ranging indigenous goats. S. Afr. J. Anim. Sci., 30: 115–120. https://doi.org/10.4314/sajas.v30i2.3859
- Patel, MD, Lateef A, Das H, Prajapati MV, Kakati P, Savani HR (2016). Estimation of blood biochemical parameters of Banni buffalo (*Bubalus bubalis*) at different age, sex and physiological stages. J. Livest. Sci., 7: 250–325.
- Piao DC, Wang T, Lee JS, Vega RSA, Kang SK, Choi YJ (2015). Determination of reference intervals for metabolic profile of Hanwoo cows at early, middle and late gestation periods. J. Anim. Sci. Biotechnol., 6: 9. https://doi.org/10.1186/s40104-015-0009-0
- Piccione G, Caola G, Giannetto C, Grasso F, Runzo SC, Zumbo A, Pennisi P (2009). Selected biochemical serum parameters in ewes during pregnancy, post-parturition, lactation and dry period. Anim. Sci. Pap. Rep., 27: 321–330.
- Piccione G, Messina V, Marafioti S, Casella, S (2012). Change of some haematochemical parameters in dairy cows during late gestation, postpartum, lactation and dry periods. Vet. Med. Zoot., 58.
- Puppel K, Kuczyńska B (2016). Metabolic profiles of cow's blood. A review. J. Sci. Food Agric., 96: 4321–4328. https://doi.org/10.1002/jsfa.7779
- Radkowska I, Herbut E (2014). Hematological and biochemical blood parameters in dairy cows depending on management system. Anim. Sci. Pap. Rep., 32: 317–325.
- Radostits ON, Blood DC, Gay CC (2007). Veterinary medicine. A textbook of the diseases of cattle, sheep, goats and horses. 8th ed. London.
- Salem NY (2017). Effect of lactation on hemato-biochemical and minerals constituents in small ruminant. Int. J. Vet. Sci., 6: 53–56.
- Sattler N, Fecteau G (2014). Hypokalemia syndrome in cattle. Vet. Clin. North Am. Food Anim. Pract., 30: 351–357. https://doi.org/10.1016/j.cvfa.2014.04.004
- Schonewille J (2013). Magnesium in dairy cow nutrition: An overview. Plant Soil, 368: 167–178. https://doi.org/10.1007/s11104-013-1665-5
- Skrzypczak W, Kuroinska A, Stanski L, Jarosz A (2014). Sodium, potassium and chloride homeostatis in cows during pregnancy and first months of lactation. Acta Biol. Cracovienzia Ser. Zool., 55/56: 58–64.
- Soares GS, Souto RJC, Cajueiro JFP, Afonso JAB, Rego RO, Macedo ATM, Soares PC, Mendonca CL (2018). Adaptive changes in blood biochemical profile of dairy goats during the period of transition. Revue. Méd. Vét., 169(1): 65–75.
- Sobiech P, Milewski S, Zduńczyk, S (2008). Yield and composition of milk and blood biochemical components of ewes nursing a single lamb or twins. Bull. Vet. Inst. Pulawy., 52: 591–596.
- Soliman EB (2014). Effect of physiological status on some hematological and biochemical parameters of Ossimi sheep. Egypt. J. Sheep Goat Sci., 9: 33– 42.
- Stojevic Z, Filipovic N, Bozic P, Tucek Z, Daud J (2008). The metabolic profile of Simmental service bulls. Vet. Arhiv., 78:

123–129.

- Sulieman MS, Makawi SEA, Ibrahmim KEE (2017). Association between postpartum blood levels of glucose and urea and fertility of cross-bred dairy cows in Sudan. S. Afr. J. Anim. Sci., 47: 595–605. https://doi.org/10.4314/sajas.v47i5.2
- Sun, J, Xu J, Ge R, Wang M, Yu L, Wang H (2018). Effects of different dietary ratio of metabolizable glucose and metabolizable protein on growth performance, rumen fermentation, blood biochemical indices and ruminal microbiota of 8 to 10-month-old dairy heifers. Asian-Aust. J. Anim. Sci., 31: 1205–1212. https://doi.org/10.5713/ajas.17.0893
- Teleb DF, Ahmed NAH, El-Din HAT, El Soud SMA, Hassan OM (2014). Study on levels of some blood hormonal and biochemical constituents during different reproductive status in Saidi ewes. Egypt. J. Sheep Goat Sci., 9: 105–113. https://doi.org/10.21608/ajfm.2014.19160
- Watanabe U, Takagi M, Yamato O, Otoi T, Tshering C, Okamoto K (2013). Metabolic profile of Japanese Black breeding cattle herds: usefulness in selection for nutrient supplementation to enhance reproductive performance and regional differences. J. Vet. Med. Sci., 75: 481–487. https://doi.org/10.1292/jvms.12-0441
- Wathes DC, Cheng Z, Chowdhury W, Fenwick MA, Fitzpatrick R, Morris D G, Patton J, Murphy JJ (2009). Negative energy balance alters global gene expression and immune responses in the uterus of postpartum dairy cows. Physiol. Genomics, 39: 1–13. https://doi.org/10.1152/physiolgenomics.00064.2009
- Waziri MA, Ribadu AY, Sivachelvan N (2010). Changes in the serum proteins, hematological and some serum biochemical profiles in the gestation period in the Sahel goats. Vet. Arhiv., 80: 215–224.
- Zaidan NK, Mohamed WM, Hamad AS (2015). Activity of phosphatase enzymes, concentration of protein and divalent ions in sheep sera during different physiological status. J. Anim. Health Prod., 3: 78–81. https://doi.org/10.14737/journal.jahp/2015/3.4.78.81