Received: 27 August 2023 | Accepted: 1 October 2023
DOI: 10.1111/rda.14489

ORIGINAL ARTICLE

Reproduction in Domestic Animals WILEY

Blood metabolic pattern and somatic cells dynamic in Achai and Holstein Friesian cows during transition period

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Funding information

Researchers Supporting Project (No. RSPD2023R833), King Saud University, Riyadh, Saudi Arabia

Abstract

This study focused on assessing blood metabolites and somatic cell count (SCC) during the transition period in Achai and Holstein Friesian cows. Blood samples were collected from cows of both breeds on days −21, −14, −7 (pre-partum period), on day 0 (parturition day) and then on days 7, 14 and 21 (post-partum period). Additionally, milk samples were obtained on the day of parturition and on days 7, 14 and 21 post-partum for SCC assessment. Among Holstein cows, blood glucose levels showed a significant increase on day −21 before calving, and a decrease on the 14th and 21st days post-partum. Similarly, the blood triglycerides concentration exhibited a significant rise in Holstein cows 21 days before calving, while Achai cows experienced a significant decline in blood triglycerides on the day of parturition and throughout the entire post-partum period. Comparing Holstein and Achai cows, blood cholesterol was significantly higher in Holstein cows on day −21 before calving, whereas Achai cows had significantly lower blood cholesterol levels on the day of parturition. Regarding blood protein, Holstein cows exhibited significantly higher levels on day 14 post-partum, while Achai cows had lower protein levels 7 days before calving. The results further demonstrated that SCC was significantly elevated in Holstein cows on day 21 of parturition and lower on the day of parturition in Achai cows. Overall, the metabolic profile trend and SCC were comparable, yet the studied parameters were more pronounced in Holstein Friesian compared to Achai cows.

KEYWORDS

Achai, blood biochemical, Holstein Friesian, parturition, pregnancy, transition period

1 | INTRODUCTION

The transition period, spanning from 3 weeks before calving to 3 weeks post-calving, presents a formidable challenge for dairy cattle. This critical phase is marked by various factors including regrouping, alterations in diet, the act of calving and the commencement of lactation (Macmillan et al., 2020). In dairy cows, pregnancy triggers notable physiological and metabolic adaptations that are

[Correction added on 19 October 2023, after first online publication: New Funding information section has been added].

crucial for ensuring the proper development of the fetus and for providing the necessary substrates both during gestation and after birth (Arfuso et al., 2016). In the period just before parturition and throughout the initial phase of lactation, heightened mammary gland activity leads to an energy deficit and an escalation in the mobilization of lipids from bodily reserves (Fiore et al., 2018). While homeostatic mechanisms strive to uphold blood parameters within physiological ranges, alterations in metabolites transpire due to escalated metabolic requirements during pregnancy and lactation (Ashmawy, 2015; Tufarelli et al., 2023). These shifts do not necessarily signify diseases, but they render pregnant animals physiologically vulnerable, heightening their susceptibility to various metabolic disorders during this phase as opposed to other life stages, thereby potentially compromising productivity. Homeostasis control entails the preservation of a physiological equilibrium or the stability of environmental conditions within the animal. Homeostasis orchestrates a coordinated regulation of the metabolism of bodily tissues, essential to sustain a specific physiological state (Bauman & Currie, 1980) The peripartum period, likewise, emerges as a pivotal life phase in buffaloes (Abdulkareem, 2013; Fiore et al., 2018), demanding metabolic adjustments to accommodate the heightened energy and nutrient demands required for milk production (Abdulkareem, 2013; Bauman & Currie, 1980; Fiore et al., 2018).

In dairy cows, the primary alterations in metabolic pathways typically commence around 3 weeks before calving, reaching their peak during the calving period and continuing for approximately 3 weeks post-calving (Piccione et al., 2011). These intervals are marked by the mobilization of body fat, protein and mineral reserves to meet the nutritional needs of the developing fetus and to fulfil the demands for both milk production and maintenance (Van Dorland et al., 2009). Milk somatic cells, denoted as somatic cell count (SCC), encompass a range of bodily cells, with a predominant presence of macrophages, neutrophils and lymphocytes. The quantification of SCC holds significant importance, as it is closely linked to sub-clinical mastitis and reproductive disorders. Recently, Shoukat et al. (2022) observed that the SCC count in Achai cows was comparatively lower than that in high-producing crossbred cows. This observation implies that local Achai cows exhibit greater resistance to both productive and reproductive ailments. Numerous researchers have delved into the metabolic profile of high-producing dairy cows during the transition phase. However, there remains a paucity of information regarding the metabolic profile of Achai cows in comparison to Holstein Friesian cows during this critical transition period. Consequently, the objective of the current study was to elucidate the dynamic alterations in serum metabolic profiles and somatic cell count in Achai cows, juxtaposed with Holstein Friesian cows, throughout the transition period.

2 | MATERIALS AND METHODS

A total of 50 multiparous Achai cows and 70 Holstein Friesian cows, all averaging 5 years of age, were selected randomly. The farm maintained a dry period of 60 days. The farm's annual milk production stands at approximately 5000 kg, characterized by a milk quality of 3.8% fat and 3.5% protein. Each of the selected cows exhibited sound health conditions, devoid of internal and external parasites. Their health during pregnancy underwent thorough evaluation under the supervision of expert veterinarians. All cows were provided with a well-balanced diet tailored to meet the nutritional prerequisites of the peripartum phase, and a continuous supply of water was ensured. The chemical composition of the diets employed during the dry period and the ensuing early lactation is delineated in Table 1.

2.1 | Blood sampling and analysis

Blood samples were meticulously collected from each animal in the morning (at 07:00) through jugular venipuncture, with the same operator responsible for the procedure. The collected blood was carefully transferred into vacutainer tubes. For every cow, blood sampling was conducted at specific intervals: −21, −14 and −7 days before calving, on the day of calving (considered day 0), and subsequently on days 7, 14 and 21 post-calving. Blood samples were allowed to stand at room temperature for a duration of 20 min, after which they were subjected to centrifugation at 3000 *g* ×10 min. The resulting sera were subsequently stored at a temperature of −20°C until the time of analysis. Solely non-hemolyzed sera were subjected to analysis for the determination of glucose, total protein, cholesterol and triglycerides concentrations.

TABLE 1 Ingredients and composition of diet fed to cows during dry and lactation periods.

Ingredients	Dry period	Early lactation
Total mixed ration (%)		
Corn gluten	28.0	26.0
Corn grain	25.0	28.0
Molasses	15.0	12.0
Corn seed cake	12.0	11.0
Sunflower cake	8.0	10.0
Mustard seed cake	8.0	10.0
Dicalcium phosphate	1.0	2.0
Sodium chloride	1.0	1.0
Green grass, kg/cow/day		
Oat	20.0	30.0
Chemical analysis, %		
Crude protein	15.0	18.0
Neutral detergent fibre	26.0	32.0
Crude fat	3.40	4.30
Calcium	0.85	1.00

2.2 | Milk somatic cell count

Two milk samples were manually obtained from each milking session for each animal to ascertain the somatic cell count (SCC) on specific days (0, 7, 14 and 21 days). The collection of mammary secretion was executed under aseptic conditions. Initial external cleansing of the teat ends was carried out using commercial pre-milking disinfectant solutions. Subsequently, the teat ends were dried using individual towels and then re-cleaned using alcohol. The initial streams of fore-milk were discarded, and a pooled quantity of 25 mL of milk, amalgamated from the different quarters, was meticulously collected within sterile containers. This collected milk was then treated with sodium azide for preservation. The assessment of SCC was conducted using a Fossomatic cell counter (Foss Electric).

2.3 | Statistical analysis

Collected data, presented as mean values along with their standard deviations (mean ± SD), underwent assessment for normality using the Shapiro–Wilk normality test. It was determined that all the data exhibited normal distribution ($p < .05$), and accordingly, statistical analysis was conducted. The analysis involved employing a two-way ANOVA, taking into account breed and days as primary factors, along with their interaction. This analytical approach was facilitated through the utilization of statistical software (Statistics version 8.1). To discern significant distinctions among the means, Tukey's test was applied.

3 | RESULTS

The average blood concentration of Achai and Holstein cows on various days before and after calving is outlined in Table 2. The findings indicate a statistically significant ($p < .01$) elevation in blood glucose levels on day 21 of parturition among Holstein cows. Conversely, there was a notable ($p < .01$) reduction in blood glucose levels on the 14th and 21st days of the post-partum period among Holstein cows.

TABLE 2 Plasma glucose (mg/dL) concentration of Achai and Holstein Friesian cows during the transition period.

Periods	Days	Achai	Holstein Friesian
Pre-partum	−21	$64.65^{e} \pm 0.92$	$76.97^{cd} \pm 0.74$
	−14	$66.38^{e} \pm 0.79$	$75.35^{d} \pm 0.75$
	−7	$75.49^{b} \pm 0.95$	$78.83^{c} \pm 0.21$
Parturition day	0	$70.64^{c} \pm 1.33$	$74.35^{d} \pm 1.76$
Post-partum	7	$81.83^{b} \pm 0.50$	$82.96^{b} \pm 0.71$
	14	$81.54^{b} \pm 2.49$	$84.83^{ab} \pm 2.23$
	21	$83.652^{a} \pm 0.63$	$87.64^{a} \pm 0.85$

Note: p-Values: Days = .02; Breed = .01; Days × Breed = .01. Mean values with different superscripts in columns are different ($p < .05$).

The mean blood concentration of triglycerides in Achai and Holstein cows across different days before and after calving is summarized in Table 3. Notably, the blood triglyceride concentration displayed a significant increase in Holstein cows 21 days before calving. Conversely, Achai cows exhibited a significant decrease in blood triglyceride levels on the day of parturition and throughout the entire post-partum period.

The mean blood concentration of cholesterol in Achai and Holstein cows across different days before and after calving is

TABLE 3 Plasma triglycerides (mg/dL) of Achai and Holstein Friesian cows during the transition period.

Periods	Days	Achai	Holstein Friesian
Pre-partum	−21	$18.170^{b} \pm 0.37$	$23.20^{a} \pm 0.25$
	−14	$17.353^{bc} \pm 0.30$	$21.74^{ab} \pm 0.57$
	−7	$15.185^{c} \pm 037$	$18.99^{b} \pm 0.56$
Parturition day	0	$12.672^{d} \pm 0.32$	$15.98^{bc} \pm 0.47$
Post-partum	7	$14.637^{d} \pm 0.42$	$16.82^{c} \pm 0.33$
	14	$13.978^{d} \pm 0.29$	$15.77^{d} \pm 0.42$
	21	$12.790^{d} \pm 0.42$	$16.36^{bc} \pm 0.24$

Note: p-Values: Days = .04; Breed = .02; Days × Breed = .02; Mean values with different superscripts in columns are different ($p < .05$).

TABLE 4 Blood cholesterol (mg/dL) of Achai and Holstein Friesian cows during the transition period.

Periods	Days	Achai	Holstein Friesian
Pre-partum	−21	$174.63^{c} \pm 0.60$	$170.85^{d} \pm 0.69$
	−14	$166.23^{d} \pm 0.45$	$178.62^{b} \pm 0.59$
	−7	$174.72^{c} \pm 0.57$	$175.98^{c} \pm 0.38$
Parturition day	0	$161.68^{e} \pm 0.35$	$164.13^{d} \pm 0.47$
Post-partum	7	$177.55^{b} \pm 0.62$	$179.20^{b} \pm 0.50$
	14	$172.17^{d} \pm 0.42$	$175.12^{c} \pm 0.51$
	21	$181.58^{ab} \pm 0.51$	$185.37^{a} \pm 0.61$

Note: p-Values: Days = .001; Breed = .002; Days × Breed = .003; Mean values with different superscripts in columns are different ($p < .05$).

TABLE 5 Serum protein (g/dL) concentration of Achai and Holstein Friesian cows during the transition period.

Periods	Days	Achai	Holstein Friesian
Pre-partum	−21	$6.66^{d} \pm 4.28$	$7.65^{b} \pm 5.62$
	−14	$6.65^{d} \pm 6.09$	$7.65^{b} \pm 5.57$
	−7	$6.62^{e} \pm 4.28$	$7.61^{c} \pm 0.02$
Parturition day	0	$6.70^{d} \pm 8.02$	$7.73^{a} \pm 6.66$
Post-partum	7	$6.64^{de} \pm 6.09$	$7.62^{c} \pm 7.77$
	14	$6.68^{d} \pm 7.03$	$7.70^{a} \pm 0.01$
	21	$6.63^{de} \pm 3.33$	$7.63^{b} \pm 4.01$

Note: p-Values: Days = .001; Breed = .001; Days × Breed = .001; Mean values with different superscripts in columns are different ($p < .05$).

TABLE 6 Milk somatic cells count ($n \times 10^5$) of Achai and Holstein Friesian cows during the post-partum period.

Period	Days	Achai	Holstein Friesian
Post-partum	0	$3.03^f \pm 0.137$	$5.07^d \pm 0.291$
	7	$3.46^{ef} \pm 0.245$	$5.50^b \pm 0.263$
	14	$3.73^e \pm 0.170$	$5.48^c \pm 0.221$
	21	$4.00^e \pm 0.129$	$5.65^a \pm 0.172$

Note: *p*-Values: Days = .001; Breed = .001; Days × Breed = .001. Mean values with different superscripts in columns are different ($p < .05$).

summarized in Table 4. Blood cholesterol was significantly higher on day 21 in Holstein cows compared to Achai cows on the day of parturition.

The mean blood concentration of blood protein in Achai and Holstein cows across different days before and after calving is summarized in Table 5. The results revealed that blood protein was significantly higher on day 14 in Holstein cows post-partum and significantly lower in Achai cows 7 days before calving.

The mean blood concentration of SSC in Achai and Holstein cows across different days before and after calving is summarized in Table 6. The results showed that SCC was significantly ($p < .01$) higher in Holstein cows on day 21 of parturition and significantly lower on the day of parturition in Achai cows.

4 | DISCUSSION

Throughout the peripartum period, there is a heightened demand for the regulatory mechanisms governing the intricate processes associated with milking (Krajnicakova et al., 2003). In the present study, blood glucose increased with the advancement of pregnancy and following a post-partum period in both breeds. These results are similar to the general findings of Fiore et al. (2018), Saqib et al. (2018) and Shoukat et al. (2022). During the pre-partum period, the serum glucose levels exhibited lower values when compared to the post-partum time points. This discrepancy implies an increased rate of gluconeogenesis following calving, which is adequate to support lactose synthesis (Medhammar et al., 2012) Throughout the post-partum period, the glucose results were largely steady. It has been shown that in healthy dairy cows, glucose decrease only happens after calving and not before. This is mostly because pregnant cows need less glucose (Fiore et al., 2015). The steady pattern of blood glucose content in postpartum buffaloes seen in this study may indicate that there have not been any significant changes in the absolute rates of glycogenolysis and gluconeogenesis. Both the potential for lipogenesis in ruminant adipose tissue and the responsiveness of insulin to increase glucose absorption by adipose tissue and skeletal muscle are negatively impacted by lactation. It is significant that both adipose and muscle cells now respond less sensitively to insulin. Relevantly, glucose absorption by the placenta and mammary gland in ruminants remains insensitive to insulin despite the existence of insulin receptors in these tissues (Tsuda et al., 1991). This has an effect on the distribution of nutrients. In the current study, serum triglycerides were significantly higher at the start of sampling and then gradually decreased till the end of the study period. The decreasing trend, however, was higher in the Achai breed compared to the Holstein Friesian cows. During the early stages of lactation, cows find themselves in a state of negative energy balance, making body reserves a crucial source of fuel to support the attainment of their genetic potential for milk synthesis (Grummer, 1995). The escalated levels of triglycerides can be attributed to the liberation of fatty acids from adipose tissue, which transpires during periods of negative energy balance or stress. Notably, our study observed an upward trajectory in cholesterol and triglyceride levels over the post-partum period. The observed elevation in serum triglyceride levels has been linked to augmented voluntary feed intake and proper nutritional provisioning, as underscored by previous research (Bertics et al., 1992). Furthermore, a higher concentration of serum triglycerides has been associated with increased milk production (Ashmawy, 2015; Civelek et al., 2011). The rising levels of metabolic indicators across the post-partum period indicate the utilization of stored energy and augmented energy demand during this phase. Additionally, as the post-partum days progress, the animals tend to experience a reduction in the stress associated with parturition, potentially allowing for the utilization of stored energy resources.

The serum cholesterol concentration was high in both the breeds before calving and decreased drastically on the day of parturition, however, just after parturition, an increasing trend was observed. These findings are similar to the results of Arfuso et al. (2016) and Saqib et al. (2018) in similar experimental models. The cholesterol levels experience a gradual increase after calving, reflecting the phenomenon of fat mobilization that transpires during this period. The peripartum phase brings about an augmented demand for the regulatory mechanisms accountable for the intricate processes inherent in milking (Krajnicakova et al., 2003). Consequently, distinctive alterations in lipid metabolism are observed in the majority of mammals during pregnancy and lactation (Roche et al., 2009). This period sees changes in endocrine profiles, alongside regulated lipolysis and lipogenesis, aimed at enhancing the lipid reserves during pregnancy. These stored lipids are then mobilized post-calving and upon the commencement of lactation (Roche et al., 2009).

This investigation has unveiled that the serum total protein levels were comparatively lower during the late stages of pregnancy as compared to the period of parturition. Subsequently, these levels experienced a gradual decline during the post-partum period across both breeds, albeit consistently registering higher values in Holstein Friesian cows throughout the sampling periods. This finding aligns well with the outcomes of the other studies (Kurpinska et al., 2015; Mohammed et al., 2021) that highlighted a reduction in serum total protein during the latter stages of pregnancy. Interestingly, in the post-partum period, the serum total protein levels exhibited an elevation in comparison to the late pregnancy phase.

This observation concurs with a prior study that indicated serum total protein levels being significantly influenced by physiological phases, showing an increase during lactation compared to the later stages of gestation in dairy cows (Piccione et al., 2012). In the present study, a notable upward trend in serum protein levels was observed leading up to parturition in both breeds. However, this trend was subsequently reversed during the post-partum period. The declining trend might signify a potential deficiency in dietary protein intake. A reduction in pre-partum protein circulation among cows often points towards decreased dry matter intake (DMI), which can trigger negative energy balance (NEB). While alterations in serum protein concentrations suggest the potential for NEB, it is important to note that this indication is relatively weak. Conversely, the noteworthy increase in post-partum circulating levels of triglycerides and cholesterol serves as a more robust indicator of NEB (Macmillan et al., 2020).

In the current study, the SCC was significantly higher in Holstein Friesian cows compared to the Achai breed. Interestingly, an increasing trend was observed in both breeds, however, the upward trend was higher in Holstein Friesian cows compared to the Achai cows. This observation suggests a strong correlation between milk somatic cell count and milk production. Moreover, it implies that the occurrence of mastitis is less frequent in the local breed (Shoukat et al., 2022). The variation in SCC appears to be contingent on the interplay of cow breed and milk production. Local breeds typically yield a lower quantity of milk in comparison to high-producing cows. Consequently, the prevalence of mastitis appears to be influenced by both the milk production level and the specific breed of cows.

5 | CONCLUSION

From the results of the present study, it was concluded that the transition period is characterized by great changes in the metabolic profile of dairy cows. Further, it was found that metabolic profile and somatic cell count showed the same pattern in both breeds, however, the trend was significantly higher in Holstein Friesian cows compared to Achai cows. The interactions observed between periods and health status highlight that the levels of blood metabolites during the peripartum phase could potentially offer insights into the risk of post-partum diseases. These findings hold the potential to serve as a valuable tool for herd monitoring, providing a fresh approach to enhance farm management strategies.

AUTHOR CONTRIBUTIONS

All the authors equally contributed.

ACKNOWLEDGEMENTS

The authors extend their appreciation to the lab technicians involved. We extend our appreciation to the Researchers Supporting Project (No. RSPD2023R833), King Saud University, Riyadh, Saudi Arabia.

CONFLICT OF INTEREST STATEMENT

None of the authors have any conflict of interest to declare.

DATA AVAILABILITY STATEMENT

Data that support the findings of this study are available upon request from the corresponding author.

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How to cite this article: Ullah, N., Khan, M. T., Naz, S., Alhidary, I. A., Khan, R. U., Losacco, C., Pugliese, G., & Tufarelli, V. (2023). Blood metabolic pattern and somatic cells dynamic in Achai and Holstein Friesian cows during transition period. *Reproduction in Domestic Animals*, *58*, 1712–1717. https://doi.org/10.1111/rda.14489