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A Comparative Analysis of The Composition of Camel Milk From Thorny Natural Pastures in The Syrian Deir Ez-Zor Steppe And Semi-Intensive Systems in Hama

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ABSTRACT

This research aimed to study the composition of milk from camels that graze naturally on thorny plants in the Deir ez-Zor steppe and compare it to the composition of milk from camels raised under semi-intensive conditions in Hama, Syria. The average solids, protein, and lactose components of the Deir ez-Zor camel milk samples were higher than those of Hama samples, respectively (8.26% vs. 7.49%), (3.97% vs. 3.54%), and (3.71% vs. 3.36%). The fat content was similar, with little variation, in Deir ez-Zor milk. Mineral analysis revealed higher concentrations of calcium, phosphorus, magnesium, manganese, iron, zinc, copper, and selenium in Deir ez-Zor camel milk compared to Hama camel milk. This is typical for camels grazing in extensive pastoral areas rich in diverse and resilient vegetation in the harsh steppe environment. Analysis of the antioxidant vitamins A, C, E, D, and B (especially B2 and B3) in the camel milk of Deir ez-Zor showed significantly higher levels than in the camel milk of Hama. This underscores the importance of natural grazing on diverse thorny plants rich in oils, carotenoids, and flavonoids in enhancing the nutritional and potential therapeutic value of camel milk, particularly from free-range camels. This study highlights the crucial role of camels as a resilience factor for populations in arid and semi-arid regions, which are highly susceptible to climate changes. This necessitates the preservation of traditional Bedouin camel grazing systems in the Syrian steppe as a source of functional and nutrient-rich camel milk with other potential health benefits.

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INTRODUCTION

Throughout history, the Syrian steppes have been a vital habitat for camels. They were used for transportation and warfare. They provided food, clothing, and furnishings for Bedouin families living in one of the driest regions of Syria. This steppe is classified within the fifth stability zone, where the average rainfall does not exceed 150 mm every two years, and cover an area of 10.218 million hectares, equivalent to 55.1% of the total area of Syria, which is usually used as permanent pastures or nature reserves (Hassan and Krepl, 2014).

Many nomadic Bedouin today are shifting their livestock farming from camels to sheep, due to declining demand for camel products and the high demand for the renowned Awassi sheep breed. Despite this shift, large herds of camels still graze in the Syrian Steppe, serving as a vital source of food and medicine. Grazing on highly saline thorny plants provides camels with milk similar to the rehydration solutions we use today for severe dehydration caused by diarrhea or high temperatures. Bedouin use this milk during their travels to withstand the intense desert heat and avoid sunstroke. Camels also form an important part of the Syrian Arab heritage, a source of pride for the Bedouin people. Today, camels can be found near Palmyra, east of Aleppo, and in the deserts of Deir ez-Zor, Raqqa, Hasakah, the Damascus countryside, and Al-Suwayda. These areas were suffering from climate change and recurring droughts. Because camels, with their physiological adaptation to heat and water scarcity, require less water and feed per unit of milk produced compared to sheep, they now represent a strategic necessity for food security in arid and semi-arid regions. Furthermore, global camel milk production is expanding, with its market value expected to reach approximately US$13 billion by 2030, and it is gaining prominence in many parts of the world as a healthy alternative to cow and sheep milk (Shaji George, 2024).

Camel milk is a white liquid with a mild taste ranging from sweet to salty (Abbas et al., 2013). Its composition is influenced by geographical location, lactation stage, feeding conditions, and the health status of the camels (Konuspayeva et al., 2009). The average composition of camel milk is approximately 3.4% protein, 3.5% fat, 4.4% lactose, 0.79% ash, and 87% water (AL-Kanhal, 2010). Its density ranges from 1.026 to 1.035, and its pH ranges from 6.2 to 6.5 (Jilo and Tegegne, 2015). It is also rich in minerals and trace elements such as sodium, potassium, calcium, phosphorus, magnesium, iron, zinc, and copper. Its levels are affected by diet, camel breed, and water intake (Haddadin et al., 2008; Onjoro et al., 2003). Camel milk is rich in vitamins A, D, E, and B vitamins, and its vitamin C levels are often higher than those in cow's milk, contributing to enhanced antioxidant capacity and improved shelf life (Stal et al., 2006; Mal et al., 2007).

The composition of camel milk has been affected by climate change, as drought and overgrazing have led to the proliferation of thorny plants such as wild safflower

(Carthamus oxyacantha), thistles, and other thorny species that are consumed exclusively by camels. Safflower (Carthamus tinctorius) contains oils, proteins, minerals, phenols, flavonoids, alkaloids, lignans, steroids, polysaccharides, and quinocalcone glycosides, giving it antioxidant, lipid-lowering, and multisystemic properties (Al-Snafi, 2015). Wild safflower (Carthamus oxyacantha) is rich in linoleic, oleic, palmitic, and stearic acids, and amino acids such as arginine, glycine, valine, and leucine (Ahmed et al., 2010). Echinops species contain thiophenes, flavonoids, terpenes, and alkaloids such as apigenin and echinozolone, as well as triterpenoids such as lupeol and beta-amyrin (Singh et al., 1989). All of these phytochemicals influence the nutritional value of camel milk.
This study aims to determine the chemical, mineral, and vitamin composition of milk from camels graz naturally on various types of thorny plants in the Deir ez-Zor steppe, and to compare it with the composition of milk from camels raised in a semi-intensive feeding system based on concentrated feeds in Hama, in order to determine the role of traditional grazing systems in arid regions in supporting the lives of the inhabitants of these regions.

MATERIAL AND METHOD

Ethical Statement

The ethical approval for this study was obtained from the Veterinary Medical Research Ethics Committee, Faculty of Veterinary Medicine, Hama University (Session No: 12, ID No: 7, dated 01 May 2025).

Study Area and Animals

Milk samples were collected from a camel herd of 294 camels (286 females and 8 males), including 189 lactating adult females, each producing about 5 liters of milk per day, at a station belonging to the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) in the Deir ez-Zor desert (Figure 1). The camels grazed naturally in areas rich in thorny and forage plants, including wild safflower (Carthamus oxyacantha, locally also referred to as wild turmeric), wild thyme, wild eggplant, camelthorn, reeds, and a variety of annual grasses and cereals (oats, wild barley, clover, sedge, wild wheat, and other palatable species).

Figure 1. A herd of camels from Deir ez-Zor grazing in areas of thorny vegetation steppe

For comparison, milk samples were collected from camels kept in semi-intensive systems in Hama governorate. These animals were housed in pens and fed local fodder consisting mainly of barley, straw, and commercial cattle concentrates, adjusted according to body weight, physiological status, and milk yield. These camels did not have access to natural grazing.

Sample Collection

Six individual milk samples were collected from lactating camels in the Deir ez-Zor herd after a period of grazing in areas rich in thorny plants. Similarly, six samples were collected from lactating camels in Hama under semi-intensive management. Milk was collected hygienically into sterile containers and transported chilled to the Faculty of Veterinary Medicine, Hama University.

Laboratory Analyses

Milk samples were divided into two portions. One portion was analyzed at the Agricultural Research Laboratories in Hama for basic composition: density, total solids, lactose, protein, and fat. The second portion was analyzed at the Modern Chemistry Laboratory, Faculty of Veterinary Medicine, Hama University, for mineral and vitamin content.

Basic composition: Density, total solids, lactose, protein, and fat were determined using standard dairy analytical methods routinely applied in the Agricultural Research Laboratories.

Minerals and trace elements: Calcium (Ca), phosphorus (P), magnesium (Mg), sodium (Na), potassium (K), chloride (Cl), manganese (Mn), iron (Fe), zinc (Zn), copper (Cu), and selenium (Se) were measured using reference methods validated in the laboratory (atomic absorption spectrophotometry or equivalent – SHIMADZO model AA6800).

Vitamins: Vitamins C, A, D, E, K, and B-complex (B1, B2, B3, B5, B6, B9, B12) were quantified using reference methods approved in the Faculty laboratory (HPLC-based assays LC 20AT pump, oven CTO-M20A, Detector SPD-M20A, Column), autosampler SIL 20AC C18 (25 cm x 4,6 mm, 5 MicroM) made by SUPELCO Analytical SHIMADZO.

Statistical Analysis

Data were entered into Microsoft Excel for calculation of means and standard deviations. A one-way analysis of variance (ANOVA) was performed using Origin 8 software to compare the means of Deir ez-Zor and Hama groups. Differences were considered statistically significant at ($P<0.05$). Different superscript letters in tables indicate significant differences between means.

RESULTS AND DISCUSSION

Basic Composition of Camel Milk

Table 1. presents the basic composition of camel milk samples from Deir ez-Zor, and Hama

Table 1. Comparison of basic milk composition between Deir ez-Zor and Hama (Mean ± SD)

Parameter	Deir ez-Zor	Hama
Density	29.05 ± 4.95	27.61 ± 0.96
Total solids (%)	8.26 ± 1.30	7.49 ± 0.16
Lactose (%)	3.71 ± 0.58	3.36 ± 0.08
Protein (%)	3.97 ± 0.60	3.54 ± 0.09
Fat (%)	3.32 ± 1.01	3.24 ± 0.75

Deir ez-Zor milk had higher total solids than Hama milk (8.26 ± 1.30% vs. 7.49 ± 0.16%). Protein content was higher in Deir ez-Zor (3.97 ± 0.60%) than in Hama (3.54 ± 0.09%). Lactose was slightly higher in Deir ez-Zor (3.71 ± 0.58%) compared with Hama (3.36 ± 0.08%). Fat content was similar between regions (3.32 ± 1.01% in Deir ez-Zor vs. 3.24 ± 0.75% in Hama), but it showed greater variability in Deir ez-Zor samples, reflecting heterogeneous grazing conditions. Milk density was slightly higher in Deir ez-Zor (29.05 ± 4.95) than in Hama (27.61 ± 0.96).

These results indicate that natural grazing on thorny plants in Deir ez-Zor is associated with higher solids and protein content, while semi-intensive feeding in Hama yields a more homogeneous but less concentrated milk composition.

Mineral and Trace Element Composition

The mineral composition of camel milk differed between Deir ez Zor and Hama production systems (Table 2). Calcium (Ca) and magnesium (Mg) concentrations were significantly higher in Deir ez Zor milk compared with Hama ($P<0.05$).

Table 2. Comparison of mineral composition between Deir ez-Zor and Hama (Mean ± SD)

Parameter	**Deir ez-Zor**	**Hama**
Ca (g/L)	2.76 ± 0.38^{a}	2.29 ± 0.28^{b}
P (g/L)	0.945 ± 0.16	0.81 ± 0.11
Mg (g/L)	0.072 ± 0.01^{a}	0.05 ± 0.02^{b}
Mn (µg/L)	229.03 ± 151.32	166.72 ± 42.41
Fe (µg/L)	225.18 ± 59.57	188.93 ± 22.17
Zn (mg/L)	1.20 ± 0.41	1.05 ± 0.25
Cu (mg/L)	0.79 ± 0.23	0.69 ± 0.14
Se (µg/L)	78.48 ± 37.66	76.13 ± 21.69
Na (g/L)	0.76 ± 0.08	0.71 ± 0.07
K (g/L)	0.99 ± 0.15	0.98 ± 0.06
Cl (g/L)	2.91 ± 0.35	2.82 ± 0.35

Different superscripts indicate significant differences ($P<0.05$).

Calcium, phosphorus, and magnesium were higher in Deir ez-Zor milk (Ca 2.76 ± 0.38 g/L vs. 2.29 ± 0.28 g/L; P 0.945 ± 0.16 g/L vs. 0.81 ± 0.11 g/L; Mg 0.072 ± 0.01 g/L vs. 0.05 ± 0.02 g/L). Differences in Ca and Mg were statistically significant ($P<0.05$).
Manganese and iron were higher in Deir ez-Zor milk (Mn 229.03 ± 151.32 µg/L vs. 166.72 ± 42.41 µg/L; Fe 225.18 ± 59.57 µg/L vs. 188.93 ± 22.17 µg/L). Zinc, copper, and

selenium were also slightly higher in Deir ez-Zor. Electrolyte levels (Na, K, and Cl) were similar between the two regions, with only minor variations observed.

Overall, camel milk from Deir ez Zor exhibited a higher mineral profile, which may be associated with the mineral-rich vegetation of natural thorny pastures, potentially enhancing its nutritional quality.

Vitamin Composition

The vitamin concentrations of camel milk from Deir ez Zor and Hama are presented in Table 3. Vitamin profiles differed between the two production systems, with generally higher levels observed in Deir ez Zor milk. Vitamins A, E, and D were significantly higher in Deir ez Zor compared with Hama ($P<0.05$), while vitamin C showed a slightly higher mean value in Deir ez Zor. Vitamin K concentrations were comparable between regions.

Table 3. Comparison of vitamin concentrations between Deir ez-Zor and Hama (Mean ± SD)

Vitamin	**Deir ez-Zor**	**Hama**
Vit C (mg/L)	173 ± 15.4	167.2 ± 19.1
Vit A (μg/L)	1068.5 ± 66.4[a]	920 ± 86.7[b]
Vit E (μg/L)	1009.6 ± 23.6[a]	912.8 ± 68.7[b]
Vit D (μg/L)	393.6 ± 21.9[a]	285.2 ± 14.9[b]
Vit K (μg/L)	161.2 ± 17.0	159.5 ± 5.9
B1 (μg/L)	1106.3 ± 126.1	977 ± 89.6
B2 (μg/L)	1967.3 ± 122.1	1869.4 ± 39.9
B3 (μg/L)	5196.3 ± 867.8	4916.1 ± 82.2
B5 (μg/L)	917.2 ± 74.0	882.2 ± 30.9
B6 (μg/L)	716.3 ± 105.3	620.1 ± 69.0
B9 (μg/L)	86.8 ± 6.6	81.6 ± 11.6
B12 (μg/L)	18.8 ± 5.4	14.2 ± 3.3

Different superscripts indicate significant differences ($P<0.05$).

All B-complex vitamins (B1, B2, B3, B5, B6, B9, and B12) were consistently higher in Deir ez Zor milk, with the most pronounced differences observed for vitamins B2, B3, and B12.

Antioxidant-related vitamins (C, A, D, and E) were also elevated in Deir ez Zor milk. Vitamin C concentrations were 173 ± 15.4 mg/L in Deir ez Zor and 167.2 ± 19.1 mg/L in Hama. Similarly, vitamin A (1068.5 ± 66.4 vs. 920 ± 86.7 μg/L), vitamin D (393.6 ± 21.9

vs. 285.2 ± 14.9 μg/L), and vitamin E (1009.6 ± 23.6 vs. 912.8 ± 68.7 μg/L) were significantly higher in Deir ez Zor milk ($P<0.05$).

These results indicate that grazing on vegetation rich in carotenoids and flavonoids (e.g., wild safflower, thistles, and other steppe plants) promotes the synthesis or transfer of antioxidant and water-soluble vitamins into milk.

The results of this study are consistent with previous research demonstrating the influence of geographical origin, feeding conditions, and season on the composition of camel milk (Konuspayeva et al., 2009; Haddadin et al., 2008). The effect of natural grazing on thorny plants such as wild safflower and thistle, rich in oils and secondary metabolites, is evident in the high protein and solids content of Deir ez-Zor milk (Ahmed et al., 2010; Al-Snafi, 2015; Singh et al, 1989). The availability of essential fatty acids, amino acids, and bioactive compounds in these plants contributes to the alteration of the biochemical composition. The fact that Deir ez-Zor camel milk is richer in calcium, phosphorus, magnesium, iron, manganese, zinc, copper, and selenium than Hama camel milk aligns with research confirming that camel milk is a good source of sodium, potassium, calcium, phosphorus, magnesium, iron, zinc, and copper (Onjoro et al., 2003; Abbas et al., 2013), and that these levels are influenced by diet, breed, and water intake (Haddadin et al., 2008). This supports the notion that Deir ez-Zor milk has anti-ulcer, immune-modulating, and general health-promoting benefits (Al-Hassani, 2024; Al-Juboori et al., 2013).

The superior vitamin composition of Deir ez-Zor camel milk is a result of natural grazing, particularly its higher levels of vitamins A, D, and E, as well as B vitamins, especially B2 and B3. The high vitamin C content is consistent with research supporting its role as an antioxidant, which increases shelf life (Stal et al., 2006; Mal et al., 2007). Furthermore, in conjunction with other antioxidant vitamins (A and E), it contributes to protection against oxidative stress, infections, chronic diseases, and aging. The high levels of these vitamins in Deir ez-Zor camel milk may be due to the consumption of plants rich in carotenoids and flavonoids, which act as precursors or regulators of these vitamins (Mal et al., 2007; Gul et al., 2015).

The high protein, mineral, and vitamin content of Deir ez-Zor camel milk may play a role in preventing many health conditions, such as diabetes, gastrointestinal disorders, liver disease, and autoimmune diseases, as indicated by previous studies (Al-Hassani, 2024; Al-Juboori et al., 2013).

CONCLUSION and RECOMMENDATIONS

Analysis of camel milk from camels grazing freely on thorny plants in the Deir ez-Zor desert showed higher levels of total solids and protein compared to camel milk from camels grazing in semi-intensive systems in Hama. The milk also exhibited higher levels of essential minerals and elements (calcium, phosphorus, magnesium, iron, manganese, zinc, copper, and selenium). Furthermore, natural grazing resulted in higher concentrations of antioxidant vitamins (A, C, D, and E) and B vitamins, particularly B2 and B3. This enhances the potential nutritional and therapeutic value of camel milk from these arid and semi-arid regions affected by climate change. These findings underscore the importance of preserving traditional camel grazing systems in the Syrian desert, as these systems are crucial for supporting the livelihoods of families living in arid and drought-stricken areas worldwide, providing essential nutrients and promoting health. In addition, these animals hold significant cultural and heritage value for the inhabitants of these regions. This study also paves the way for future research to study more broadly the changes in the composition of camel milk in different seasons, breeds and grazing areas, and to discover the bioactive compounds and their diverse clinical effects on humans. Analysis of camel milk from camels grazing freely on thorny plants in the Deir ez-Zor desert showed higher levels of total solids and protein compared to camel milk from camels grazing in semi-intensive systems in Hama. The milk also exhibited higher levels of essential minerals and elements (calcium, phosphorus, magnesium, iron, manganese, zinc, copper, and selenium). Furthermore, natural grazing resulted in higher concentrations of antioxidant vitamins (A, C, D, and E) and B vitamins, particularly B2 and B3. This enhances the potential nutritional and therapeutic value of camel milk from these arid and semi-arid regions affected by climate change. These findings underscore the importance of preserving traditional camel grazing systems in the Syrian desert, as these systems are crucial for supporting the livelihoods of families living in arid and drought-stricken areas worldwide, providing essential nutrients and promoting health. In addition, these animals hold significant cultural and heritage value for the inhabitants of these regions. This study also paves the way for future research to study more broadly the changes in the composition of camel milk in different seasons, breeds and grazing areas, and to discover the bioactive compounds and their diverse clinical effects on humans.

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Conflict of Interest Statement

The authors have declared that there are no competing interests.

Authors Contribution

Authors declares the contribution of the authors is equal.

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