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Assessing the impact of camel breed and their grazing habits on the nutritional profile of milk

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Camel milk has numerous nutraceuticals and therapeutical properties due to camel's desert habitat and grazing habits on wild vegetation. The current study aims to evaluate the impact of breed type and grazing habits on variations in nutritional aspects of milk among camel breeds of south Punjab, Pakistan. The samples were collected from local area (Vehari Chowk) of Multan and Bahawalpur (Cholistan dessert). The milk was taken from the twelve camels of four breeds i.e., B1 (Sindhri) and B2 (Malgadhi) from Multan and B3 (Desi) and B4 (Marrechi) from Bahawalpur and pool was prepared by thoroughly mixing. The various parameters of milk, i.e., physicochemical analysis, fatty acids composition, protein contents, amino acid profiling, and mineral concentrations, were evaluated and characterized. Minerals, i.e., Na, K, Zn and Pb in camel milk were found in considerable concentrations such as 405.94±0.02, 204.16±0.10, 2.45± 0.02 and 0.25±0.02 ppm accordingly. During physicochemical analysis, pH and protein were present in higher amounts. Casein of camel breeds contains higher amounts of amino acids i.e., Leucine (0.25±0.039 %), Lysine (0.12±0.019 %), Aspartic acid (0.18±0.017 %) and Glutamic acid (0.56±0.087 %). Fatty acids were present in significant concentrations in all camel breeds, i.e., Butyric acid (0.760±0.012 g/100g), Lauric acid (0.770±0.120 g/100g), Myristic acid (12.420±1.163 g/100g) and Linoleic acid (2.390±0.112 g/100g). Hence, the results concluded that the nutritional value of camel milk was varied due to their different breeds, genetic variations, grazing pattern and environmental conditions, which should be considered before camel milk consumption and utilization for various therapeutical applications.

Keywords: Camel Milk Composition, Amino Acid Profiling, Fatty Acid Profiling, Grazing Habits

INTRODUCTION

The trends toward milk and milk products have increased in the last few decades. Many studies have been conducted on the milk of various lactating species like cows, buffalo, goats and sheep. Unfortunately, camel milk remained undervalued (Balhara *et al*., 2017). Besides buffalo and cow milk, camel milk is the best option for dairy products due to its particular nutritional composition as it contains a low concentration of fats and lactose and high concentrations of minerals (Fe and K) and Vitamin C (Mohamed *et al*., 2021; Sumaira *et al*., 2020). The worldwide population of camels is ~35.53million, and Pakistan come on 8th rank (GOP, 2021-2022; FAO, 2020a). According to the economic survey of 2021, the reared population of camels was almost 1.1 million in Pakistan (PES, 2021). The camel population can be divided on provinces level i.e., the population of camels in Balochistan (hilly), Sindh (desert), Punjab (Cholistan) and KPK, is 41 %, 30 %, 22 % and 7 %, respectively (Fatih *et al*., 2021). The worldwide fresh milk production from cows, buffalo, goats, sheep, and camels is 82.7, 13.3, 2.3, 1.3 and 0.4 %, respectively. According to FAO, camel milk production ranked fifth globally (FAO, 2020b). Camel milk production increased from 0.908to 0.932million-tonnes in 2018 to 2021accordingly (PES, 2021).

Camels have ability to adapt the different environments, preserve their life-cycles under warmth deserts and bearing the severe ecological situations of weather. Therefore, this solitary physiological predilection makes camel strong to bear awful flowers, sun emissions, water scarcity, higher

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temperature and severe geographical conditions. Camels diverse in their grazing habits and are familiar for their performance in wide ranges of environmental conditions (Faraz, 2022). Camel grazing regions and migrating arcades are being estranged hastily leading to the major problem for the herders. This issue may resolve by providing the save passages and sources of pastures to prevent the alteration in milk nutritional profile (Köhler-Rollefson and Wanyama, 2022). Camels are well known for cruising in comparison to grazing and their habits to graze on beneficial flora of nature make them exceptional. During glancing they continue rumination for the longer period, therefore they prefer surfing overgrazing (Faraz et al., 2023). Moreover, the forage type consumed during the grazing of camels can affect their milk compositions and also contribute in provision of beneficial nutrients in milk. Moreover, the grazing management systems i.e., continuous and rotational grazing may also affect the milk composition. Camels mostly associate with the rotational grazing and graze on fresh pastures resulting in highly nutritional milk production (Ikanya et al., 2022).

Camel milk depicted various medicinal and nutritional attributes and is being utilized to manage various mental and physical disorders. Camel milk constitutes of total solids (11.9 %), fat contents (3.5 %), protein (3.1 %), further categorized into casein (52–87 %) and whey (20-25 %), lactose (4.4 %) and vitamin B1, B2 and ascorbic acid (3-5 times greater than human and bovine milk) (Berhe *et al.*, 2017; Kamal and Karoui, 2017). Camel milk has insulin-like proteins and helps reduce cell resistance in patients with type II Diabetes (Hussain *et al*., 2021). Whey proteins of camel milk are more heat stable. Camels contain higher concentrations of lactoferrin, lysozyme and immunoglobulin G (IgG) than other milching animals (Sharaf Eddin *et al*., 2021).

Composition changes in camel milk are because of variation in factors like feeding behavior (Al-Saiady *et al*., 2012), different breeds (Aljumaah *et al*., 2012), geographical location, season, and age, lactation stage and calving number (Musaad *et al*., 2013). The proteins present in camel milk provides health benefits by enhancing antiviral and antibacterial activities (Sharma and Singh, 2014). It is beneficial for children and people suffering from lactose intolerance because it lacks β-lactoglobulin that is primary cause of allergy in children-consuming cow milk and lactose obtained from camel milk can be metabolized as it makes more exposure to lactose to lactase enzyme, which metabolizes lactose (Cardoso *et al*., 2010). It is also effective against various food allergies, diarrheal diseases and autism spectrum disorders (Ziba *et al*., 2015).

Camel milk is being ignored due to its high salts, acidic nature and lake of knowledge about its health benefits in Pakistan. Camel milk consumption is limited to the pastoral regions. The aim of current study was to investigate the impact of camel breeds and their grazing habits on nutritional profile of camel milk taken from Southern Punjab native breeds (Bahawalpur and Multan).

MATERIALS AND METHODS

***Procurement of milk samples*:** Samples of different breeds were collected from the local area (Vehari Chowk) of Multan and Bahawalpur (Cholistan dessert). The milk was taken from the twelve camels of each breed by using random sampling method and then mixed thoroughly to make a pool and breeds were named B1 (Sindhri) and B2 (Malgadhi) from Multan and B3 (Desi) and B4 (Marrechi) from Bahawalpur. All these samples were stored at 4°C in refrigerator for further analysis. Physicochemical analysis was performed (in triplicate) within 24 h of collection in the Dairy Technology Laboratory, Institute of Food Science and Nutrition, Bahauddin Zakariya University, Multan and PCSIR labs in Karachi. The Minerals, amino acids and fatty acids profiles of camel milk were also determined.

***Physicochemical analysis*:** The pH of milk samples was measured by using a pH meter (Inolab WTW Series 720), and titratable acidity (%) was determined by the method given in AOAC- 947.05 (2000). Total solids (TS) were calculated by following AOAC (AOAC, 2000) procedure (925.23). Fat of milk was estimated according to the protocol of IDF-105. Solid-not-fat (SNF) contents were determined by IDF-21 method using a lactometer. Lactose was calculated by method, as given in AOAC (No.930.28) (AOAC, 1999). Moreover, Crude protein (CP), true protein (TP), casein, non-casein-nitrogen (NCN), whey proteins and non-protein-nitrogen (NPN) contents were determined by the Kjeldahl method. Crude protein of total protein was calculated by multiplying the total amount of nitrogen (%) with a factor of 6.38, as described in the ISO 8968-1/IDF 20-1, ISO (2014). NCN and NPN contents were measured by following methods given in ISO 8969-1/IDF 20-1 (2014) and ISO 8969-4/IDF 20-4 (2014). Nitrogen (%) was used to find out the NPN (%) and NCN (%) using conversion factors 6.25 and 3.60, respectively.

$$TP = CP - NPN \quad (1)$$

$$\text{Casein}\,(N\%) = \text{Total Protein}\,(N\%) - \text{NCN}\,(N\%) \quad (2)$$

$$\text{Casein}\,(N\%) = \text{NCN}(N\%) - \text{NPN}\,(N\%) \quad (3)$$

***Amino acid profiling*:** The skim milk was divided into whey and casein proteins at 37°C via isoelectric precipitations at pH 4.6 by using 1 N HCl as provided by Shanmugam *et al*. (2021). Then, casein and whey freeze-dried samples were subjected to amino acids analyzer to determine the amino acid composition in proteins by following the method of Schuster (1988).

***Determination of fatty acids in camel milk*:** The milk fat extraction was done by following the modified method of (Feng *et al*., 2004). Separated lipid (40mg) was trans-esterified by the trans-methyl at ion procedure of Christie with modifications (Destaillats, 2003). After that, the fatty acid

methyl esters were quantified using a Shimadzu Gas Chromatograph Model 14-A (Shimadzu Co., Japan) fitted with a methyl lignose rate coated (film thickness = 0.25µm) polar capillary column SP-2330 (30m×0.32mmSpelco). The peaks were evaluated utilizing the standard mixtures of already recognized fatty acids and unknown samples were compared with these samples for characterization under ideal chromatographic conditions.

***Protein analysis*:** Protein band separation was performed via gel electrophoresis (Sharma et al., 2021). Separated Whey was a liquid sample, and casein is solid that was converted into liquid. Tris-HCl (0.221g) and casein (1g) was dissolved in distilled water (100 ml) in this solution by maintaining buffer solution pH (8). The prepared solution was placed in boiling water for 20 min, filtration was carried out via Whatman filter paper and placed at 4ºC in refrigerator for further use.

***Vitamins determination*:** The extraction of fat-soluble vitamins was carried out by using the modified technique of Augustin *et al*. (1984). The residues were mixed in the mobile phase of acetonitrile: methanol (75:25, 25 ml) and analyzed by HPLC (Isocratic HPLC with a UV/Visible detector-Jasco Model 880, Jasco Co., Tokyo, Japan).

***Statistical analysis*:** The collected data was statistically analyzed by applying Statistical software (Statistics 8.1) and using techniques, i.e., factorial 2-way ANOVA and Completely Randomized Design (Rietveld and Van Hout, 2011).

RESULTS

***Physicochemical analysis of milk from different breeds of camel*:** The physicochemical analysis of camel milk of different breeds revealed that pH and acidity showed minimum variations while other components, i.e., total solids (TS), fat, and solid-not-fat (SNF), showed maximum variation in milk composition of different breeds of camel (Table 1). The change in camel milk composition was evaluated to confirm the effect of summer and winter seasons by measuring aforementioned components in milk. In the current study, the acidity and pH of milk showed non- significant differences among different breeds of the camel. In the current study, proteins, total solids, fat, SNF and ash percentages were decreased in the summer season. Moreover, a higher concentration of fat was found in the Malgadhi breed (B2), followed by Sindhri (B1), Marrechi (B4), and Desi (B3) breeds in both seasons. At the same time, total solids, solid-not-fat and lactose were higher in the camel's Sindhri breed (B1). The total solids (TS) results of camel breeds ranged (from 3.82±0.004-12.93±0.017 %). The SNF concentrations were higher in all breeds in winter season as compared to summer season.

***Protein contents in camel breads*:** Proteins are heterogeneous group of compounds comprised of amino acids and their different polymers. In the present investigation, protein nitrogen fractions like TP, CP, casein, whey protein, NPN and NCN were determined as shown in Figure 1. Among these fractions, NCN and NPN showed non-significantdifferences. At the same time, crude protein, true protein, casein, and whey protein depicted significant differences in the milk of different breeds of the camel. The Malgadhi breed depicted the higher percentiles of true proteins and The Desi breed showed the least true protein contents. In current study, the Desi breed showed a higher percentages of whey proteins and a minimum in the Sindhri breed. The non-casein nitrogen (NCN) was highest in Desi (B3) breeds and lowest in Malgadhi (B2). The concentrations of NPN in B3 (1.98±0.38 %) and B4 (1.98±0.44 %) were higher and least concentration was observed in B2 (1.66±0.26 %).

Table 1. Seasonal comparison of physicochemical properties of milk from different camel breeds

Parameter	Season	B1	B2	B3	B4
pH	Winter	6.73±0.02^{a}	6.74±0.02^{a}	6.72±0.02^{a}	6.73±0.02^{a}
	Summer	6.69±0.03^{a}	6.70±0.04^{a}	6.68±0.02^{a}	6.71±0.03^{a}
Total Acidity	Winter	0.14±0.02^{b}	0.14±0.04^{b}	0.13±0.01^{a}	0.13±0.03^{c}
	Summer	0.15±0.03^{a}	0.15±0.01^{a}	0.15±0.02^{c}	0.14±0.02^{b}
Protein	Winter	3.85±0.001^{b}	4.02±0.02^{a}	3.58±0.01^{d}	3.66±0.05^{c}
	Summer	3.71±0.01^{b}	3.89±0.02^{a}	3.46±0.02^{d}	3.52±0.01^{c}
Total Solids	Winter	12.93±0.02^{a}	12.61±0.01^{b}	12.37±0.02^{d}	12.47±0.01^{c}
	Summer	10.54±0.02^{a}	10.32±0.04^{b}	9.98±0.01^{d}	10.12±0.03^{c}
Fat	Winter	4.18±0.02^{b}	4.41±0.02^{a}	3.82±0.00^{d}	4.11±0.05^{c}
	Summer	3.84±0.01^{b}	4.01±0.02^{a}	3.66±0.01^{d}	3.79±0.03^{c}
SNF	Winter	8.83±0.02^{a}	8.24±0.01^{d}	8.55±0.01^{b}	8.32±0.01^{c}
	Summer	8.71±0.03^{a}	8.15±0.01^{d}	8.42±0.01^{b}	8.21±0.03^{c}
Ash	Winter	0.98±0.01^{b}	0.94± 0.01^{c}	0.87± 0.03^{d}	1.15±0.03^{a}
	Summer	0.94±0.02^{b}	0.92± 0.02^{c}	0.86± 0.01^{d}	1.06±0.03^{a}

B1 =Sindhri; B2 = Malgadhi; B3= Desi; B4 = Marrechi

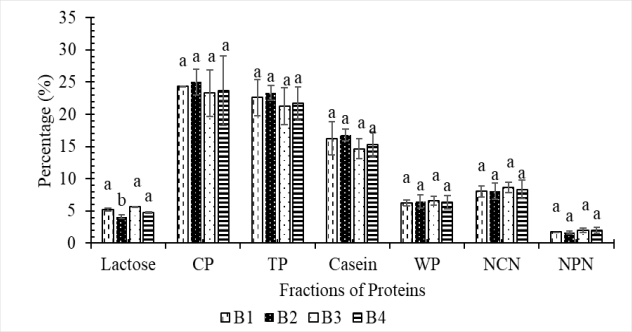

Figure 1. Comparison of various proteins (%) in camel breeds.

B1 =Sindhri; B2 = Malgadhi; B3= Desi; B4 = Marrechi; CP=Crude Proteins; TP=Total Proteins; WP=Whey Proteins; NCN= Non-Casein Nitrogen; NPN=Non-Protein Nitrogen

***Amino acid profiling of camel breeds*:** The fundamental blocks of protein are amino acids. The whey and casein contain considerable amounts of different essential and non-essential amino acids. The amino acids concentrations were non-significant among the milk of different camel breeds. Essential amino acids found in milk of selected breeds in the current study were tryptophan, phenylalanine, leucine, isoleucine, methionine, valine, lysine and threonine. Statistical analysis revealed the significant variations in essential amino acids in whey and casein proteins among milk of all camel breeds. Current study showed that leucine (0.25±0.1 %) in the Mariachi breed was found to be higher in casein among the essential amino acids. In contrast, threonine (0.18±0.1 %) in the Mariachi breed was second to leucine in concentration, as shown in Table 2. In whey protein, threonine contents (0.10±0.05 %) were highest in the Marrechi and Desi breeds. A substantial amount of other amino acids, i.e., valine, isoleucine, phenylalanine, lysine, tryptophan, and methionine, were also observed in casein and whey proteins. Non-essential amino acids found in whey and casein proteins of milk of selected breeds in the current investigation were alanine, aspartic acid, arginine, cysteine, glycine, glutamic acid, proline, serine, and tyrosine. The results depicted a significant change in non-essential amino acids in whey and casein proteins among milk of all camel breeds. Glutamic acid content was highest (0.56±0.02 %) in casein protein. Whey protein contained a maximum arginine concentration, whereas glutamic acid was second to arginine in the Magadhi breed.

***Comparison of fatty acids*:** The fatty acid composition of camel breeds was compared to evaluate the fatty acid combination. A variety of fatty acids was present in all camel breeds ranging from butyric acid to Heneicosanoic acid, along with methyl esters. Although some fatty acids were detected in significant concentrations, i.e., palmitic acid was observed highest in all camel breeds, followed by oleic, myristic, stearic, palmitoleic acid and pentadecanoic acid, the other fatty acids (e.g. linoleic, α-linolenic, elaidic, butyric, caproic, lauric, myristoleic, heptadecanoic, cis-10 heptadecenoic, and Heneicosanoic acid) were observed in small fractions as given in Table 3.

***Seasonal comparison of minerals*:** The seasonal comparison of various mineral components was done to study the effects of the winter and summer seasons. Primarily the concentrations (ppm) of minerals, e.g., Fe, Co, Mn, Zn and Ni, were increased in the summer season, but some minerals, i.e., Na, K, Pb, and Cu, showed decreasing trends in the summer season as shown in Table 4. However, the increase and decrease in mineral concentrations may be due to the change in forage type, as the camel herders shift camels from deserts to the arid and semi-arid areas during the summer

Table 2. Comparison of essential and non-essential amino acids (%) in camel breeds

	Amino Acids	Bread 1		Bread 2		Bread 3		Bread 4		F Ratio
		Casein	Whey	Casein	whey	Casein	Whey	Casein	whey	
Essential Amino Acids	Isoleucine	0.03±0.004^{a}	0.00±0.000^{c}	0.02±0.003^{a}	0.01±0.001^{d}	0.01±0.001^{b}	0.00±0.000^{d}	0.03±0.004^{c}	0.00±0.000^{d}	82.6**
	Leucine	0.24±0.037^{ab}	0.01±0.002^{d}	0.20±0.031^{bc}	0.01±0.002^{d}	0.19±0.030^{c}	0.00±0.000^{d}	0.25±0.039^{a}	0.00±0.000^{d}	68.0**
	Lysine	0.12±0.019^{a}	0.01±0.002^{e}	0.05±0.008^{c}	0.00±0.000^{e}	0.08±0.012^{b}	0.01±0.002^{e}	0.03±0.005^{d}	0.00±0.000^{e}	75.6**
	Methionine	0.01±0.001^{f}	0.04±0.004^{d}	0.00±0.000 ^{g}	0.07±0.008^{b}	0.04±0.004^{d}	0.08±0.009^{a}	0.02±0.002^{e}	0.05±0.005^{c}	87.9**
	Phenylalanine	0.11±0.012^{a}	0.00±0.000^{d}	0.09±0.010^{b}	0.01±0.001^{d}	0.05±0.005^{c}	0.00±0.000^{d}	0.11±0.012^{a}	0.00±0.000^{d}	139.0**
	Threonine	0.09±0.001^{c}	0.07±0.001^{e}	0.08±0.001^{d}	0.06±0.001^{f}	0.10±0.002^{b}	0.08±0.001^{d}	0.18±0.003^{a}	0.10±0.002^{b}	1703.0**
	Tryptophan	0.07±0.005^{b}	0.02±0.001^{e}	0.06±0.004^{c}	0.01±0.001^{f}	0.04±0.003^{d}	0.01±0.001^{f}	0.08±0.006^{a}	0.02±0.001^{e}	205.0**
	Valine	0.09±0.006^{a}	0.01±0.001^{e}	0.08±0.005^{b}	0.00±0.000^{f}	0.05±0.003^{c}	0.00±0.000^{f}	0.09±0.006^{a}	0.02±0.001^{d}	379.0**
Non-essential Amino Acids	Alanine	0.06±0.011^{a}	0.01±0.002^{d}	0.05±0.009^{ab}	0.04±0.007^{bc}	0.03±0.006^{c}	0.04±0.007^{bc}	0.05±0.009^{ab}	0.03±0.006^{c}	11.9**
	Arginine	0.11±0.002^{e}	0.00±0.000 ^{g}	0.09±0.001^{f}	0.32±0.005^{a}	0.15±0.002^{c}	0.00±0.000 ^{g}	0.16±0.002^{b}	0.13±0.002^{d}	4986.0**
	Aspartic Acid	0.18±0.017^{a}	0.00±0.000^{d}	0.15±0.014^{b}	0.00±0.000^{d}	0.10±0.009^{c}	0.00±0.000^{d}	0.11±0.010^{c}	0.00±0.000^{d}	203.0**
	Cysteine	0.01±0.002^{b}	0.00±0.000^{c}	0.01±0.002^{b}	0.02±0.003^{a}	0.00±0.000^{c}	0.00±0.000^{c}	0.01±0.002^{b}	0.00±0.000^{c}	76.5**
	Glutamic acid	0.56±0.087^{a}	0.10±0.016^{d}	0.45±0.070^{b}	0.09±0.014^{d}	0.28±0.044^{c}	0.17±0.027^{d}	0.26±0.041^{c}	0.16±0.025^{d}	38.1**
	Glycine	0.02±0.002^{c}	0.01±0.001^{d}	0.01±0.001^{d}	0.03±0.004^{b}	0.01±0.001^{d}	0.04±0.005^{a}	0.01±0.001^{d}	0.02±0.002^{c}	50.6**
	Proline	0.03±0.003^{b}	0.00±0.000^{c}	0.02±0.002^{b}	0.03±0.003^{b}	0.03±0.003^{b}	0.00±0.000^{c}	0.21±0.020^{a}	0.00±0.000^{c}	285.0**
	Serine	0.16±0.020^{a}	0.10±0.012^{cd}	0.12±0.015^{bc}	0.08±0.010^{d}	0.13±0.016^{b}	0.09±0.011^{d}	0.10±0.012^{cd}	0.10±0.012^{cd}	10.0**
	Tyrosine	0.10±0.008^{b}	0.01±0.001^{e}	0.09±0.007^{c}	0.00±0.000^{f}	0.05±0.004^{d}	0.00±0.000^{f}	0.12±0.009^{a}	0.00±0.000^{f}	288.0**

**= Highly significant (P=<0.0001); B1 =Sindhri; B2 = Malgadhi; B3= Desi; B4 = Marrechi

Table 3. Comparison of fatty acids (%) in camel breeds

Fatty Acids	No. of C	B1(g/100g)	B2(g/100g)	B3(g/100g)	B4(g/100g)	F Ratio
Butyric acid	(C4:0)	0.42±0.007^{c}	0.11±0.002^{d}	0.72±0.006^{b}	0.76±0.012^{a}	4981.00**
Caproic acid	(C6:0)	0.35±0.044^{a}	0.12±0.015^{b}	0.03±0.004^{c}	0.00±0.000^{c}	140.00**
Lauric acid	(C12:0)	0.77±0.120^{ab}	0.59±0.092^{b}	0.73±0.114^{ab}	1.00±0.156^{a}	5.75*
Myristic acid	(C14:0)	11.47±1.074^{ab}	12.42±1.163^{a}	9.82±0.920^{bc}	9.13±0.855^{c}	6.65*
Myristoleic acid	(C14:1)	0.62±0.077^{b}	0.97±0.121^{a}	0.62±0.077^{b}	1.09±0.136^{a}	15.5**
Pentadecanoic acid	(C15:0)	2.05±0.384^{a}	1.81±0.339^{a}	2.33±0.437^{a}	2.21±0.414^{a}	0.97^{ns}
Palmitic acid	(C16:0)	37.58±5.867^{a}	36.73±5.734^{a}	33.73±5.266^{a}	32.42±5.062^{a}	0.59^{ns}
Palmtoleic acid	(C16:1)	7.57±0.473^{b}	7.98±0.498^{ab}	8.84±0.552^{ab}	8.18±0.510^{b}	3.24*
Heptadecanoic acid	(C17:0)	0.79±0.086^{c}	0.52±0.057^{b}	1.13±0.123^{a}	0.77±0.084^{b}	22.9**
Cis-10 Heptadecenoic acid	(C17:1)	0.62±0.087^{c}	0.15±0.022^{d}	0.83±0.117^{b}	1.17±0.164^{a}	44.9**
Stearic acid	(C18:0)	11.77±1.838^{a}	11.69±1.825^{a}	11.91±1.859^{a}	10.70±1.671^{a}	0.28^{ns}
Elaidic acid	(C18:1n9t)	1.88±0.147^{a}	0.97±0.076^{b}	0.46±0.036^{c}	0.96±0.075^{b}	123.00**
Oleic acid	(C18:1n9c)	20.11±2.200^{b}	21.27±2.327^{b}	24.68±2.700^{ab}	27.41±2.999^{b}	4.98*
Linoleic acid	(C18:2n6c)	2.10±0.098^{b}	1.73±0.081^{c}	1.87±0.088^{c}	2.39±0.112^{a}	27.5**
a-Linolenic acid	(C18:3n3)	1.22±0.086^{b}	1.21±0.085^{b}	1.42±0.100^{a}	0.93±0.065^{c}	16.9**
Heneicosanoic acid	(C21:0)	0.67±0.105^{b}	1.32±0.206^{a}	0.89±0.139^{b}	0.74±0.116^{b}	11.8**

*=Significant (P=<0.01); **= Highly significant (P=<0.0001); ns= Non-significant; B1 =Sindhri; B2 = Malgadhi; B3= Desi; B4 = Marrechi

Table 4. Seasonal comparison of Minerals concentration (ppm) in milk of different camel breeds

Mineral	Season	B1	B2	B3	B4
Fe	Winter	3.34±0.04^{b}	3.59±0.02^{a}	3.19±0.02^{d}	3.23±0.03^{c}
	Summer	3.27±0.02^{b}	3.54±0.03^{a}	3.25±0.03^{d}	3.17±0.01^{c}
Na	Winter	719.23±0.07^{a}	698.14±0.04^{b}	616.92±0.01^{d}	578.01±0.03^{c}
	Summer	786.51±0.01^{a}	743.64±0.06^{b}	701.52±0.02^{c}	610.87±0.02^{d}
K	Winter	1093.21±0.32^{b}	962.62±0.24^{d}	1132.19±0.11^{a}	1007.87±0.16^{c}
	Summer	1163.46±0.05^{a}	1029.11±0.31^{d}	1145.32±0.66^{b}	1034.72±0.42^{c}
Ca	Winter	1256.21±0.05^{b}	1306.56^{a}±0.02^{a}	849.20±0.01^{d}	1092.44±0.03^{c}
	Summer	1201.32±0.03^{b}	1296.41^{a}±0.03^{a}	841.12±0.02^{d}	1076.53±0.06^{c}
Mn	Winter	0.10±0.02^{c}	0.19±0.01^{b}	0.28±0.03^{a}	0.07±0.01^{d}
	Summer	0.07±0.01^{c}	0.17±0.02^{b}	0.23±0.03^{a}	0.01±0.04^{d}
Zinc	Winter	5.74±0.06^{b}	6.28±0.02^{a}	4.52±0.02^{d}	5.46±0.04^{c}
	Summer	5.69±0.03^{b}	6.26±0.01^{a}	4.43±0.02^{d}	5.40±0.04^{c}
Ni	Winter	0.26±0.02^{b}	0.18±0.01^{d}	0.24±0.05^{c}	0.34±0.03^{a}
	Summer	0.23±0.01^{c}	0.17±0.03^{d}	0.24±0.02^{b}	0.36±0.02^{a}
Pb	Winter	0.23±0.04^{a}	0.03±0.03^{d}	0.09±0.03^{c}	0.14±0.02^{b}
	Summer	0.26±0.01^{a}	0.11±0.02^{d}	0.18±0.01^{c}	0.22±0.03^{b}
Cu	Winter	0.14±0.01^{b}	0.32±0.01^{a}	0.26±0.04^{d}	0.19±0.02^{c}
	Summer	0.16±0.02^{b}	0.38±0.03^{a}	0.29±0.01^{d}	0.24±0.01^{c}

B1 =Sindhri; B2 = Malgadhi; B3= Desi; B4 = Marrechi

season due to high temperatures. Therefore, the camel feed changed from wild plants to simply growing forage crops which might have lowered the concentrations of some mineral contents due to seepage of these minerals in soils through irrigated water. In contrast, some minerals increased due to forage consumption might be due to applications of different fertilizers on these forage crops. It was observed that all breeds of camels showed almost the same pattern for each mineral-like Fe increased in all breeds in the summer season and Na decreased in all breeds.

DISCUSSION

The assessment of camel milk nutritional composition is much important for its utilization in different sectors i.e. processing, therapeutical and cosmetic sectors. For instance, the acidity and pH levels of camel milk were observed in winter and summer season. It was noticed that acidity level was increased, and pH decreased during the summer season in all camel breeds. The camel milk composition varied due to several factors such as geographical condition, stage of lactation, season, health and age of the animal, feed given to

the animal, and breed (Muthukumaran *et al*., 2022). The results of other conducted studies regarding the pH and acidity of camel milk were in relevance to the findings of the current study (Bouhaddaoui *et al*., 2019; Khaskheli *et al*., 2005). A similar study revealed that the biochemical and physicochemical analysis of camel milk in Morocco showed the pH, dornic acidity, ash contents, and density in camel milk were 6.5, 15°D, 1.029 g/L and 8.06 g/L, accordingly. According to a reported study, camel milk contains higher concentrations of macronutrients like fats (34.09 g/L), proteins (32.4 g/L) and carbohydrates (49.8 g/L) (Bouhaddaoui *et al*., 2019). The fat percentage varies from 3.88-4.70 % in the milk of the dromedary camel (Faraz *et al*., 2020). The amount of fat found in the current study is also in line to the results of Abdalla *et al*. (2015) and Babiker and El-Zubeir (2014). The results of total solids in current study were similar to the findings of Mal *et al*. (2007). Dromedary camel milk showed 11.9 % of TS contents. The solid-not-fat is the part of milk includes all constituents except water and fat. Current findings of SNF % (8.15±0.009-8.83±0.015 %) are in line with the previous studies depicting 7.25 to 8.25 % of solid-not-fat contents reported by Mal *et al*. (2007) and Mal *et al*. (2006). The variation in the different contents in the current study was supposed to be due to the high temperatures, feeding pattern, water availability, forage type, season, variant breed, and management conditions which may alter the nutritional composition of the milk in all breeds (Faraz *et al*., 2021a, b). The fractions of different proteins such as lactose, CP, TP, casein, WP, NCN and NPN were observed in significant concentrations however the non-significant variations were observed among the selected breeds in current. A study depicted higher concentrations of total protein contents (2.15-4.90 %) in camel milk (Pastuszka *et al*., 2016). Maximum dried crude protein contents (25.01±1.99 %) were noticed in the Malgadhi breed and least in Desi breed. Another study depicted lower protein contents (2.48 %) in summer (August) and higher protein contents (2.9 %) in winter (January/December) (Haddadin *et al*., 2008). Casein is an important class of protein and contributes 61.8 to 88.5 % to the total proteins (Ereifej *et al*., 2011). In the current study, the highest casein percentages were observed in the Malgadhi breed and the least concentrations were found in the Desi breed. The casein percentage in different breeds of camel milk were similar to the results of Khaskheli *et al*. (2005), he depicted 1.63-2.76 % (on wet bases) of casein in camel milk. Whey proteins/serum protein constitutes about 20 to 25 % of total protein in milk. Peptidoglycan recognition protein, lactoferrin, Immunoglobulin, and serum albumin are major components of whey protein (Kappeler *et al*., 2004). Khaskheli *et al*. (2005) depicted 0.63-0.80 % of whey protein in dromedary camel milk, which was almost similar to the current results. Maximum contents of non-casein nitrogen (NCN) were observed in Desi (8.61±0.81 %) breed, followed by Marrechi (8.36±1.44 %), Malgadhi (8.10±1.27 %) and Sindhri (8.04±0.88 %) in current research. NCN result of the recent study in line with the results of Shamsia (2009). Moreover, Ahmad *et al*. (2008) found that NCN concentrations increased because of proteolysis.

The amino acids profile of the current study was in coherence with the study of El-Agamy (2006). Moreover, a comparative study of dry and raw camel milk was conducted to evaluate the amino acid profile and showed similar percentiles of amino acids (Aralbayev *et al*., 2019). The fatty acid profiling suggested that camel milk contains a variety of fatty acids in reasonable amounts from C4 to C21. This versatility in the fatty acid range might be due to the feeding pattern of camels in cholistan or dessert areas as they feed on wild grasses and herbs. Various studies conducted in different regions of the world exhibited the coherency in fatty acids percentages. In a study conducted in China, Fan and its research group work on fatty acid profiling of raw hand homogenized milk. The results of raw camel milk depicted that the trends of fatty acids percentages were almost similar to our study (Fan et al., 2023). Meribai *et al*. (2018) depicted that camel milk contained myristic acid (14.51±0.01 %), which was slightly higher than the results of the current study. Konuspayeva *et al*. (2004) resulted that camel milk contained plasmatic acid (34.65±3.91 %) and some other fatty acids in similar percentages. Another study reported the fatty acids profile was consistent with the current research, i.e., butyric acid (0.37±0.41 %), caproic acid (0.38±0.28 %), lauric acid (1.01±0.46 %), Myristic acid (12.83±4.11 %), palmitic acids (31.34±4.19 %) and oleic acid (21.40±5.40 %) (Konuspayeva *et al*., 2008). He *et al*. (2019) also depicted camel milk's similar fatty acid profile.

The significant concentrations of different minerals were observed in current study. The results of Elhassa et al. (2023) were contradicting the results of current study. They reported that lower concentrations of K, Na, and Ca i.e., (317.8±12.17 mg/100g), (215.6±8.39 mg/100g) and (154.6±2.3 mg/100g) respectively, in comparison to current results. The significant difference in concentrations of micromineral in camel milk of Sudan and Pakistan is might be due to grazing habits in nomadic and seminomadic production systems. However, the Fe contents were similar to Fe (2.981ppm) found in camel milk as reported in Saudi Arabia (El-Wabel, 2008). The potassium contents were in line with the study of Nnadozie *et al*. (2014) conducted in Nigeria. The study reported that the potassium concentrations were 1133.33 ppm in camel milk. The Cu results were found in coherence to the study of Shamsia (2009) reported Cu (0.19 ppm) in Egypt and Raziq *et al*. (2011) reported Cu (0.22 ppm) in Pakistan.

Conclusion: It was concluded that the nutritional composition varied significantly among the milk of different camel breeds due to their grazing habits, and seasonal, environmental, and geographical variations. The profiling of different nutrients of camel breeds would be helpful for further studies and can be

useful in the pharmaceutical and nutraceutical sectors according to their attributes.

Conflict of Interest: This work is original and not submitted or published in any other journal. Moreover, the authors have no potential conflict of interest.

Author contributions: AH Conceptualize and planned the research, MJA performed Data curation and Formal analysis, OMT developed the Methodology Plan, SWA applied Software, AF Validate, NA Investigate the raw data, MN work on writing original draft, ASK worked on editing of manuscript.

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