
# Geographical Variation in The Chemical and Physical Properties of Local Buffalo Milk Between the Governorates of Basra And Babylon In Iraq

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**Abstract**
This study aimed to evaluate the influence of environmental conditions on milk yield and selected physicochemical properties of Iraqi buffalo milk in Babylon and Basrah Governorates during the period from December 2025 to February 2026. A total of 40 lactating buffaloes were included in the study and managed under a uniform feeding and husbandry system. Milk samples were analyzed for freezing point, relative density, and solids-not-fat (SNF) using a Lacto Flash–Funke Gerber analyzer.The results showed a progressive decline in both daily and monthly milk yield in the two governorates, accompanied by an increase in SNF and relative density, as well as a decrease in freezing point over the study period. Buffaloes in Babylon Governorate recorded higher milk production compared with those in Basrah Governorate, which may be attributed to more moderate environmental conditions in Babylon. The findings indicate that climatic and environmental factors play a significant role in determining milk productivity and composition traits in Iraqi buffaloes.

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**Keywords:** Iraqi buffalo milk, geographical variation, milk composition

## Introduction

The buffalo (Bubalus bubalis) possesses considerable strategic and economic importance worldwide due to its unique physiological efficiency in converting low-quality roughages into highly valuable nutritional products such as milk and meat [16]. In addition, buffalo play a vital role in supporting irrigated agricultural systems and adapting to humid environments. In the local context, the Iraqi buffalo represents an essential physiological and economic pillar for populations in central and southern Iraq, particularly within the southern marshlands environment, which constitutes its natural habitat and historical extension [4].

The largest buffalo populations are concentrated in the southern governorates of Basra, Maysan, and Dhi Qar, particularly within and around the Mesopotamian marshlands, these regions represent the native habitat of the Iraqi buffalo, where the animals depend on shallow water bodies, reeds, and wet pastures, and have historically served as a major source of milk production and livelihood for local communities [6]. In southern Iraq, buffalo production is closely associated with the ecological status of the marshlands, and recent reports have indicated that water scarcity, increased salinity, and wetland desiccation have directly contributed to declines in herd size and milk production [7, 16].

However, the sustainability and productive efficiency of this animal resource in the central and southern provinces are confronted with critical environmental constraints, as productivity rates and survival opportunities are directly influenced by the availability of water resources, especially the severe decline in the water levels of the Tigris and Euphrates rivers and the southern marshes during recent years [1]. Furthermore, the worsening salinity problem, variations in available environmental habitats, recurrent heat waves, and reduced rainfall have all imposed additional challenges on buffalo production systems [9].

Buffalo milk production in Iraq varies by region depending on environmental conditions, feed availability, and access to water, in Basra, production is closely linked to marsh ecosystems and irrigated fodder systems, while in Babylon it relies more on managed feeding systems with limited wetland influence, overall, buffalo are mainly concentrated in southern Iraq and perform best in humid, water-abundant environments [2].

Milk has considerable industrial importance due to its wide use in the production of various dairy products such as cheese, butter, yoghurt, and milk powder, it is primarily composed of water, fat, proteins, lactose, and minerals, in addition to the remaining solids-not-fat (SNF), the freezing point, specific gravity, and solids-not-fat content of milk are considered useful quality indicators, as they vary with compositional changes and may reflect both milk authenticity and the animal's physiological as well as environmental conditions [12, 21, 15]. Milk contains a high proportion of water, along with fat, protein, lactose, and minerals. The fat-free portion is referred to as SNF (Solids-Not-Fat), which includes proteins, lactose, and minerals ; a higher SNF content generally indicates richer milk and better processing quality. Since buffalo milk typically contains higher total solids than cow milk, it is characterized by greater density and superior suitability for products such as cheese and yoghurt [14]. Milk does not freeze at exactly 0°C due to the presence of dissolved constituents, which lower its freezing point. In buffalo milk, the freezing point is typically around −0.55°C, although reported values may vary according to breed, feeding practices, season, and management conditions. The freezing point is widely used as a key indicator of milk quality and authenticity, since the addition of water raises the freezing point toward 0°C. Therefore, deviations from normal values may indicate adulteration or alterations in milk composition [19]. Relative density (specific gravity) is an important physical property used to describe milk quality, representing its weight relative to water. Buffalo milk generally shows a slightly higher specific gravity than cow milk, mainly due to its higher solids-not-fat (SNF) content, despite the lower density of fat, Standard references indicate that the specific gravity of buffalo milk ranges from approximately 1.030 to 1.034, while that of cow milk is usually slightly lower, ranging from about 1.028 to 1.032 [18]. Furthermore, SNF (Solids-Not-Fat) is considered a key indicator of milk quality, as it represents the total concentration of valuable non-fat constituents, including proteins, lactose, and minerals. A higher SNF content improves the flavour, body, and processing yield of dairy products, and is therefore closely associated with greater industrial and economic value [20]

Although buffalo production in Iraq has been extensively studied in the context of climate stress and marsh degradation, most research has focused on the southern marshlands as a whole rather than providing clear comparisons between different geographical regions such as Babylon and Basra. There is still a strong need for comprehensive studies to evaluate how environmental differences influence buffalo milk production.

This study aims to compare buffalo milk production in Babylon and Basra provinces in terms of the influence of environmental conditions on milk yield and some of its physicochemical properties.

## Material and Methods

### Study Location and Experimental Period

This study was conducted at the University of Basrah, College of Veterinary Medicine, from December 2025 to February 2026 in cooperation with local buffalo breeders' farms in Basra Governorate and Babylon Governorate. The experiment included 40 Iraqi lactating female buffaloes aged between 4 and 5 years. All animals were clinically healthy and free from diseases. Animals in both governorates were managed and fed according to a unified system. Buffaloes were housed in traditional barns and had continuous access to clean drinking water.

### Sample Collection and Milk Components Analysis

Milk samples were collected from 40 buffaloes from the two governorates (20 samples from Al-Hashimiyah District/Babylon and 20 samples from Al-Madinah District/Basra) once monthly during the morning milking [21]. Approximately 50 mL of milk was collected from each buffalo. Milk components, including freezing point, specific gravity, and solids-not-fat (SNF), were determined three times throughout the experimental period, which lasted for three months, using a German-made Lacto Flash–Funke Gerber device at the Public Health Laboratory, Department of Public Health, College of Veterinary Medicine, University of Basrah. Sample analysis was performed according to the operating manual and the manufacturer's instructions. A total of 120 milk samples were analyzed.

### Statistical Analysis

Statistical analysis of the studied traits was conducted over the three-month study period using IBM SPSS Statistics software to assess the (temporal) effect of the sampling month (December, January, February) on milk production and its physical characteristics. Statistically significant differences between the monthly means were determined at a significance level of $P \leq 0.05$ [22].

The data were analyzed based on the following mathematical model:

$$Yij = u + Mi + eij$$

Where:

Yij: The observation or measurement of the studied trait for the j-th animal during the i-th month.
u: The overall mean of the studied trait.
Mi: The fixed effect of the sampling month (i = 1, 2, and 3 for December, January, and February, respectively).
eij: The random residual error associated with the j-th animal within the i-th month.

## Results and Discussion

The results of the studied traits presented in Tables 1, 2, and 3 revealed a gradual and marked decline in both daily milk yield and total monthly milk production from December to February in both study regions. In Babylon Governorate, the average daily milk yield decreased from 10.10 kg/day in December (Table 1) to 8.35 kg/day in January (Table 2) and subsequently to 6.60 kg/day in February (Table 3), resulting in a decline in total monthly milk production from 202 kg to 167 kg and then to 132 kg (Figure 1). Similarly, buffaloes in

Basrah Governorate exhibited a comparable reduction from 7.95 kg/day to 7.40 kg/day and finally to 5.65 kg/day, which reduced the total monthly milk yield from 159 kg to 148 kg and subsequently to 113 kg (Figure 2). Statistical analysis demonstrated significant differences ($P \leq 0.05$) in daily and total monthly milk yield during December (Table 1) and February (Table 3) in favor of Babylon buffaloes, which exhibited significantly higher production compared with Basrah buffaloes. However, no significant differences ($P > 0.05$) were observed between the two governorates in daily milk yield during January (Table 2), despite the numerical superiority of Babylon and the persistence of significant differences ($P \leq 0.05$) in total monthly milk production. This continuous decline is mainly attributed to the natural progression of the lactation stage, as milk secretion gradually decreases after animals pass the peak of lactation [17, 8].

Regarding the differences in milk production between the two geographical regions (Babylon and Basrah), despite the provision of a unified feeding system in both governorates, buffaloes in Babylon maintained a higher level of milk production compared with buffaloes in Basrah. This variation may be attributed to regional climatic differences and their effects on animal productive performance. Babylon Governorate is characterized by a relatively moderate climate due to the presence of freshwater rivers, palm groves, and extensive cultivated areas, which contribute to reducing ambient temperatures and improving local environmental conditions. Despite the environmental challenges faced by the governorate in recent years, including water shortages and urban expansion, it still maintains relatively moderate climatic conditions. In contrast, Basrah Governorate is characterized by a harsh local climate involving extremely high summer temperatures and pronounced winter cold accompanied by elevated relative humidity due to marine influence. In addition, salinity-related challenges associated with the marshlands, Shatt al-Arab River, and its tributaries have intensified during recent years as a consequence of national water scarcity. Other factors, such as desertification, urban expansion at the expense of green areas, and the geographical proximity of Basrah to the equator compared with Babylon (Latitude: 30.536242, Longitude: 47.815819 for Basrah; Latitude: 32.5009124, Longitude: 44.5843126 for Babylon), collectively impose greater environmental stress on animals and negatively affect milk production. Heat stress adversely affects respiration, hormonal balance, feed intake, and rumen function, thereby reducing the animal's efficiency in milk production and accelerating the decline in lactation persistency [15]. The productive performance of Iraqi buffaloes is greatly influenced by climatic stress during both summer and winter seasons, and local environmental conditions play a major role in determining lactation curves and daily milk yield. Furthermore, cattle and buffaloes reared in central Iraqi regions consistently exhibit higher milk production than those raised in the far southern regions due to the more moderate climatic conditions [2].

In contrast to milk yield, solids-not-fat (SNF) percentage and relative density values showed a gradual and marked increase throughout the experimental months. In Babylon Governorate, SNF percentage increased from 11.35% in December (Table 1) to 12.57% in January (Table 2) and then to 13.50% in February (Table 3), accompanied by a direct increase in relative density from 1.03 to 1.04 and subsequently to 1.08. A similar pattern was observed in Basrah Governorate, where SNF values increased from 8.85% in December to 9.93% in January and remained stable at 9.93% during February. This trend was accompanied by relative density values that remained constant at 1.03 during December and January before increasing numerically in February with a higher standard deviation. Statistical analysis confirmed the presence of significant differences ($P \leq 0.05$) between the two governorates in SNF percentage throughout the three study months (Tables 1, 2, and 3), with Babylon buffaloes exhibiting significantly higher values than Basrah buffaloes. In contrast, relative density showed no significant differences ($P > 0.05$) between the two regions during all experimental months despite the observed numerical variations. This clear inverse relationship between milk volume and milk constituents represents the biological phenomenon known as the Dilution Effect. As milk yield decreases, the proportion of water in milk declines, leading to a higher concentration of dissolved milk solids, particularly minerals, per unit volume [13]. Accordingly, the increase in both SNF percentage and relative density can be attributed to the concentration of milk solids under reduced milk yield conditions [10]. Furthermore, SNF content increases significantly during periods of low milk production as a consequence of climatic influences and increased concentration of total solids, which is consistent with findings previously reported in the literature [5].

On the other hand, the progressive accumulation of milk solids directly affected milk freezing point values, causing them to shift toward more negative values over time. In Babylon Governorate, the freezing point decreased from −0.678 °C in December (Table 1) to −0.827 °C in January (Table 2) and further to −0.903 °C in February (Table 3), whereas in Basrah Governorate the freezing point declined from −0.658 °C in December to −0.719 °C in January and remained stable at −0.719 °C during February. Statistical analysis revealed no significant differences ($P > 0.05$) in freezing point values between the two governorates during December (Table 1), whereas significant differences ($P \leq 0.05$) were observed during January (Table 2) and February (Table 3), with Babylon buffaloes exhibiting significantly lower and more negative freezing point values compared with Basrah buffaloes. Fundamentally, milk freezing point is governed by water-soluble constituents, particularly lactose and free mineral salts, which play a major role in maintaining osmotic equilibrium with the animal's bloodstream. Therefore, the marked reduction in freezing point during the late stage of the study is considered a direct physicochemical consequence of the elevated concentration of solids-not-fat. As lactose and dissolved mineral concentrations increase due to reduced milk volume, the osmotic pressure of milk rises, thereby lowering the temperature required for freezing. This interpretation is consistent with previous reports [11],which demonstrated that the reduction in buffalo milk freezing point during periods characterized by low milk production and increased total solids concentration is primarily associated with elevated solute concentration, representing the principal factor responsible for freezing point depression in milk [3]

**Table 1:** Daily and monthly milk yield, solids-not-fat (SNF) percentage, relative density, and freezing point of Iraqi buffalo milk during the first month (Mean ± SE).

| Location | Freezing point | Relative density | Snf | Milk yield | Total monthly milk yield (kg) |
|---|---|---|---|---|---|
| Babylon | -0.678 ± 0.07 | 1.03 ± 0.00 | 11.35 ± 0.58 a | 10.100±0.42 a | 202 a |
| Basrah | -0.658 ± 0.00 | 1.03 ± 0.00 | 8.85 ± 0.05 b | 7.950 ± 0.59 b | ***159*** b |
| Significance Level | N.S | N.S | * | * | * |

**Table 2:** Daily and monthly milk yield, solids-not-fat (SNF) percentage, relative density, and freezing point of Iraqi buffalo milk during the second month (Mean ± SE).

| Location | Freezing point | Relative density | Snf | Milk yield | Total monthly milk yield (kg) |
|---|---|---|---|---|---|
| Babylon | -0.827 ± 0.02 b | 1.04 ± 0.00 | 12.57 ± 0.52 a | 8.35 ± 0.49 | 167 a |
| Basrah | -0.719 ± 0.02 a | 1.03 ± 0.00 | 9.93 ± 0.40 b | 7.40 ± 0.53 | 148 b |
| Significance Level | * | N.S | * | N.S | * |

**Table 3:** Daily and monthly milk yield, solids-not-fat (SNF) percentage, relative density, and freezing point of Iraqi buffalo milk during the third month (Mean ± SE).

| Location | Freezing point | Relative density | Snf | Milk yield | Total monthly milk yield (kg) |
|---|---|---|---|---|---|
| Babylon | -0.903 ± 0.03 a | 1.08 ± 0.02 | 13.50 ± 0.62 a | 6.60 ± 0.42 | 132 a |
| Basrah | -0.719 ± 0.02 b | 1.03 ± 0.00 | 9.93 ± 0.40 b | 5.65 ± 0.20 | 113 b |
| Significance Level | * | N.S | * | N.S | * |

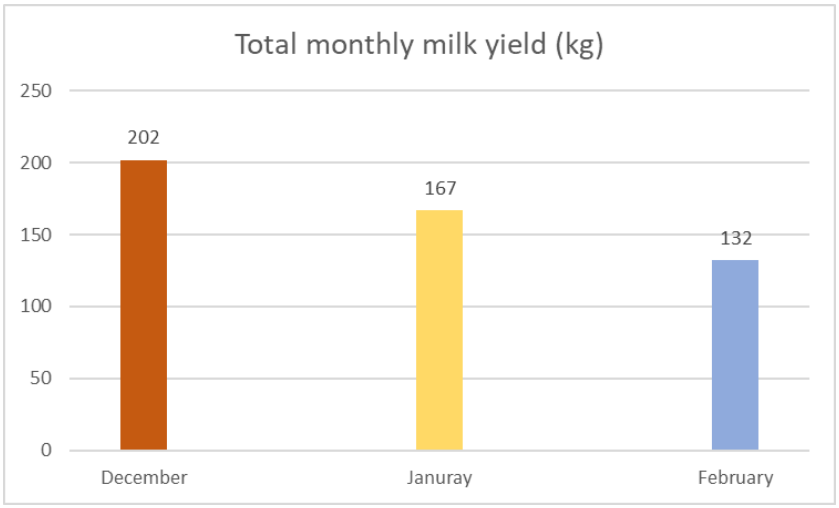


**Fig 1:** Monthly milk production levels in Babylon Governorate during the study months.

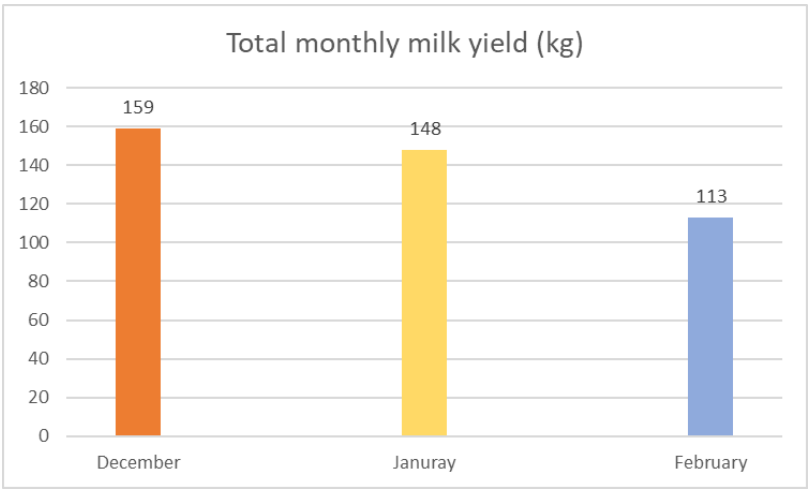


**Fig 2:** Monthly milk production levels in Basrah Governorate during the study months.

## Conclusion

The results of the present study demonstrated that milk yield and the physicochemical properties of Iraqi buffalo milk differed significantly during the study period in Babylon and Basrah Governorates. The gradual decline in milk production was accompanied by increases in solids-not-fat (SNF) percentage and relative density, as well as a decrease in freezing point values, reflecting the physiological and environmental influences on lactating buffaloes managed under unified production systems. Furthermore, buffaloes reared in Babylon Governorate exhibited better milk production performance compared with those reared in Basrah Governorate, indicating the important role of regional environmental conditions in determining milk productivity and composition. Therefore, further studies involving different seasons and environmental stress indicators are recommended in order to improve the productive efficiency of Iraqi buffaloes under local field conditions.

## Ethical Considerations

All data used in this study were collected without any handling, interference, or disturbance of the experimental animals.

Conflict of Interest

The authors declare that there are no conflicts of interest.

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