Research Article

Colostrum Composition and Immunoglobulins Secretion Dynamics in Majaheem and Waddah Camels Reared under Extensive Management System

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Abstract | Colostrum, the first mammary secretion post-parturition, is indispensable for the survival and health of newborns. Due to the epitheliochorial placental structure in camels, maternal immunoglobulins (Igs) are not transferred *in utero*, making colostrum the sole source of passive transfer immunity. The current study aimed to explore the composition and immunoglobulins secretion dynamics across the four first days postpartum in Majaheem and Waddah she-camels. Ten Majaheem and ten Waddah she-camels of 2-4 parity were followed for colostrum composition (day 1) and immunoglobulins concentrations over four days postpartum period. The results indicated key differences in colostrum composition ($P < 0.05$), particularly in the concentrations of fat, protein, and minerals, which are critical determinants of colostrum quality and subsequent neonatal health outcomes. Majaheem colostrum had significantly higher values ($P<0.05$) of fat, protein and minerals if compared to Waddah camels. Additionally, Majaheem camels colostrum had non-significantly higher values of SNF and lactose if compared to Waddah camels. Furthermore, highly significant ($P < 0.05$) of immunoglobulins values (refractometer brix %) during the four days period of Majaheem if compared to Waddah she-camel breed. Understanding these variations in colostrum composition and immunoglobulins concentrations during post-term period is vital for developing calves' management strategies to mitigate the rates of failure passive transfer (FPT) observed across these calves species.

Keywords | Colostrum, Quality, Camels, Majaheem, Waddah, Passive immunity

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INTRODUCTION

Colostrum, the initial mammary secretion following parturition, is recognized as a biological necessity for neonates, serving as a critical bridge between the sterile intrauterine and the external environment (Sangild *et al*., 2021; Baumrucker *et al*., 2023). Its primary function is to provide a concentrated, easily digestible source of energy, vitamins, and growth factors, and, crucially, to facilitate passive immunity through the transfer of maternal immunoglobulins (Rostoll-Cangiano *et al*., 2025). This passive transfer is vital for protecting the newborn against prevalent pathogens during the first weeks of life until its own adaptive immune system matures (Albrecht and Arck 2020). Consequently, the quality, volume, and timing of colostrum secretion are fundamental determinants of neonatal health, vitality, and subsequent survival across diverse mammalian species (Silva *et al*., 2024).

In camelid species, the reliance on colostral intake is particularly acute due to their epitheliochorial placental structure, which largely precludes the prenatal transfer of maternal antibodies (Baker *et al*., 2025). Camel calves are therefore born "agammaglobulinemic" necessitating the rapid absorption of immunoglobulins from colostrum within the first 24 hours of life to achieve adequate passive transfer (Kamber *et al*., 2001). Failure of passive transfer (FPT) due to insufficient colostrum quantity, poor chemical quality, or delayed intake is the leading cause of morbidity and mortality in young neonates (Raboisson *et al*., 2016; James *et al*., 2022). Furthermore, the specialized composition of camel colostrum, rich in specific proteins, serves as a precise barometer of the dam's intense metabolic demands and periparturient physiological status (Konuspayeva *et al*., 2010).

Camel colostrum, the first milk produced by camels after giving birth, is rich in essential nutrients and bioactive compounds that support the health and development of newborn calves (Alshaibani and Mohammed, 2025). It's chemical composition includes a high concentration of immunoglobulins, particularly IgG, which play a crucial role in providing passive immunity to the calves. Additionally, camel colostrum contains higher levels of proteins, fats, and vitamins compared to cow colostrum, making it particularly beneficial for growth and immune functions (Khaliq *et al*., 2024). The presence of various minerals, such as calcium and phosphorus, further supports bone development (Mutassim *et al*., 2025). Moreover, camel colostrum and milk is noted for its unique oligosaccharides that promote gut health and modulate the immune response, distinguishing it as a vital nutritional resource for young camels (Almasri *et al*., 2024; Kocyigit *et al*., 2024). Overall, the unique chemical composition of camel colostrum is tailored to meet the specific needs of neonates in harsh environments.

Factors ranging from genetic to environmental factors can lead to change in colostrum secretion (Wicki *et al*., 2025). Given that mammary gland maturation and the concentration of immunoglobulins are highly synchronized with hormonal shifts and the precise timing of term delivery (Feigman *et al*., 2020). Understanding these effects is essential, as altered colostrum quality due to timing of colostrum secretion after delivery may predispose calves to FPT and nutritional deficits, regardless of management intervention (Westhoff *et al*., 2024; Pérez-Marín *et al*., 2023).

The objective of the present study was, therefore, to conduct a comprehensive comparative analysis of colostrum derived from Majaheem and Waddah camels during first four days postpartum. Specifically, we aimed to compare the detailed chemical composition, focusing on total solids, protein, fat, lactose, and key immunoglobulins IgG concentrations (Brix%), across these four days. The findings will offer practical guidance for camel newborns management strategies in commercial and smallholder camel production system.

MATERIALS AND METHODS

Study design and ethical approval

The study was designed to compare between colostrum quality obtained from ten Majaheem and ten Waddah camels during the first four days period (Figure 1). Majaheem and Waddah she-camel were bred under extensive management system. The she-camels were multiparous, 2–4 lactations. The she-camels were fed on extensive grazing system in addition to berseem hay only. The temperature (°C) and relative humidity (%) values during the study were recorded 29.0±2.30°C and 35±8.0%, respectively. The study protocol was approved by the ethical committee of King Faisal University [KFU-REC-2025-SEP-EA253]. The samples of Majaheem and Waddah camel colostrum were collected from September to October 2025 and were analyzed in the department of animal and fish production of King Faisal University.

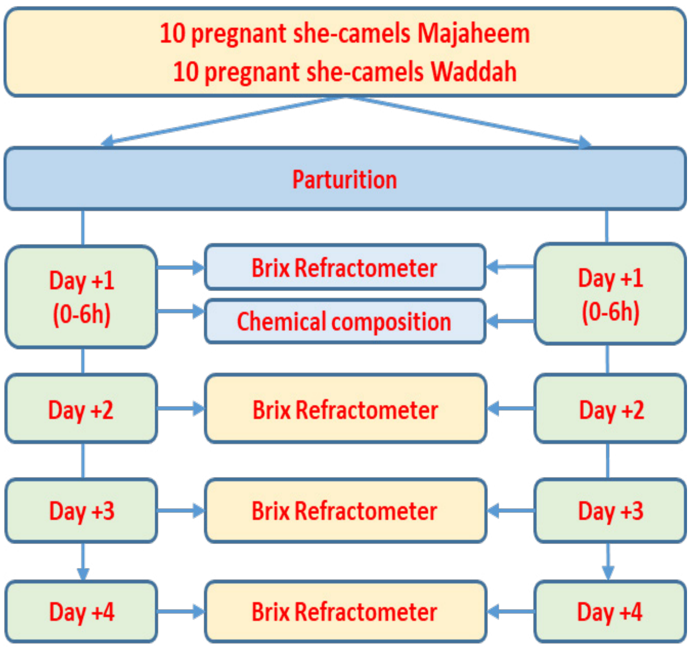

Figure 1: Experimental design, timing of colostrum collection, colostrum chemical and refractometery analyses.

Colostrum collection

Colostrum samples were collected at a standardized time point after delivery, typically the first milk expressed post-delivery before calves suckling. Samples were collected using sterile technique via hand milking into the pre-labeled, sterile collection plastic containers. The she-camel was restrained safely and calmly. The udder and teats were cleaned and dried gently with warm water and a clean towel, respectively. The first few jets of colostrum are often discarded to ensure a cleaner sample. Colostrum samples (50 ml) were collected from the first milking postpartum and subsequently for days 2, 3 and 4 days. The collected samples of colostrum is immediately labeled, sealed, and freezed to preserve its quality.

Colostrum analysis using brix refractometer

The colostrum samples were analyzed using milk analyzer (Milk analyzer Master LM2, Bulgaria). Twenty millimeters of colostrum samples were used for sample analyses of fat, SNF, protein, lactose and minerals through 60 seconds measurement speed and 5°C–40°C sample temperature.

The digital Brix refractometer (SOONDA Official Store, China) was used to measure immunoglobulins values (refractometer brix %). The refractometer was cleaned and calibrated with distilled or deionized water before the first use of the day and periodically throughout the measurement period. The instrument was adjusted until the reading was 0.0% Brix. Colostrum samples were mixed thoroughly to ensure homogeneity before analysis. A small, representative aliquot of the colostrum (2–3 drops) was drawn using a disposable pipette and placed onto the clean prism surface of the refractometer. The cover was gently closed, ensuring the sample covered the entire surface without air bubbles. The reading was taken after allowing 15–30 seconds for temperature equilibration and the digital Brix value was recorded. The refractometer prism and cover were thoroughly cleaned with a soft, clean cloth/tissue and wiped with distilled water, then dried completely between each sample to prevent cross-contamination.

Data statistical analysis

The Brix values (%) for colostrum samples (days 1-4) of Majaheem and Waddah camels were compared (SPSS version 27.0). In addition, the chemical composition values including fat, SNF, protein, lactose, minerals, density and freezing point for colostrum samples (day 1) of Majaheem and Waddah were compared. Independent samples t-tests were used to compare between the two groups, with $p < 0.05$ considered statistically significant.

RESULTS

Colostrum chemical composition of Majaheem and Waddah camel breeds and immunoglobulin values (Brix, %) across the first four days postpartum are presented in Tables 1 and 2.

Chemical milk composition

The chemical colostrum composition of Majaheem and Waddah breeds within the 0-6h postpartum is presented in Table 1. The study indicated significant differences in the colostrum composition between Majaheem and Waddah camels. Majaheem colostrum had significantly higher values (P<0.05) of fat percentage (0.76 vs. 0.53%), protein (8.98 vs. 8.12%) and minerals (0.64 vs. 0.55) if compared to Waddah colostrum. Additionally, Majaheem camels colostrum had non-significantly higher values of SNF (22.63 vs. 22.21) and lactose (12.52 vs. 12.29) if compared to Waddah camels. There were no significant differences in colostrum density (P<0.08) or freezing point (P< 0.10) between the two breeds.

Table 1: Colostrum chemical composition of Majaheem and Waddah camels before calves suckling.

Parameters, %	Majaheem	Waddah	SEM	P value
No. samples	10	10	-	-
Fat	0.76^{a}	0.53^{b}	0.03	0.001
SNF	22.63	22.21	1.45	0.09^{NS}
Protein	8.98^{a}	8.12^{b}	0.70	0.01
Lactose	12.52	12.29	0.47	0.08^{NS}
Minerals	0.64^{a}	0.55^{b}	0.05	0.05
Density, g/mL*	1.0898	1.0839	0.12	0.08^{NS}
Freezing point	-0.812	-0.815	0.06	0.10^{NS}

^{a,b} Values between Majaheem and Waddah groups in the same row with different superscripts significantly differ at P < 0.05. SEM pooled standard error of means; SNF Solids-Not-Fat; NS not significant ; * Measurement at 20°C

Rerfractometry immunoglobulin secretion dynamics

The dynamics of immunoglobulins secretion, as measured by refractometry (Refractometry immunoglobulins %), across four days postpartum are presented in Table 2. The data revealed a clear and significant dichotomy between Majaheem and Waddah in immunoglobulins levels. The Brix colostrum percentage declined steadily for both breeds from Day 1 to Day 4 postpartum. At day 1, Majaheem colostrum Brix was highest at 29.0 points, which was 16.0% percentage higher than Waddah (25.0 points). The steepest drop in quality occurred between Day 1 and Day 4 for both breeds. For Majaheem, the percentage dropped by 16.95 points, while for Waddah, it dropped by 14.85 points. Across the four-day period, the Majaheem breed showed a significantly (P < 0.05) higher overall mean colostrum percentage (20.90 points) compared to the Waddah breed (17.98 points).

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Table 2: Brix refractometer (%) of immunoglobulins of Majaheem and Waddah camel breeds before calves suckling.

Parameters	Majaheem	Red. %	Waddah	Red. %	SEM	P value
No. samples	10	-	10	-	-	-
Day 1	29.00[a]	-	25.00[b]	-	0.70	0.05
Day 2	24.10[a]	16.89	20.40[b]	18.40	0.67	0.04
Day 3	18.46[a]	36.34	16.20[b]	35.20	0.60	0.04
Day 4	12.05[a]	58.44	10.15[b]	59.40	0.55	0.05
Overall mean	20.90[a]	-	17.98[b]	-	0.65	0.05

[a,b] Values between Majaheem and Waddah groups in the same row with different superscripts significantly differ at P < 0.05.; Red. Percentage reduction from Day 1 value; SEM pooled standard error of means.

DISCUSSION

The objective of this study was to conduct a comparative analysis of the colostrum chemical composition and immunoglobulins (Brix, %) values of Majaheem and Waddah colostrum secreted over four days post-term period. The core findings reveal differences in key colostral components (immunoglobulins, protein, fat, and minerals) between the Majaheem and Waddah camel breeds (Tables 1 and 2). Colostrum is the "first milk" produced by females immediately after giving calves, within the first few days. It's a highly concentrated and nutrient-rich fluid that provides essential components for the newborn's health and development (Swelum *et al*., 2021; El-Hatmi *et al*., 2023). The neonatal period is a time of high vulnerability for camels, characterized by a susceptible immune system and reliance on external nutrient and energy sources (Khaliq *et al*., 2024; Alshaibani and Mohammed, 2025; Mohammed *et al*., 2025). The consumption of colostrum shortly after birth is a crucial event, providing neonates with a concentrated source of energy, growth factors, and most importantly, maternal immunoglobulins (Igs) necessary for passive immunity. Camels, as ruminants, all possessing an epitheliochorial placenta, prevent the prenatal transfer of Igs, resulting in agammaglobulinemic offspring at birth (Wernery, 2001; Baumrucker *et al*., 2023). Consequently, the timely intake of high-quality colostrum is paramount for survival and protection against infectious agents (Bessalah *et al*., 2024).

To the best of our knowledge, camel colostrum immunoglobulin secretion dynamics are not previously studied. It has been indicated that the single most influential factor affecting colostrum quality is the time elapsed between parturition and colostrum collection (Soufleri *et al*., 2021). The concentration of immunoglobulins (IgG) is at its peak immediately following birth and declines exponentially thereafter across all ruminants (Rabaza *et al*., 2023). For instance, the IgG content in cow colostrum can drop by over 50% within the first 6 to 12 hours, with a corresponding decrease in key bioactive components like Lactoferrin and Vitamins A and E (Costa *et al*., 2023). Colostrum collected during the second milking (usually 12 hours later) may be insufficient to provide adequate passive transfer of immunity to the newborn (Uyama *et al*., 2022).

Additionally, there is no studies carried out exploring colostrum immunoglobulin secretion dynamic and colostrum composition of Majaheem and Waddah camel breeds. The physiological status of the dam plays a significant role in determining colostrum quality (Lichtmannsperger *et al*., 2023). Genetics and environmental factors might be the factors determine the quality of colostrum. It has been indicated that parity is positively correlated with IgG concentration; multiparous cows, ewes, and goats typically produce colostrum with higher antibody values than first-time females (heifers, ewe-lambs, and doe-kids) (Grodkowska *et al*., 2023). Breed also introduces variability; for example, dairy breeds often have lower overall IgG concentrations than beef or dual-purpose breeds, a consequence of selection for high milk volume (Martin *et al*., 2021). Our previous study indicated that Majaheem camel breed produce high milk volume if compared to Waddah camels (Mohammed and Alshaibani 2025). Because Majaheem camels are genetically selected for high milk production, their mammary glands have a higher capacity for the active transport of IgG from the bloodstream into the colostrum before birth.

Furthermore, it has been found that calves of thin cows (BCS < 3) showed higher serum Ig concentrations compared to the reference group of cows (BCS 3–4). This is in line with the results of another study on the relationship between BCS and lymphocyte function in periparturient cows, where over conditioned cows had lower IgM secretion and INF-gamma secretion compared to medium and thin cows (Lacetera *et al*., 2005; Immler *et al*., 2022). Remarkably, a study on the presence of lymphocytes in colostrum found that BCS was positively related to the presence of lymphocytes in colostrum (Meganck *et al*., 2015). Taken together, there is some evidence that the body condition of dams is associated with immune function and serum Ig concentration in calves. Therefore, the variance between Majaheem and Waddah breeds might relate to genetic factors in addition to parity, and low body condition score of Majaheem due to high milk yield (Mohammed *et al*., 2025).

Majaheem camels have been selectively bred for centuries by the tribes of central Arabia specifically for high milk output and survival in harsh conditions (Dioli *et al*., 2023). We hypothesize that Majaheem might have a higher number of active mammary epithelial cells (MECs) per gram of udder tissue. This doesn't just increase milk volume; it increases the surface area available for the transfer of antibodies from the blood. In many species, high volume dilutes quality. However, because Majaheem are genetically selected for high total solids (fat and protein), their "set point" for colostrum synthesis is likely higher across the board. The higher mineral concentration in Majaheem colostrum likely might relate back to the breed's superior mammary gland efficiency. Most calcium and phosphorus in milk are "colloidal", which meaning they are physically bound to casein micelles. Since Majaheem generally have higher protein content and Brix values, they naturally carry a higher "mineral load" into the colostrum.

CONCLUSIONS

The species variation in the formation and composition of colostrum serves the individual neonate. These findings provide vital practical guidance for calves camel management through genetic management and colostrum banking. Selection of Waddah and Majaheem females that produce highest-quality colostrum is recommended in addition to frozen Majaheem colostrum to give for calves by artificial suckling. Future research is needed to correlate these chemical findings with genetic, hormonal, and environmental factors to precisely characterize the timing key points of the colostrogenesis and quality in camels.

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NOVELTY STATEMENT

The article presents, for the first time, the dynamics of immunoglobulins secretion of Majaheem and Waddah camel breeds reared under extensive management system.

AUTHORS CONTRIBUTION

NA and KA conducted the study. IA and HH carried out the experimental design and statistical analysis of data. SA-S and AE-NAM prepared the manuscript for publication.

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Generative AI and AI-assisted technology statement

No generative AI tools were used for the writing, data analysis, or conceptual development of this study.

Conflict of interest

The authors have declared no conflict of interest.

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