SRYAHWA PUBLICATIONS

Journal of Animal Husbandry and Dairy Science
ISSN: 2637-5354 | Volume 10, Issue 1, 2026
https://doi.org/10.22259/2637-5354.1001004

RESEARCH ARTICLE

Peripartum Metabolic Adaptation: Comprehensive Biochemical, Mineral, and Endocrine Profiles in Baggara Cattle (*Bos indicus*) During Gestation, Parturition, and Early Lactation

Omer Adam Ibrahim Salih, Hosameldeen Mohamed Husien, Elsir Abdelhai Babiker, Ashwag Elnour Ahmed Musaad

Faculty of Veterinary Medicine,University of Albutana, Sudan.

Received: 21 July 2026 Accepted: 06 August 2026 Published: 13 August 2026

Corresponding Author: Hosameldeen Mohamed Husien, Faculty of Veterinary Medicine,University of Albutana, Sudan.

Abstract

Background: The periparturient period imposes substantial metabolic demands on dairy cattle, with adaptation failure predisposing to production diseases (Drackley, 1999). Breed-specific reference data are essential for indigenous breeds like Baggara cattle.

Objective: To characterize changes in serum biochemical parameters, minerals, and enzymes in Baggara cattle throughout gestation and the peripartum period.

Methods: Eight pregnant Baggara cows were monitored monthly during gestation (Experiment 1) and through parturition to 60 days postpartum (Experiment 2). Serum was analyzed for metabolites (total protein, albumin, globulin, cholesterol, urea, creatinine, triacylglycerols), minerals (Ca, P, Na, K), enzymes (AST, ALT), and progesterone.

Results: During gestation, albumin increased significantly from day 65 (4.46±0.56 g/dL) to day 275 (4.64±0.54 g/dL; P<0.05), while globulin decreased at days 95 (2.13±1.00 g/dL) and 155 (2.25±0.85 g/dL). Cholesterol doubled from 97.73±26.95 mg/dL (non-pregnant) to 175.0±11.90 mg/dL by day 245 ($P < 0.01$). Minerals and enzymes remained stable throughout gestation. At parturition, progesterone declined from 11.73±0.81 pg/mL (72h pre-calving) to 3.21±0.57 pg/mL (48h postpartum; P<0.001). AST was elevated at calving (81.46±5.42 U/L) compared to postpartum (70.80±4.29 U/L; $P < 0.05$). Cholesterol decreased postpartum from 162.9±7.08 mg/dL (calving) to 150.0±8.34 mg/dL by day 45 ($P < 0.05$).

Conclusion: Baggara cattle maintain remarkable metabolic homeostasis during the peripartum period, with adaptive changes primarily in protein metabolism and cholesterol. The transient AST elevation at calving represents physiological stress. These findings establish breed-specific reference values and demonstrate the metabolic resilience of this indigenous breed.

Keywords: Baggara Cattle, Transition Period, Metabolic Adaptation, Peripartum Biochemistry, Hypocalcemia, Negative Energy Balance.

1. Introduction

The transition period, spanning approximately three weeks before to three weeks after parturition, represents the most metabolically challenging phase in the productive life of a dairy cow (Drackley, 1999). During this critical window, the animal must undergo profound physiological adaptations to meet the exponentially increasing nutrient demands of late gestation and the sudden onset of copious milk synthesis. Failure to adapt successfully predisposes

Citation: Omer Adam Ibrahim Salih, Hosameldeen Mohamed Husien, Elsir Abdelhai Babiker, *et.al.* Peripartum Metabolic Adaptation: Comprehensive Biochemical, Mineral, and Endocrine Profiles in Baggara Cattle *(Bos indicus)* During Gestation, Parturition, and Early Lactation. Journal of Animal Husbandry and Dairy Science. 2026;10(1):22-29.

cattle to a spectrum of metabolic disorders including ketosis, fatty liver syndrome, hypocalcemia (milk fever), and displaced abomasum, collectively termed "production diseases" (Goff & Horst, 1997).

The transition to lactation is characterized by a state of negative energy balance, as dry matter intake fails to keep pace with the energy demands of lactogenesis (Grummer, 1995). This necessitates mobilization of body reserves, reflected in elevated circulating non-esterified fatty acids (NEFA) and the ketone body beta-hydroxybutyrate (BHBA). Concurrently, mineral homeostasis is severely challenged, particularly calcium metabolism, as the daily secretion of calcium in colostrum can reach 20-30 grams—approximately ten times the normal extracellular pool. This massive efflux can overwhelm homeostatic mechanisms, leading to clinical or subclinical hypocalcemia (Horst et al., 1994).

Hepatic function is also stressed during this period, as the liver must process increased loads of mobilized fatty acids and ammonia from protein catabolism (Bobe et al., 2004). Serum enzymes such as aspartate aminotransferase (AST) and gamma-glutamyl transferase (GGT) serve as valuable indicators of hepatocellular integrity and function, with elevated activities suggesting hepatic stress or damage.

While extensive research has characterized peripartum metabolic adaptations in high-producing *Bos taurus* dairy breeds, indigenous African cattle breeds with *Bos indicus* ancestry remain understudied. The Baggara cattle of Sudan, a hardy, humped zebu breed adapted to semi-arid environments, likely possess distinct metabolic characteristics shaped by both genetics and traditional management systems. These breeds may exhibit different adaptive strategies to the metabolic challenges of the peripartum period, potentially conferring greater resistance to production diseases (Hernández et al., 2015).

Establishing breed-specific reference intervals for biochemical parameters during gestation and early lactation is essential for several reasons: (1) accurate diagnosis of metabolic disorders, (2) formulation of appropriate nutritional interventions, (3) assessment of transition cow management programs, and (4) understanding the genetic basis of metabolic adaptation. Currently, such comprehensive data are lacking for Baggara cattle, which is a significant gap for the management of indigenous breeds adapted to semi-arid climates (Quiroz-Rocha et al., 2017; Alam et al., 2016).

This study was therefore designed to comprehensively profile metabolic, mineral, and endocrine changes in Baggara cattle throughout gestation and the peripartum period. Specific objectives were to: (1) characterize longitudinal changes in serum metabolites, minerals, and enzymes during gestation; (2) document the progesterone profile during the peripartum period; and (3) establish postpartum recovery patterns for key biochemical parameters. The findings will provide fundamental insights into the metabolic adaptation strategies of this important indigenous breed and establish baseline data for improved peripartum management.

2. Materials and Methods

2.1 Experimental Animals and Design

This study comprised two sequential experiments conducted on the same cohort of animals. Initially, 12 Baggara cows were synchronized using the Ovsynch protocol and artificially inseminated as described by Pursley et al. (1995) with modifications.

Eight cows that conceived (66.7% conception rate) and maintained pregnancy to term formed the experimental group.

2.1.1 Experiment 1 (Gestation)

Blood samples were collected monthly from confirmed pregnancy (day 35) until day 275 of gestation (approximately 2 weeks prepartum), representing the first, second, and third trimesters. Samples were collected prior to morning feeding.

2.1.2 Experiment 2 (Peripartum)

The same eight cows were monitored intensively around parturition. Blood samples were collected at: 245 days of gestation, 72 hours, 48 hours, and 24 hours before expected calving, at the time of calving (within 2 hours of parturition), and at 24 and 48 hours postpartum. Additional samples were collected at 15, 30, 45, and 60 days postpartum to assess recovery.

All animals were managed under identical conditions as described in Paper 1, with diets adjusted according to physiological stage. The prepartum diet was formulated to meet NRC requirements for late gestation, while the postpartum diet supported early lactation.

2.2 Blood Sample Collection and Processing

Blood samples (10 mL) were collected from the jugular vein using sterile technique. Samples for serum biochemistry were collected in plain tubes, allowed to clot at room temperature for 1-2 hours,

then centrifuged at 3000 rpm for 5 minutes. Serum was aliquoted and stored at -20°C until analysis. For progesterone analysis, additional samples were collected in heparinized tubes, processed similarly, and stored at -20°C.

2.3 Biochemical Analyses

All biochemical analyses were performed using commercial kits on a spectrophotometer (Unicam, England) according to manufacturers' instructions.

2.3.1 Metabolites

Total protein: Biuret method; Albumin: Bromocresol green method; Globulin: Calculated as (total protein - albumin); Urea: Urease-Berthelot method; Creatinine: Jaffe reaction; Total cholesterol: Cholesterol oxidase-peroxidase method; Triacylglycerols: GPO-PAP method.

2.3.2 Minerals

Calcium: o-Cresolphthalein complexone method; Inorganic phosphorus: Ammonium molybdate method; Sodium and Potassium: Flame photometry.

2.3.3 Enzymes

Aspartate aminotransferase (AST): IFCC method; Alanine aminotransferase (ALT): IFCC method.

2.3.4 Hormone Analysis

Progesterone concentrations were determined using a commercial ELISA kit (Biorex Diagnostic Ltd, UK) according to manufacturer's instructions. The intra- and inter-assay coefficients of variation were <10%.

2.4. Statistical Analysis

Data are presented as mean ± standard deviation. For Experiment 2, one-way ANOVA with repeated measures was used to compare parameters across gestation time points, with Tukey's post-hoc test for multiple comparisons. For Experiment 3, peripartum changes were analyzed using paired t-tests comparing each time point to baseline (245 days gestation). Postpartum recovery was analyzed using one-way ANOVA. Pearson correlation coefficients were calculated to examine relationships between parameters. All analyses were performed using SPSS version 16.0, with statistical significance set at $P < 0.05$.

3. Results

3.1 Experiment 1

3.1.1 Biochemical Changes During Gestation

Protein Metabolism

Total protein concentrations remained stable throughout gestation, ranging from 6.85 ± 0.90 g/dL to 7.60 ± 0.65 g/dL with no significant differences between time points (**Table 1**). In contrast, albumin showed a significant increase from 3.29 ± 0.52 g/dL in non-pregnant cows to 4.46 ± 0.56 g/dL by day 65 of gestation ($P < 0.05$), remaining elevated through day 275. Globulin concentrations exhibited a biphasic pattern, decreasing significantly at days 95 (2.13 ± 1.00 g/dL) and 155 (2.25 ± 0.85 g/dL) compared to non-pregnant levels (3.74 ± 0.93 g/dL; $P < 0.05$), then gradually recovering thereafter. The albumin:globulin ratio increased from 0.88 in non-pregnant cows to 2.22 by day 95 of gestation.

Lipid Metabolism

Total cholesterol increased dramatically during gestation, from 97.73 ± 26.95 mg/dL in non-pregnant cows to 175.0 ± 11.90 mg/dL by day 245 ($P < 0.001$; **Table 1**). This represents a 79% increase from baseline. Triacylglycerol concentrations remained stable throughout gestation, ranging from 14.81 ± 2.01 mg/dL to 17.96 ± 2.69 mg/dL with no significant trends.

Nitrogen Metabolism

Urea concentrations showed a modest but significant increase at day 245 of gestation (19.34 ± 2.32 mg/dL) compared to non-pregnant levels (14.79 ± 3.88 mg/dL; $P < 0.05$). Creatinine concentrations remained stable throughout gestation (0.99-1.40 mg/dL) (**Table 1**).

Table 1. *The effect of pregnancy on blood metabolites in Baggara cattle (n=8)*

Parameter (units)	Non-pregnant	35 days	65 days	95 days	125 days	155 days	185 days	215 days	245 days	275 days
Total protein (g/dL)	7.03± 0.69	7.10± 0.78	7.06± 0.75	6.85± 0.90	7.10± 0.65	7.15± 0.55	7.24± 0.56	7.60± 0.65	7.35± 0.71	7.50± 0.72
Albumin (g/dL)	3.29± 0.52[a]	3.55± 0.55[a]	4.46± 0.56[b]	4.73± 0.63[b]	4.54± 0.53[b]	4.90± 0.55[b]	4.81± 0.56[b]	4.79± 0.49[b]	4.68± 0.54[b]	4.64± 0.54[b]
Cholesterol (mg/dL)	97.73± 26.95[a]	148.7± 16.13[b]	163.5± 11.25[b]	168.6± 16.37[b]	166.0± 12.15[b]	162.8± 15.14[b]	167.4± 17.32[b]	169.2± 13.31[b]	175.0± 11.90[b]	164.7± 7.24[b]

Parameter (units)	Non-pregnant	35 days	65 days	95 days	125 days	155 days	185 days	215 days	245 days	275 days
Globulin (g/dL)	3.74± 0.93^{ab}	3.55± 0.74^{ab}	2.60± 0.77^{ab}	2.13± 1.00^{b}	2.56± 0.53^{ab}	2.25± 0.85^{b}	2.43± 0.82^{ab}	2.81± 1.08^{ab}	2.68± 0.98^{ab}	2.86± 0.93^{ab}
Urea (mg/dL)	14.79± 3.88^{a}	16.05± 2.76^{a}	17.64± 3.48^{a}	17.20± 2.77^{a}	17.45± 2.71^{a}	17.01± 2.33^{a}	17.30± 1.65^{a}	18.40± 2.26^{a}	19.34± 2.32^{b}	18.96± 1.53^{a}
Creatinine (mg/dL)	1.29± 0.40	0.99± 0.51	1.15± 0.49	1.25± 0.26	1.11± 0.27	1.15± 0.18	1.28± 0.23	1.40± 0.20	1.36± 0.27	1.21± 0.19
Triacylglycerol (mg/dL)	16.40± 2.57	17.31± 2.57	17.96± 2.69	17.25± 1.39	17.40± 2.27	17.46± 1.26	17.78± 1.65	15.83± 2.76	14.81± 2.01	15.58± 1.69

Values are mean ± SD. Different superscript letters within rows indicate significant differences ($P < 0.05$).

3.1.2 Mineral Homeostasis

All measured minerals maintained stable concentrations throughout gestation (**Table 2**). Calcium ranged from 9.14 ± 1.30 mg/dL to 10.70 ± 0.56 mg/dL, phosphorus from 5.5 ± 0.93 mg/dL to 6.7 ± 0.49 mg/dL, sodium from 135.7 ± 1.64 mEq/L to 140.7 ± 2.62 mEq/L, and potassium from 4.30 ± 0.53 mEq/L to 4.80 ± 0.39 mEq/L. No significant changes were observed for any mineral across gestation.

Table 2. *The effect of pregnancy on blood minerals in Baggara cattle (n=8)*

Parameter (units)	Non-pregnant	35 days	65 days	95 days	125 days	155 days	185 days	215 days	245 days	275 days
Calcium (mg/dL)	9.38± 0.82	9.14± 1.30	9.40± 1.24	9.66± 1.09	9.98± 0.67	10.60± 0.70	10.29± 0.81	10.70± 0.56	10.40± 0.76	10.64± 0.81
Potassium (mEq/L)	4.80± 0.39	4.30± 0.53	4.31± 0.86	4.69± 0.48	4.36± 0.49	4.50± 0.57	4.65± 0.52	4.69± 0.49	4.69± 0.56	4.68± 0.53
Sodium (mEq/L)	140.7± 2.62	137.6± 4.55	136.5± 3.31	136.2± 2.56	135.9± 2.31	135.7± 1.64	137.7± 2.22	138.2± 3.19	138.4± 3.88	137.6± 1.89
Phosphorus (mg/dL)	6.0± 1.1	5.5± 0.93	5.6± 0.47	6.0± 0.61	6.1± 0.87	6.2± 0.81	6.5± 0.46	6.5± 0.76	6.7± 0.49	6.2± 0.55

3.1.3 Hepatic Enzymes

AST activity showed a non-significant increasing trend from 63.83 ± 10.43 U/L at day 35 to 80.00 ± 9.09 U/L at day 185, then stabilized (**Table 3**). ALT activity remained stable throughout gestation except for elevations at days 245 (23.45 ± 4.92 U/L) and 275 (23.91 ± 3.11 U/L; $P < 0.05$ compared to earlier time points).

Table 3. *The effect of pregnancy on blood enzymes in Baggara cattle (n=8)*

Parameter (units)	Non-pregnant	35 days	65 days	95 days	125 days	155 days	185 days	215 days	245 days	275 days
AST (U/L)	64.89± 13.28	63.83± 10.43	69.43± 9.55	71.03± 10.75	70.53± 10.67	73.80± 10.11	80.00± 9.09	76.56± 8.01	77.08± 9.34	76.40± 8.69
ALT (U/L)	17.59± 3.92^{a}	15.03± 3.96^{a}	16.13± 3.54^{a}	17.10± 2.20^{a}	16.64± 2.07^{a}	15.90± 4.33^{a}	16.33± 3.74^{a}	17.90± 2.87^{a}	23.45± 4.92^{b}	23.91± 3.11^{b}

3.2 Experiment 2

3.2.1 Peripartum and Postpartum Changes

Progesterone Dynamics

Serum progesterone concentrations demonstrated the characteristic peripartum decline (**Table 4**).

Table 4. *Progesterone profile during calving in Baggara cattle (n=8)*

Time point	245 days gestation	72h pre-calving	48h pre-calving	24h pre-calving	At calving	24h postpartum	48h postpartum
Progesterone (pg/mL)	12.43±0.14^{a}	11.73±0.81^{a}	9.14±0.65^{b}	6.53±0.51^{c}	5.45±0.68^{c}	4.45±0.36^{d}	3.21±0.57^{e}

Different superscript letters indicate significant differences ($P < 0.05$).

From 12.43 ± 0.14 pg/mL at 245 days gestation, progesterone decreased to 11.73 ± 0.81 pg/mL at 72 hours pre-calving, followed by a precipitous decline to 9.14 ± 0.65 pg/mL at 48 hours, 6.53 ± 0.51 pg/mL at 24 hours, and 5.45 ± 0.68 pg/mL at calving ($P < 0.001$ for all compared to 245 days). The decline continued postpartum to 4.45 ± 0.36 pg/mL at 24 hours and 3.21 ± 0.57 pg/mL at 48 hours postpartum.

3.2.2 Postpartum Metabolic Recovery

Total protein and albumin concentrations showed no significant changes from calving through 60 days postpartum (**Table 5**). Cholesterol decreased significantly from 162.9 ± 7.08 mg/dL at calving to 150.0 ± 8.34 mg/dL by day 45 postpartum ($P < 0.05$), remaining at this level through day 60. Urea, creatinine, and triacylglycerols remained stable throughout the postpartum period.

Table 5. *Blood metabolites in Baggara cattle during calving and postpartum period (n=8)*

Parameter (units)	At calving	15 days PP	30 days PP	45 days PP	60 days PP
Total protein (g/dL)	7.39±0.54	7.08±0.41	7.06±0.59	7.30±0.61	7.11±0.43
Albumin (g/dL)	4.36±0.59	4.06±0.67	4.23±0.58	4.51±0.76	4.39±0.32
Cholesterol (mg/dL)	162.9±7.08^{a}	154.6±8.23^{ab}	152.9±8.17^{ab}	150.0±8.34^{b}	150.6±6.00^{b}
Globulin (g/dL)	2.90±0.65	3.01±0.80	2.84±0.86	2.79±0.94	2.73±0.71
Urea (mg/dL)	17.69±1.29	18.20±2.49	17.25±1.59	17.51±1.89	17.71±1.27
Creatinine (mg/dL)	1.18±0.07	1.15±0.18	1.20±0.11	1.24±0.15	1.25±0.16
Triacylglycerol (mg/dL)	14.84±1.78	14.49±1.51	14.79±0.51	15.58±0.95	14.38±1.55

PP = postpartum. Different superscript letters within rows indicate significant differences ($P < 0.05$).

3.2.3 Mineral Homeostasis Postpartum

All minerals maintained stable concentrations from calving through 60 days postpartum, with no evidence of hypocalcemia or other mineral disturbances (**Table 6**). Calcium concentrations ranged from 10.05 ± 0.41 mg/dL to 10.36 ± 0.46 mg/dL, all within normal reference ranges.

Table 6. *Blood minerals in Baggara cattle during calving and postpartum period (n=8)*

Parameter (units)	At calving	15 days PP	30 days PP	45 days PP	60 days PP
Calcium (mg/dL)	10.36±0.46	10.20±0.67	10.08±0.69	10.05±0.41	10.19±0.67
Potassium (mEq/L)	4.61±0.57	4.35±0.47	4.50±0.43	4.44±0.42	4.46±0.45
Sodium (mEq/L)	137.4±1.84	136.6±1.57	136.8±0.91	136.3±1.44	137.8±2.60
Phosphorus (mg/dL)	5.86±0.59	5.83±0.96	5.69±0.57	6.33±0.64	5.90±0.71

3.2.4 Hepatic Enzymes Postpartum

AST activity was significantly elevated at calving (81.46 ± 5.42 U/L) compared to all postpartum time points (70.80 ± 4.29 U/L at day 15; $P < 0.05$; **Table 7**). By day 15 postpartum, AST had returned to levels comparable to late gestation. ALT activity showed no significant changes across the peripartum period.

Table 7. *Blood enzymes in Baggara cattle during calving and postpartum period (n=8)*

Parameter (units)	At calving	15 days PP	30 days PP	45 days PP	60 days PP
AST (U/L)	81.46±5.42^{a}	70.80±4.29^{b}	72.26±7.05^{b}	74.73±7.97^{b}	72.64±9.30^{b}
ALT (U/L)	21.65±2.07	18.50±3.76	18.54±3.24	22.15±6.26	22.94±3.42

3.3. Correlation Analyses

Significant positive correlations were observed between: (1) albumin and cholesterol throughout gestation ($r = 0.71$, $P < 0.01$); (2) progesterone and cholesterol in late gestation ($r = 0.66$, $P < 0.05$); and (3) AST at calving and the magnitude of progesterone decline ($r = 0.69$, $P < 0.05$). A negative correlation was found between albumin and globulin during mid-gestation ($r = -0.58$, $P < 0.05$).

4. Discussion

This comprehensive longitudinal study provides the first detailed characterization of peripartum metabolic adaptations in Baggara cattle, an important indigenous *Bos indicus*breed of Sudan. The findings reveal both similarities and distinct differences compared to well-studied *Bos taurus*dairy breeds, highlighting the metabolic resilience of this adapted breed.

4.1 Protein Metabolism Adaptations

The significant increase in albumin concentrations from early gestation onward contrasts with patterns reported in high-producing dairy cows, where albumin often decreases or remains stable during gestation (Seifi et al., 2003; Quiroz-Rocha et al., 2017). This elevation likely reflects increased hepatic synthetic activity to support the expanding plasma volume, maintain oncotic pressure, and provide amino acids for fetal and uterine growth. The positive correlation between albumin and cholesterol suggests coordinated upregulation of hepatic export protein synthesis. The decrease in globulin at mid-gestation (days 95 and 155) is intriguing and may indicate immunological adaptation to prevent rejection of the fetal allograft, though this requires verification through specific immunoglobulin assays. The resultant increase in albumin:globulin ratio may enhance nutrient transport capacity during peak fetal growth.

4.2 Lipid Metabolism and Energy Balance

The dramatic increase in total cholesterol during gestation (79% above non-pregnant levels) exceeds the 30-50% increases typically reported in dairy cattle (Kaneene et al., 1997; Alam et al., 2016). This substantial elevation likely supports several physiological processes: (1) provision of substrate for placental and fetal steroidogenesis, (2) incorporation into fetal membranes and tissues, and (3) preparation for lactogenesis. Cholesterol serves as the precursor for progesterone synthesis by the placenta, explaining the positive correlation observed between cholesterol and progesterone in late gestation. The peripartum period is characterized by significant metabolic stress and immune activation, which can alter hepatic and lipid metabolism parameters (Pascottini et al., 2020). The postpartum decline in cholesterol reflects the metabolic shift from steroidogenic support of pregnancy to lipid mobilization for milk fat synthesis. Notably, triacylglycerols remained stable throughout, suggesting that unlike high-producing dairy breeds, these Baggara cows did not enter substantial negative energy balance postpartum under the study conditions (Reynolds et al., 2003).

4.3 Mineral Homeostasis Resilience

Perhaps the most striking finding is the maintenance of normocalcemia throughout the peripartum period. In high-producing dairy breeds, subclinical hypocalcemia (serum calcium<8.5 mg/dL) affects 25-50% of multiparous cows, with clinical milk fever occurring in 3-10% (Lean et al., 2006; Reinhardt et al., 2011; DeGaris and Lean, 2008; Wilkens et al., 2020; McArt and Neves, 2020). The consistent calcium concentrations observed here (all >9.0 mg/dL) suggest that Baggara cattle possess efficient calcium homeostatic mechanisms, possibly through: (1) lower milk yield reducing calcium efflux, (2) more efficient intestinal absorption mediated by 1,25-dihydroxyvitamin D, (3) enhanced bone resorption capacity, or (4) genetic factors influencing calcium-regulating hormones. The stability of phosphorus, sodium, and potassium further demonstrates effective mineral homeostasis in this breed.

4.4 Hepatic Function and Stress Markers

The transient elevation of AST at calving, followed by rapid return to baseline, represents a physiological stress response rather than pathological liver damage (Uddin et al., 2020). AST is found in both hepatocytes and muscle tissue, and its increase at parturition likely reflects myofiber damage during labor rather than hepatocellular injury (Sattler and Fürll, 2012), particularly given the stability of ALT (a more liver-specific enzyme) (Uddin et al., 2020). The correlation between AST elevation and progesterone decline magnitude suggests that cows experiencing more rapid progesterone withdrawal (and presumably more intense parturition) exhibited greater tissue stress. The late-gestation increase in ALT, while statistically significant, remained within normal reference ranges and likely represents normal hepatic adaptation to increased metabolic load.

4.5 Progesterone Dynamics

The progesterone profile demonstrates the characteristic prepartum decline essential for initiation of parturition. The timing and magnitude of decline are consistent with reports in other breeds, confirming normal luteoplacental function. The continued decline postpartum reflects complete luteolysis and clearance of placental progesterone.

4.6 Comparative Perspective

The metabolic profile of Baggara cattle reveals a breed with remarkable homeostatic capacity. Compared to high-producing Holsteins, these indigenous cows exhibited: (1) stable rather than decreasing albumin, (2) more pronounced cholesterol elevation, (3) absence of hypocalcemia, (4) stable triacylglycerols suggesting minimal negative energy balance, and (5) only transient, mild increases in hepatic enzymes (Hernández et al., 2015). These differences likely reflect both genetic adaptation and the lower production pressure on these dual-purpose animals. Indigenous breeds may prioritize metabolic stability and disease

resistance over maximum production, an evolutionary strategy suited to traditional management systems with fluctuating nutrient availability, as seen in other adapted breeds (Hernandez et al., 2015; Alegría et al., 2021; Yang et al., 2022).

Practical Implications

These findings have important implications for managing Baggara cattle during the peripartum period. First, the apparent resistance to hypocalcemia suggests that aggressive calcium supplementation strategies used in dairy herds may be unnecessary and potentially detrimental for this breed. Second, the stable energy balance indicators suggest that these cows, under the management conditions studied, successfully adapted to lactation demands without excessive mobilization. Third, the established reference values will facilitate more accurate diagnosis of metabolic disorders in this breed (Islam et al., 2022). Finally, the metabolic resilience observed suggests that Baggara cattle genetics could contribute valuable traits to breeding programs aimed at improving health and fertility in commercial herds.

Study Limitations and Future Directions

This study has several limitations. First, the sample size (n=8), while adequate for establishing trends, limits statistical power for detecting subtle changes. Second, the use of non-lactating, pregnant cows in good body condition may not represent the full spectrum of production scenarios. Third, key parameters such as NEFA and BHBA were not measured, limiting assessment of negative energy balance. Future research should include these metabolites, expand sample sizes, investigate lactating animals, and examine genetic markers associated with the observed metabolic resilience (Ingvartsen & Moyes, 2013).

6. Conclusion

This comprehensive investigation establishes that Baggara cattle exhibit remarkable metabolic stability throughout gestation and the peripartum period. Key adaptations include increased albumin and cholesterol synthesis during gestation, maintenance of normocalcemia despite the challenges of parturition, and only transient, mild increases in hepatic enzymes at calving. The breed demonstrates efficient homeostatic mechanisms that likely contribute to reduced susceptibility to production diseases like milk fever and ketosis. These findings provide essential reference data for clinical assessment and nutritional management of Baggara cattle during the critical transition period. The metabolic resilience observed highlights the value of indigenous genetic resources and suggests that Baggara cattle possess adaptive traits that could benefit sustainable livestock production systems.

Acknowledgements

The authors gratefully acknowledge the technical staff of Al-Rayada laboratory for biochemical analyses, the management and staff of El-Etegahat dairy project for animal care and access, and Dr. Mohamed Fatthy, Dr. Abdulla Hassan, and Dr. Muzamel atta Ali for statistical assistance and scientific discussion. This work is dedicated to the memory of the Sudanese Revolution Martyrs of December 2018.

Funding

This research was conducted as part of a Ph.D. dissertation with institutional support from the University of Al Butana, Faculty of Veterinary Medicine. No external funding was received.

Conflict of Interest

The authors declare no conflicts of interest.

7. References

1 Alegría, K.G., et al. 2021. Insulin resistance indexes of grazing cows and mineral or vitamin supplementation under tropical conditions. Open Vet J. 11(4): 587–597. https://doi.org/10.5455/OVJ.2021.v11.i4.8

2 Alam, M.R., et al. 2016. Nutritional status of high yielding crossbred cow around parturition. J Adv Vet Anim Res. 3(1): 68–74. https://doi.org/10.5455/javar.2016.c133

3 Bobe, G., Young, J.W., Beitz, D.C. 2004. Invited review: pathology, etiology, prevention, and treatment of fatty liver in dairy cows. J Dairy Sci. 87, 3105-3124.

4 DeGaris, P.J., Lean, I.J. 2008. Milk fever in dairy cows: A review of pathophysiology and control principles. Vet J. 176(1): 58–69. https://doi.org/10.1016/j.tvjl.2007.12.029

5 Drackley, J.K. 1999. Biology of dairy cows during the transition period: the final frontier? J Dairy Sci. 82, 2259-2273.

6 Goff, J.P., Horst, R.L. 1997. Physiological changes at parturition and their relationship to metabolic disorders. J Dairy Sci. 80, 1260-1268.

7 Grummer, R.R. 1995. Impact of changes in organic nutrient metabolism on feeding the transition dairy cow. J Anim Sci. 73, 2820-2833.

8 Hernandez, E.A., Campos, G.R., Giraldo, P.L. 2015. Metabolic behaviour in the peripartum period of dairy

cows Harton del Valle creole breed, under tropical conditions. Rev Fac Med Vet Zootec. 62(2), 39-52.

9 Hernandez, L.L., et al. 2015. Evaluation of peripartum calcium homeostasis in dairy cattle. J Dairy Sci. 98(Suppl. 2): 45–56. https://doi.org/10.3168/jds.2014-8765

10 Horst, R.L., Goff, J.P., Reinhardt, T.A. 1994. Calcium and vitamin D metabolism in the dairy cow. J Dairy Sci. 77, 1936-1951.

11 Ingvartsen, K.L., Moyes, K. 2013. Nutrition, immune function and health of dairy cattle. Animal. 7(s1), 112-122.

12 Islam, M.A., Hossain, M.M., Hossain, M.M., Saha, S., Hasan, M.M. 2022. Early metabolic profiling in the periparturient period reduces the occurrence of postparturient metabolic diseases in cows. J Adv Vet Anim Res. 9(2), 295-300.

13 Kaneene, J.B., Miller, R., Herdt, T.H., Gardiner, J.C. 1997. The association of serum nonesterified fatty acids and cholesterol, management and feeding practices with peripartum disease in dairy cows. Prev Vet Med. 31(1–2): 59–72. https://doi.org/10.1016/S0167-5877(96)01141-5

14 Lean, I.J., DeGaris, P.J., McNeil, D.M., Block, E. 2006. Hypocalcemia in dairy cows: Meta-analysis and dietary cation anion difference theory revisited. J Dairy Sci. 89(2): 669–684. https://doi.org/10.3168/jds.S0022-0302(06)72130-0

15 McArt, J.A.A., Neves, R.C. 2020. Graduate Student Literature Review: What do we know about the effects of clinical and subclinical hypocalcemia on health and performance of dairy cows? J Dairy Sci. 103(9): 8466–8482. https://doi.org/10.3168/jds.2020-19371

16 Pascottini, O.B., Leroy, J.L.M.R., Opsomer, G. 2020. Metabolic stress in the transition period of dairy cows: Focusing on the prepartum period. Animals. 10(8): 1419. https://doi.org/10.3390/ani10081419

17 Pursley, J.R., Mee, M.O., Wiltbank, M.C., 1995. Synchronization of ovulation in dairy cows using PGF2α and GnRH. *Theriogenology* 44, 915–923.

18 Quiroz-Rocha, E., et al. 2017. Reference intervals for serum biochemical analytes in Holstein cows: Effects of parity, stage of lactation, and season of sampling. J Dairy Sci. 100(Suppl. 2): 131.

19 Reinhardt, T.A., et al. 2011. Prevalence of subclinical hypocalcemia in dairy herds. Vet J. 188(1): 122–124. https://doi.org/10.1016/j.tvjl.2010.03.025

20 Reynolds, C.K., Aikman, P.C., Lupoli, B., Humphries, D.J., Beever, D.E. 2003. Splanchnic metabolism of dairy cows during the transition from late gestation through early lactation. J Dairy Sci. 86(4): 1201–1217. https://doi.org/10.3168/jds.S0022-0302(03)73704-1

21 Sattler, T., Fürll, M. 2012. Creatine kinase and aspartate aminotransferase in cows–enzymes for the diagnosis of myopathies? Tierarztl Prax Ausg G Grosstiere Nutztiere. 40(1): 35–40.

22 Seifi, H.A., et al. 2003. Metabolic Profile Test in Iran: Variations of Metabolites Around Parturition at Dairy Cattle. Acta Vet Scand. 44(Suppl 1): P123. https://doi.org/10.1186/1751-0147-44-S1-P123

23 Uddin, M.K., et al. 2020. Biochemical markers of muscle stress and liver function in periparturient beef cows. Vet Clin Pathol. 49(3): 412–420. https://doi.org/10.1111/vcp.12899

24 Wilkens, M.R., et al. 2020. Symposium review: Transition cow calcium homeostasis—Health effects of hypocalcemia and strategies for prevention. J Dairy Sci. 103(3): 2909–2927. https://doi.org/10.3168/jds.2019-17268

25 Yang, Z., et al. 2022. Plasma metabolomic analysis reveals the relationship between immune function and metabolic changes in Holstein peripartum dairy cows. Metabolites. 12(10): 953. https://doi.org/10.3390/metabo12100953