Analysis of Chemical Composition and Milk Production in Dairy Buffalo and Goat in Malaysia

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Abstract

Dairy buffaloes and goats contribute significantly to Malaysia's dairy industry, providing an alternative to cow milk with distinct nutritional profiles. This study conducted a preliminary analysis of the chemical composition and milk production of dairy buffaloes and goats, focusing on their yield, macronutrient content, and overall suitability for dairy farming. The research was carried out on selected dairy farms in Malaysia, with milk samples collected from 10 dairy buffaloes and 10 dairy goats over a six-month period. The samples were analyzed for key nutritional components, such as fat, protein, lactose, total solids, and mineral content, using standard spectrophotometric and chromatographic techniques. The findings indicated that dairy buffaloes achieve greater daily milk yields compared to dairy goats, with buffaloes yielding around 15,000 L at their peak (around Day 56 postpartum), whereas goat milk peaked at 952 L at day 70. Additionally, buffalo milk exhibited elevated concentrations of fat (6.47% compared to 2.97%), protein (3.51% compared to 2.87%), and solid non-fat (SNF) (9.53% compared to 7.84%) in the early lactation stage, rendering it more suitable for dairy products like cheese and butter. Conversely, goat milk exhibited enhanced digestibility, featuring a reduced lactose content (5.31% compared to 4.27%), thereby rendering it more suitable for individuals with lactose intolerance. This study highlights the need for strategic improvements in genetic selection, feeding strategies, and dairy processing technologies to enhance buffalo and goat milk production. These findings provide crucial insights for optimising dairy farming in Malaysia and supporting the sustainable development of the local dairy industry. Further research and policy interventions are needed to fully harness the potential of these alternative dairy sources.

Keywords: Dairy buffalo, goat milk, milk composition, milk production, chemical analysis

Introduction:

The dairy industry in Malaysia relies predominantly on cattle; however, buffaloes and goats are gaining attention because of their adaptability and nutritional benefits. Buffalo milk is characterized by its high fat and protein content, making it ideal for dairy processing, whereas goat milk is valued for its digestibility and hypoallergenic properties (Meena et al., 2014). With the increasing demand for diversified dairy products and nutritional alternatives, understanding the dynamics of milk production and the composition of these species is essential for sustainable dairy farming.

Previous studies have demonstrated that buffalo milk has superior compositional attributes, including higher solid-not-fat (SNF) and mineral contents, making it particularly suitable for cheese and butter production (Viana et al., 2024). Conversely, goat milk contains lower lactose levels, making it an excellent option for individuals with lactose intolerance (Ibrahim & Ahmad Tajudin, 2021). Given these differences, evaluating the production performance and chemical composition of dairy buffalo and goat milk is crucial for enhancing Malaysia's dairy sector. The composition of milk is affected by various factors, including genetics, milking time, dietary type, age, udder hygiene and seasonal variations (Moldovan et al., 2024).

Goat milk is gaining popularity because of its nutritional value. It's naturally rich in key nutrients, including protein, calcium, magnesium, phosphorus, and potassium, as well as vitamins A, B2 (riboflavin), and D. Compared to cow milk, goat milk's fat content is slightly higher, but its smaller fat globules are easier to digest, which is great for those with sensitive digestive systems. Goat milk is also an excellent source of medium-chain fatty acids such as caproic, caprylic, and capric acids. Those fats are more rapidly metabolised in the human body and can serve as a quick energy source. They also possess antimicrobial and anti-inflammatory properties, potentially offering health benefits beyond basic nutrition (Jaswal et al., 2022).

Tropical dairy farming represents an exceptionally effective approach to transforming plentiful tropical forages into highly nutritious milk, which is regarded as one of the most beneficial foods for humans (Moti et al., 2023). Nonetheless, elevated temperatures and humidity levels in tropical and subtropical regions can negatively affect the health and productivity of dairy livestock (Singh et al., 2020). Dairy breeds cultivated in tropical and subtropical areas typically exhibit slow maturation rates and yield limited milk production, primarily due to factors such as malnutrition, inadequate management practices, and adverse environmental conditions (Das et al., 2003). Elevated temperatures impact the animal’s body surface, eliciting physiological responses such as heightened respiration rate, increased heart rate. And elevated rectal temperature (Cowley et al., 2015). The elevated temperatures during summer notably reduced the yields of milk as well as the levels of milk fat, protein, and SNF in Murrah buffaloes (Pawar et al., 2013).

This study aimed to provide a preliminary analysis of milk yield and composition in dairy buffaloes and goats, offering insights into their potential for commercial dairy production in Malaysia. We hypothesised that milk yield and composition would vary across lactation stages in both goats and buffaloes, and that these interspecies differences would highlight their respective suitability for commercial dairy production. The findings inform future genetic selection, nutritional interventions, and dairy processing advancements to optimise the productivity and sustainability of alternative dairy sources.

Materials and Methods

Animal ethics

The study protocol was conducted in accordance with the standards set forth by the UniSZA Animal and Plant Research Ethics Committee (UAPREC) (Permit No.: UAPREC/008/019). The study was conducted concurrently with the competent authority and an authorised veterinarian during the farm's official sanitary regular inspection.

Animal Selection

This study was conducted at the UniSZA Pasir Akar Farm, Besut, Terengganu, Malaysia. A total of 10 healthy Saanen goats (n = 10), with body condition scores (BCS) of 2 to 3 and symmetrical udder characteristics, were selected for this study. The Saanen goats were fed 3-4 kg of concentrates in the morning and *Brachiaria humidicola* grass (89% dry matter (DM)) in the afternoon. Milk was collected from the animal at early (20 DIM), mid (60 DIM) and late lactation stage (120 DIM). Saanen goats were raised in an intensive housing system with limited access to land.

Buffalo milk samples were obtained from 10 Murrah buffaloes (n = 10) at the AGK Farm, Beranang, Selangor, Malaysia. All the buffalo were provided with comparable diets, and the management practices were consistent across the board. The composition of milk is affected by various factors, including the season, the parity number (4 or 5) and the stage of lactation, which can be categorized into early lactation (1-2 months), mid-lactation (3-6 months) and late lactation (7-9 months). Buffalo breeds were identified based on their unique morphological characteristics, corroborated by breeding records.

Sample Collection

Raw milk samples were collected by hand milking at an early hour in the morning. The study was conducted over a six-month period, from May to October, and the milk was collected individually from each animal at early, mid and late lactation. Milk samples were collected during the afternoon milking session, and 15 mL of raw milk from each animal was collected in a Falcon tube and stored at -80 °C until further analysis.

Sample Preparation and Analysis

Milk obtained from individual animals during each stage of lactation was pooled to create a composite sample that accurately represents each species at that particular stage. Each pooled sample underwent triplicate analysis, with mean values employed for interpretation. Milkotester Ultrasonic Milk Analyser (Bulgaria) was used to determine the milk composition. Before pouring the samples into the cup of Milkotester, they were thawed and stirred completely. The cup containing the milk sample was placed in a slot, and the milk composition was calculated using a probe dipped in the milk sample. For goat milk, the "small ruminant" option was used, while the "cow" option was selected for buffalo milk. After a few seconds, the results were displayed on the Milkotester screen.

Data Management and Statistical Analysis

Microsoft Excel spreadsheet was used to manage and record the milk production obtained from sampling and analysis. Pooled milk samples were meticulously prepared from a selection of 10 Murrah buffaloes and 10 Saanen goats to analyse milk composition. Each pooled sample underwent triplicate analysis utilising the Milkotester instrument, with fresh aliquots prepared for each run. The average standard deviation (SD) of the three measurements was computed and documented. Pooled production data were recorded for milk yield from 10 animals per species. Due to the unavailability of individual animal-level data, inferential statistics could not be conducted. The findings are conveyed in a descriptive manner.

Results and discussion

Milk production in dairy animals follows a typical lactation curve characterized by an initial rise, peak, and gradual decline as lactation progresses. The graph illustrates the milk production trends in buffaloes and goats from day 14 to day 152 postpartum (early to late lactation stage), showing distinct patterns for each species. Buffaloes exhibited higher milk yields throughout the study period, whereas goats had lower but proportionally similar trends. These findings align with previous research on ruminant lactation physiology, suggesting that milk yield is influenced by factors such as genetic potential, nutrition, and mammary gland development (Strucken et al., 2015).

For buffaloes, milk production increased from 11,375 L on Day 14 to a peak of 15,000 L on Day 56. After reaching this peak, production began to decline, falling to 10,000 L by Day 110 and further decreasing to 4,500 L by Day 152. The peak at Day 56 was consistent with the lactation pattern observed in Murrah and Nili-Ravi buffalo breeds, where the highest milk yield is typically recorded between 50 and 60 days postpartum, before a gradual decrease (Reddy et al., 2019). Our findings are consistent with earlier studies carried out in tropical climates. A study conducted by Omar et al. (2024) in Bangladesh, which examined buffalo milk, revealed a comparable pattern of milk yield, peaking around Day 56 postpartum and subsequently experiencing a gradual decline, mirroring the trend identified in our research in Beranang, Selangor. The decline in production can be attributed to reduced secretory activity in mammary epithelial cells and the natural progression of the drying-off period (Capuco et al., 2003).

Table 1: Chemical composition of Buffalo and goat milk

Stages	SNF %	Fat %	Protein %	Lactose %
Early	9.53[a] ± 1.03 vs. 7.84[a] ± 0.12	6.47[a] ± 1.41 vs. 2.97[c] ± 0.12	3.51[a] ± 0.44 vs. 2.87[a] ± 0.06	5.31[a] ± 0.67 vs. 4.27[a] ± 0.06
Mid	8.14[b] ± 1.10 vs. 7.79a ± 0.09	13.56[b] ± 2.49 vs. 4.20a ± 0.00	3.30[ab] ± 0.36 vs. 2.87[a] ± 0.06	5.03[a] ± 0.25 vs. 4.27[a] ± 0.06
Late	5.95[c] ± 0.81 vs. 7.26[b] ± 0.02	5.83[a] ± 0.99 vs. 3.50[b] ± 0.00	3.00[b] ± 0.26 vs. 2.60[b] ± 0.00	4.81[a] ± 0.21 vs. 3.97[b] ± 0.06

Average ± STDev values within a column with different superscripts of "a" and "b" represent significant differences. The same alphabet indicates no significant differences in parameters. The composition was compared among its lactation stages.

Dairy breeds in tropical and subtropical regions, such as Malaysia, typically exhibit slow maturation rates and yield relatively low milk production. The main climatic elements influencing buffalo production in tropical regions include air temperature, humidity, wind speed and sunlight exposure (Upadhyay et al., 2007). The interplay of these factors, along with possible differences in feed quality and management practices across the regions of Selangor and Terengganu, may have contributed to the variability in milk yield and composition noted, thereby constraining the broader applicability of the results.

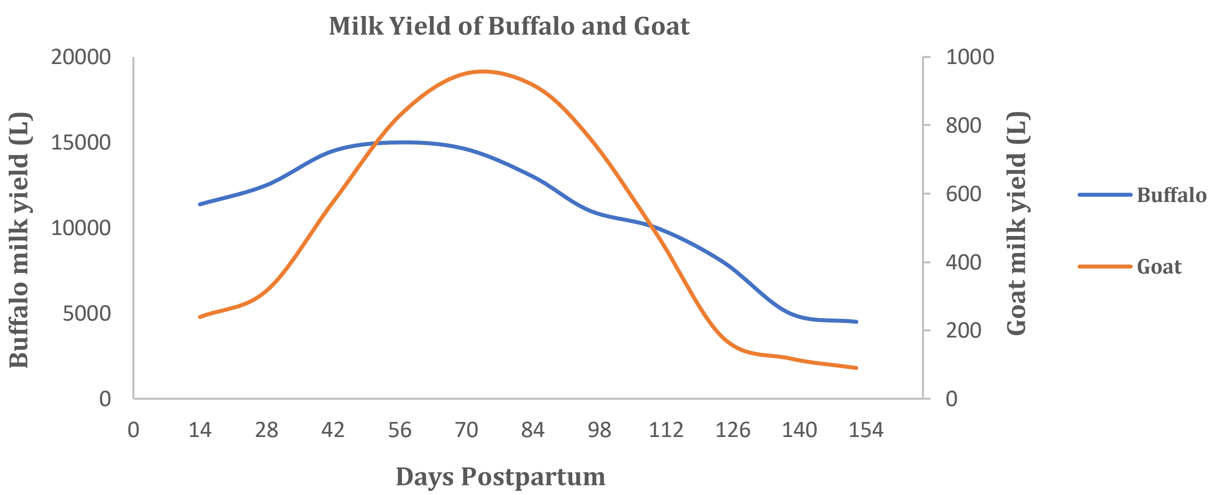

Figure 1: The milk production of buffalo and goat vs. days postpartum

Goat milk production followed a similar trend but peaked slightly later. The yield increased from 239 L on Day 14 to a maximum of 952 L on Day 70, after which it steadily declined to 482 L on Day 110 and 90 L on Day 152. The later peak in goat milk yield (compared to buffaloes) may indicate a slower rate of mammary adaptation and hormonal regulation in small ruminants (Annen et al., 2004). However, the post-peak decline in both species follows a similar biological pattern, consistent with the concept that lactation is governed by the interplay of prolactin, oxytocin, and declining progesterone levels (Strucken et al., 2015).

The differences in absolute milk yield between buffaloes and goats are largely due to species-specific variations in mammary gland structure, metabolic efficiency, and nutrient partitioning (Lemay et al., 2009). Buffaloes, being larger ruminants, have greater mammary gland capacity and higher feed intake, which supports increased milk synthesis. In contrast, goats produce lower milk volumes but often have higher milk fat and protein contents, making their milk particularly valuable for processing into cheese and other dairy products (Paschino et al., 2020).

From a dairy management perspective, these findings highlight the importance of optimizing nutrition and milking strategies during the peak lactation period. Because peak milk yield occurs around Day 56 for buffaloes and Day 70 for goats, dairy farmers should focus on providing high-energy, protein-rich diets during this period to sustain milk production. Additionally, post-peak lactation support through supplementary feeding and proper reproductive management can help extend the duration of lactation and improve overall productivity (Dela Rue et al., 2024).

A comparison of milk composition between buffaloes and goats across different lactation stages highlighted significant variations in key nutritional parameters, including solid-not-fat (SNF), fat, protein, and lactose content. These differences are influenced by species-specific lactation physiology, metabolic adaptation, and genetic factors.

Buffalo milks consistently exhibited higher SNF percentages than goat milk across all lactation stages, with a significant decline observed in late lactation (9.53% in early lactation vs. 5.95% in late lactation). However, goat milk showed a more stable SNF content throughout lactation, with a slight decrease in late lactation (7.84% in early lactation to 7.26% in late lactation). The findings regarding the SNF percentage in buffalo did not correspond with the earlier research (Kuralkar and Kulralkar, 2022; Sahin et al., 2016). A study conducted by Sarwar et al. (2009) indicated that the composition of buffalo milk is influenced by the intake and quality of nutrients. The higher SNF content in buffalo milk is advantageous for dairy processing, as it contributes to enhanced cheese yields and thicker dairy products (Viana et al., 2024). The decline in SNF towards late lactation in buffaloes can be attributed to metabolic shifts that prioritise body maintenance over milk synthesis (Khan et al., 2008).

Buffalo milk fat content showed a significant increase during mid-lactation (13.56%) before declining in the late-lactation period (5.83%). The results of the current investigation contrast with those documented in earlier research (Arote et al., 2021), which indicated that the peak milk fat levels occurred during late lactation, while the lowest levels were observed during early lactation. The milk fat percentage observed during early lactation was lower compared to mid lactation, likely due to the buffalo being in a negative energy balance, which affects the availability of precursors necessary for milk fat synthesis to meet energy requirements. Subsequently, as lactation continued, there would have been an enhancement in energy balance. Goat milk, on the other hand, maintained significantly lower fat levels throughout lactation, with a peak in late lactation (3.50%). This trend aligns with previous studies, indicating that buffalo milk has a higher butterfat percentage, making it suitable for high-value dairy products such as butter and ghee (Vargas-Ramella et al., 2021). The increase in fat content during mid-lactation in buffaloes is likely due to energy redistribution towards milk synthesis, while the decline in late lactation can be associated with the natural drying-off process. The lower fat content of goat milk makes it easier to digest, particularly for individuals with lactose intolerance or milk fat sensitivity (QH et al., 2023).

Protein content followed a decreasing trend in both species, with buffalo milk showing higher values than goat milk at all stages. In early lactation, buffalo milk contained 3.51% protein, which declined to 3.00% in late lactation, whereas goat milk protein content ranged from 2.87% in early lactation to 2.60% in late lactation. The findings regarding buffalo are inconsistent with the previous study conducted by Kuralkar and Kuralkar (2022), which indicated an increasing trend from early to late lactation. Nonetheless, Roy et al. (2003) and Garaniya et al. (2013) indicated that the stage of lactation did not significantly influence milk protein content. The higher protein content of buffalo milk contributes to its superior nutritional value and improved curd formation during dairy processing (Vargas-Ramella et al., 2021). The decline in protein content during late lactation is consistent with the general trend of decreasing milk production and compositional changes as the mammary gland undergoes involution (Zhao et al., 2019).

Lactose levels in buffalo milk remained relatively stable across lactation, with values ranging from 5.31% in early lactation to 4.81% in late lactation. These findings align with the study conducted by Arote et al. in 2024, which indicated that the lactose percentage was highest during early lactation. Furthermore, the lactose percentage observed in this study, ranging from 4.81 to 5.31%, aligns with the lactose content documented for buffalo milk in prior research (Gunathilake et al., 2024) conducted in tropical climates. Goat milk exhibited lower lactose levels (4.27% in early lactation, which decreased to 3.97% in late lactation). The elevated lactose levels observed during early lactation are likely a result of enhanced synthesis by the mammary epithelial cells during lactogenesis. As lactation continues, the overall lactose percentage tends to decrease, which can be partially explained by the degeneration of secretory cells as involution nears, as well as the escape of lactose into the bloodstream through the para-cellular pathways that become more prominent during this period. The lower lactose content of goat milk is an essential factor for individuals with lactose intolerance, making it a preferred alternative to bovine and buffalo milk (QH et al., 2023). The gradual decrease in lactose content towards late lactation in both species may be attributed to changes in mammary gland activity and the reduced synthesis of milk sugars as the lactation cycle progresses (Sadovnikova et al., 2021).

While the study sought to account for multiple variables, certain limitations remain to be acknowledged. The relatively small sample size and the inherent variability in animal health and management practices across the two regions may have influenced the results. The brief timeframe of the study likely resulted in an incomplete assessment of long-term fluctuations in milk yield. The results align with earlier studies conducted in analogous tropical environments, including the research by Omar et al. (2024) in Bangladesh, which demonstrated a similar lactation curve in buffaloes. Even with attempts to standardize feeding conditions, variations in feed quality stemming from seasonal changes, along with regional differences in rainfall and temperature, could have influenced the quality of available forage. The geographical differences between Terengganu, characterized by its higher humidity and more frequent rainfall, and Selangor, which is comparatively drier, may have significantly influenced feed quality and subsequently affected milk production. The observed regional differences may provide insights into the variations between goat and buffalo identified in the study.

Conclusion

In conclusion, the study of milk production trends in buffaloes and goats confirmed that both species exhibit a biologically determined lactation curve, with buffaloes reaching peak production earlier than goats. The gradual decline after peak lactation suggests that nutritional interventions and milking frequency adjustments are crucial for maintaining the milk yield over a longer period. These insights are essential for enhancing dairy farm efficiency and profitability and ensuring that both species contribute optimally to sustainable milk production systems (FAO, 2020). The findings indicate that buffalo milk has superior fat, protein, and SNF contents compared with goat milk, making it ideal for dairy processing and high-value dairy products. However, goat milk contains lower lactose and fat levels, which may be beneficial for individuals with dietary restrictions. Understanding these compositional variations can aid in optimizing dairy production and developing targeted nutritional strategies to enhance the milk quality of both species. Further research should focus on improving milk persistency and compositional stability across the lactation stages.

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Conflict of interest

The authors declare that there is no conflict of interest.

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