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Composition of camel milk and evaluation of food supply for camels in Uzbekistan

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Abstract

Background: In Uzbekistan, local people consumed camel milk products since ancient time. Camel milk is a source of energy and nutrients which are consumed as raw or fermented products and also provides various potential health benefits for human.

Methods: The data were collected during 2016–2018 by expeditions in desert and semi-desert regions of Uzbekistan. Three hundred sixty sheets of plants have been collected from those regions. Forty-two samples of raw camel milk were collected at two periods of the year: 21 samples during summer (June, July, and August) and 21 during winter (December, January, and February).

Results and discussion: Analysis of the composition of camel milk samples revealed the particular richness of camel milk in protein and fat content. Average values of protein and fat were found as 4.04 ± 0.36% w/v and 4.89 ± 0.26% w/v, respectively. Analysis of the composition of camel milk showed that protein, fat, and dry matter contents were comparatively lower in the summer period. Also, it was found that the average values of all components decreased from December to February and had a tendency to grow from June to August. This finding suggests a seasonal variation in available food supply. Investigation of an available fodder flora revealed that a fodder base consists of around 300 plants. Analysis of plant species revealed that 30 plants were widely used in traditional medicine.

Conclusion: Our results suggested that the healing benefit of camel milk can be connected with higher content of proteins including the various protective proteins and with secretion of the bioactive compounds from plants with medicinal properties via food.

Keywords: Camel milk, Composition of camel milk, Food supply, Medicinal plants, Uzbekistan

Introduction

Camel milk and its based products are considered to play an important role in daily food of rural communities in Asia, Africa, and the Middle East. For desert people, it is a source of energy and nutrients which are consumed as raw or fermented products [1, 2]. A distinctive feature of camel from any other domestic livestock species is that camel can produce more milk for a longer period of time in arid zones. The lactation period ranges from 12 to 18 months [3].

Many studies reported that camel milk provides various potential health benefits including angiotensin I-converting enzyme-inhibitory activity, hypocholesterolemic effect, hypoglycemic effect, and antimicrobial and hypoallergenicity effects [4, 5]. As evaluation of the healing properties, several studies were conducted regarding the camel milk composition, physicochemical characteristics, functionality, microbiological quality, and prevalence of some bacterial pathogens [6, 7]. It should be noted that fermentation of camel milk occurs naturally without prior heat treatment and without addition of starter cultures. Also, the absence of salmonella in raw camel milk presents a certain interest [8].

Uzbekistan is located in Central Asia. Over half of the Uzbek territory is covered by desert: the Kyzylkum, Ustyurt desert plateau, and Aralkum formed on the former bottom of the Aral Sea (Fig. 1). Kyzylkum is a huge desert in Central Uzbekistan, which stretches between the Amu Darya and Syr Darya on the territory

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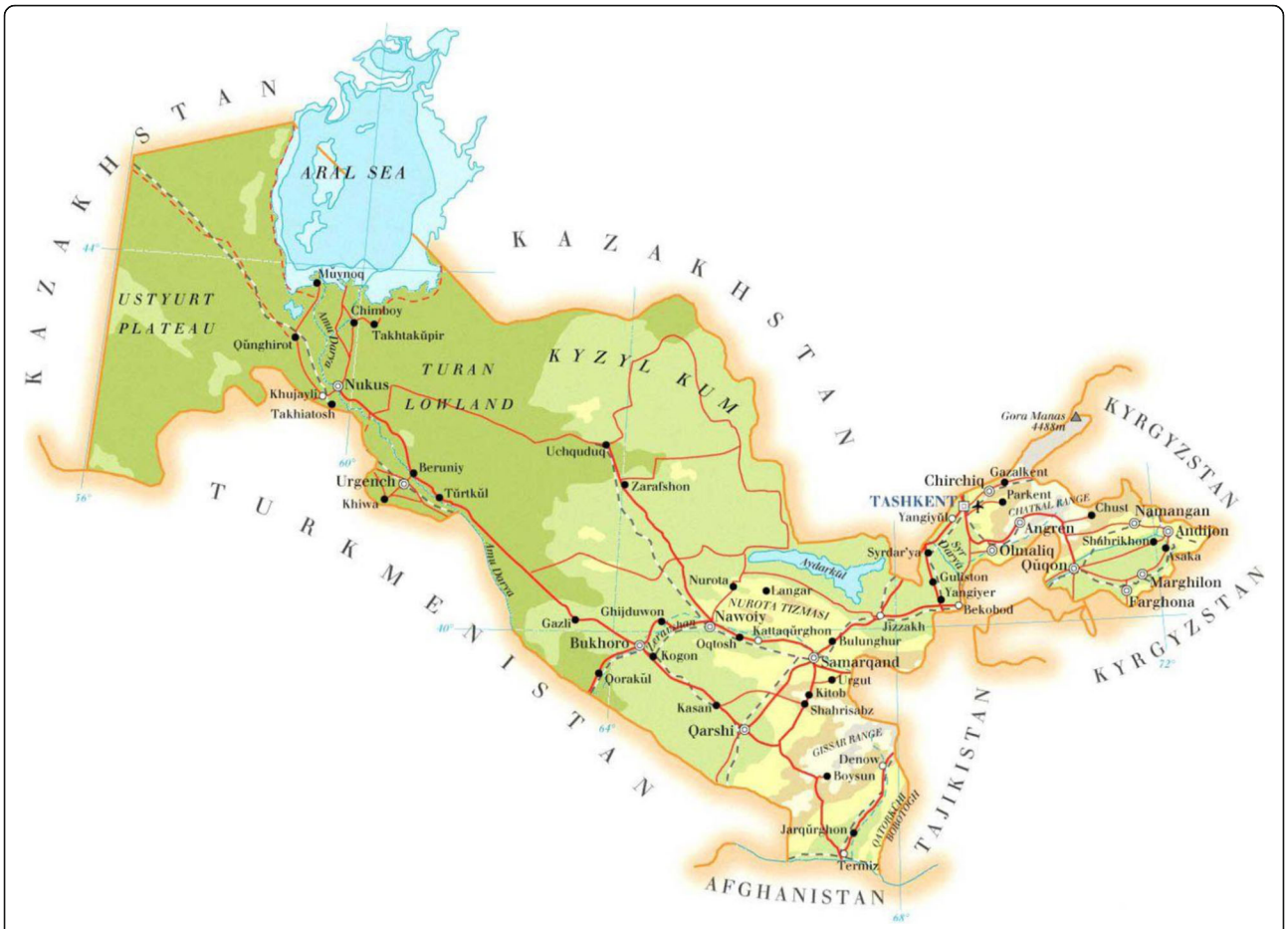

Fig. 1 Uzbekistan is located in Central Asia. Over half of the Uzbek territory is covered by desert: the Kyzylkum, Ustyurt desert plateau, and Aralkum formed on the former bottom of the Aral Sea. Kyzylkum is a huge desert in Central Uzbekistan, which stretches between the Amu Darya and Syr Darya on the territory around 300,000 km^2. Ustyurt desert is a plateau in Kazakhstan and Uzbekistan, located between Mangyshlak and the Bay of Kara-Bogaz-Gol in the west, the Aral Sea, and the Amu Darya delta in the east. The plateau occupies a total area of 200,000 km^2 and presents a clayey and rock debris desert

around 300,000 km^2. Ustyurt desert is a plateau in Kazakhstan and Uzbekistan, located between Mangyshlak and the Bay of Kara-Bogaz-Gol in the west, the Aral Sea, and the Amu Darya delta in the east. The plateau occupies a total area of 200,000 km^2 and presents a clayey and rock debris desert.

The difficult climatic conditions in the arid areas have contributed to a special approach to diet and which have been established in many generations of locals. Along with livestock such as horses, cows, donkeys, goats, and lambs, camel is the animal to adapt the most to such conditions. A camel, which was born and raised in the desert, can significantly lose the weight of its body under the influence of the sun, but, unlike other animals, does not lose its good condition. It can replenish the supply of liquid by drinking up to 180 l of water in one time and continue to stay quietly under the sun. In this way, the camel restores its shape and again saturates the body with the necessary moisture.

One of the first sources to describe products derived from camels was a “Canon”, which was written in 1012–1024 by Abu Ali Ibn Sina (Avicenna). Abu Ali Ibn Sina (980–1037) was the brilliant scientist of the Middle Ages. He was born on the territory of Uzbekistan, in the village of Afshona, near Bukhara. His legacy is 456 books; among them, 62 books were about medicine.

He wrote that any kind of milk causes blockages, especially in the liver, except for camel milk due to “low degree of curd” and due to the cleaning property of its water part. Cow milk has a lot of fat, sheep milk has “high degree of curd,” and camel milk has little fat and “low degree of curd,” which further follow mare and donkey milk. Camel milk has salinity. It was observed that camel milk is severely delayed in the stomach and in the upper parts of the abdominal cavity, longer than any other milk. Camel milk helps asthma and shortness of breath. Milk does not cause blockages in the liver, and whey from curd is useful against jaundice. Milk,

with the exception of camel milk, is harmful to the spleen and liver of patients who need a light diet. Camel milk is useful in many diseases of the spleen and liver and "moisturizes" the liver. It is very useful in hydrops, the excessive accumulation of serous fluid in tissues. Also, camel milk excites appetite. A description has been given of the integrated use of camel milk with other ingredients for the treatment of ulcers, tumors, etc.

The continued tradition of camel milk consumption and the manufacture of products based on it remain relevant today in daily life. In Uzbekistan, local people consumed camel milk products since ancient time as valuable source of nutrients. Along with consumption of camel milk, they prepare "Shubat." This camel milk product has various names in different parts of the world. It has substantial amounts of ethanol that is produced during milk fermentation [9]. It is popularly known as a beverage which is white, snappy due to its CO_2 production, and has a high degree of sourness. Another fermented milk product is known as "Qurt" (Fig. 2). It has a solid texture and salty taste and can be kept for a long time. Traditionally, "Qurt" is produced from a kind of strained yogurt called "Chaka" or "Suzma." It is obtained by drying "Qatiq," a local yogurt variety. The water is removed from this product and what remains is "Qurt" which is further dried to obtain a solid texture. Also, spices can be added to it. All procedures take 3–5 days in summer or 15–20 days in winter. In ancient times, it was the main protein source for people living in the desert area of Uzbekistan.

In Uzbekistan, two species of camels can be seen: a single-humped camel (*Camelus dromedarius*) and the two-humped camel, or a Bactrian (*Camelus bactrianus*). The single-humped camels is seen more often. It was proposed that probably feeding can explain the specific healing properties and composition of the camel milk [10]. The camels are grazed by changing location of the pastures. In flora of arid and semi-arid regions of Uzbekistan, more than 1000 species of vascular plants are growing [11, 12]. The majority of those plants have medicinal properties and found to have an application in traditional medicine.

The medicinal value of camel milk for the treatment of gastritis, asthma, stomach discomfort, tuberculosis, fever, urinary problems, and hepatitis were described in the study [5]. From these points of view, the presented research is focused on study of food supply for camels.

Materials and methods

Plant sampling

In this study, the data were collected during 2016–2018 by expeditions in desert and semi-desert regions of Uzbekistan which are located in Karakalpakstan. It is now mostly desert and occupies the whole northwestern end of Uzbekistan with an area of 164,900 km^2. During the field studies, the species of wild-growing plants which are eaten by the camels were investigated. Three hundred sixty sheets of plants have been collected from those regions, and these are stored as herbarium

Fig. 2 Qurt has a solid texture and salty taste and can be kept during a long time. Traditionally, "Qurt" is produced from a kind of strained yogurt called "Chaka" or "Suzma." It is obtained by drying "Qatiq," a local yogurt variety. The water is removed from this product and what remains is "Qurt" which further dried to obtain a solid texture

Table 1 Composition of camel milk by the sampling period

Component	Content, %w/v						Average, %w/v
	December	January	February	June	July	August	
Fat	5.2	5.15	5.01	4.57	4.61	4.82	4.89
Protein	4.47	4.33	4.27	3.62	3.71	3.82	4.04
Lactose	4.85	4.25	3.88	4.01	4.45	4.25	4.28
Ash	0.88	0.9	0.75	0.69	0.68	0.73	0.77
Dry matter	15.56	14.6	14.4	13.65	12.64	12.83	13.95

specimens in the Central Herbarium of the Institute of the Botany in the Uzbekistan Academy of Sciences and Research Institute of Natural Sciences, Karakalpakstan branch of the Academy of Sciences of Uzbekistan.

Milk sampling

Milk samples were taken from milk mixture collected from breeders of the different regions of Karakalpakstan. A total of 42 samples of raw camel milk were collected at 6 different periods of the year: 21 samples during summer (June, July, and August) and 21 during winter (December, January, and February). The collected milk was obtained by hand milking of camels in the field condition. The fresh samples of camel milk were divided on two portions. The first portions were used to test the physical-chemical analysis such as pH, acidity, and density. The second ones were kept in cold conditions for milk content analysis.

Physicochemical analysis of camel milks

The pH of camel milk samples was measured by using a digital pH meter (FiveEasy™ pH/mV Meters, Mettler Toledo, Greinfensee, Switzerland), and their titratable acidity was determined based on the accepted methodology in Association of Official Analytical Chemists (AOAC) [13]. Sample densities were measured by using a digital density meter (Mettler Toledo 30 PX, Greinfensee, Switzerland). For determination of dry matter, fat content, lactose, and ash, AOAC methods were also used [13]. Protein content was determined by the standard Kjeldahl method [13]. Each value represents the results of triplicate experiments.

Results and discussion

Many factors have an influence on the composition of camel milk such as the difference of geographical origin, physiological stage, feeding conditions, and seasonal variations [10]. In accordance with the study, the average amount of components of camel milk was found as protein—3.4%, fat—3.5%, lactose—4.4%, and ash—0.79%, while water covers 87% [4].

The obtained results of physicochemical parameters and composition of the 42 samples of raw camel milk showed that values of the pH and titratable acidity ranged from 6.22 to 6.54 and 0.15 to 0.18% w/v, respectively. The average values of milk sample density were calculated as 1.029 ± 0.003 g/cm^3 in winter and 1.022 ± 0.003 g/cm^3 in summer season. The frequency of water intake by camels had an influence on camel milk densities [7]. Average values of the component composition of camel milk samples were found as protein—4.04 ± 0.36% w/v, fat—4.89 ± 0.26% w/v, lactose—4.28 ± 0.34% w/v, ash—0.77 ± 0.09% w/v, and dry matter—13.95 ± 1.12% w/v (Table 1). Estimation of values of fat, protein, lactose, and dry matter in camel milks by an analysis of variance revealed that all results were statistically significant (p value < 0.05). The results in Table 1 showed that fat, proteins, and dry matter contents of camel milk samples were comparatively lower in summer period (June–August). This finding of seasonal variation of camel milk composition was in accordance with a number of studies [14, 15]. Comparison of the average values of dry matter in winter and summer season revealed an inverse relationship between dry matter in camel milk and water intake by camels. It was found that the

Table 2 Main diet of camels on seasons

№.	Season	Plants
1	Spring	*Bromus tectorum* L., *Poa bulbosa* L., *Chorispora tenella* (Pall.) DC., *Artemisia terrae-albae* Krasch., *A. pauciflora* Web., *Astragalus villosissimus* Bunge, *Kraschennikovia ewersmanniana* (Stschegl ex Lonsinsk.) Grub., *Kraschennikovia ceratoides* (L.) Gueldenst.
2	Summer	*Morus alba* L., *M. nigra* L., *Peganum harmala* L., *Chorispora tenella* (Pall.) DC., *Astragalus villosissimus* Bunge, *Bromus tectorum* L., *Salsola richteri* (Moq.) Kar. ex Litv., *Salsola paletzkiana* Litv., *Ephedra distachya* L., *Andrachne rotundifolia* C. A. Mey., *Dodartia orientalis* L., *Cousinia* sp., *Artemisia terrae-albae* Krasch, *Smirnowia turkestana* Bunge, *Alhagi pseudalhagi* (Bieb.) Fisch., *Chenopodium album* L., *Climacoptera transoxana* (Iljin) Botsch., *Ferula foetida* (Bunge) Regel.
3	Fall and winter	*Peganum harmala* L., *Artemisia terrae-albae* Krasch., *Ferula foetida* (Bunge) Regel, *Bromus tectorum* L., *Astragalus villosissimus* Bunge, *Haloxylon persicum* Bunge ex Boiss.& Buhse, *Haloxylon ammodendron* (C. A. Mey.) Bunge, *Climacoptera transoxana* (Iljin) Botsch., *Halocnemum strobilaceum* (Pall.) Bieb., *Triticum vulgare* L., *Zea mays* L., *Glycyrrhiza glabra* L., *Alhagi pseudalhagi* (Bieb.) Fisch.), *Halostachys belangeriana* (Moq.)Botsch., *Elaeagnus orientalis* L., *E. oxycarpa* Schlecht.

average values of all components decreased from December to February and had a tendency to grow from June to August. This finding suggests a seasonal variation in the available food supply. Table 1 also indicated that the content of protein and fat were higher in comparison with the average amount of components of camel milk which were described in the study [4].

In this aspect, it should be noted that camel milk is enriched with various protective proteins such as lysozyme, lactoferrin, lactoperoxidase, peptidoglycan recognition proteins, and immunoglobulin G and A which exert antibacterial, antiviral, antifungal and antiphrastic activity, immunological properties, growth promotion activity, and anti-tumor activity [16]. Another point is

Table 3 The wild-growing plants with medicinal properties in food supply of camels

№	Latin name	Local name	Vegetation period	Application in traditional medicine
1	*Alhagi pseudalhagi* (M. Bieb.) Fisch.	Jantak	May–June, July–August	Blood-forming organs and gastrointestinal tract
2	*Ammodendron conollyi* Bunge ex Boiss.	Qoyan suyek	April–May, October	Respiratory system
3	*Artemisia terrae-albae* Krasch.	Zhoosan	May–September, October	Gastrointestinal tract
4	*Artemisia vulgaris* L.	Shuvoq	May–September	Atherosclerosis, anemia, gastrointestinal tract stomach ulcer, at epilepsy, neurasthenia, nervous insomnia, and alkologolizm
5	*Asparagus inderiensis* F.K. Blum ex Pacz.	Shop	May–June, July–August	Rheumatism
6	*Atriplex aucheri* Moq.	Oshe, alabuta	June, August	Gastrointestinal tract and urogenital system
7	*Atriplex dimorphostegia* Kar. & Kir.	Shop	April–May, June–July	Laxative remedy
8	*Bassia hyssopifolia* (Pall.) Kuntze	Shop	May–June, August	Dermatological problems
9	*Calligonum aphyllum* (Pall.) Guerke	Qizil juzgun	May, June	Gastrointestinal tract
10	*Calligonum caput-medusae* Schrenk	Narjuzgun	May, July	Gardiovascular system
11	*Carex physodes* M. Bieb.	Ren	March, April–June	Cardiovascular and gynecological diseases
12	*Consolida camptocarpa* (Fisch. & C.A. Mey.) Nevski	Shop	May, June–July	Cardiovascular system
13	*Convolvulus hamadae* (Vved.) Petrov	Aq peshek	April–May, July–October	Gastrointestinal tract
14	*Cynodon dactylon* (L.) Pers.	Azhiriq	July, August	Oncology
15	*Ferula foetida* (Bunge) Regel	Sasiq geuerek	May–August	Gastrointestinal tract, respiratory system and cancer
16	*Glycyrrhiza glabra* L.	Boyan	June–August	Gastrointestinal tract and respiratory system
17	*Halostachys belangeriana* (Moq.) Botsch.	Qarabaraq	July–October	Hypotension
18	*Haloxylon aphyllum* (Minkw.) Iljin	Qara sexeul	May–October	Cardiovascular disease, hypertension, and blood disorders
19	*Heliotropium acutiflorum* Kar. & Kir.	Shop	May, June	Blood-forming organs
20	*Lachnoloma lehmannii* Bunge	Shop	April, May	Cardiovascular system
21	*Limonium otolepis* (Schrenk) Kuntze	Kermek	April–June, September	Gastrointestinal tract and oral cavity
22	*Medicago lupulina* L.	Zhabayi zhonyshka	May, June	Blood-forming organs
23	*Salicornia europaea* L.	Shor sora	June, July	Urinogenital system and oncology
24	*Salsola arbuscula* Pall.	Boyalysh	May–June, September–October	Cardiovascular system and gastrointestinal tract
25	*Salsola dendroides* Pall.	Karaganda, aq sora	June–July, September–October	Urogenital and hematologic systems
26	*Salsola richteri* (Moq.) Kar. ex Litv.	Aq sherkez	April–May, September–October	Cardiovascular and urogenital system
27	*Smirnowia turkestana* Bunge	Shop	April–May, May–June	Urogenital and respiratory system
28	*Spergularia marina* (L.) Griseb.	Shop	April–June, June	Urogenital system
29	*Sphaerophysa salsula* (Pall.) DC.	Partyldauik	May, August	Cardiovascular system
30	*Suaeda altissima* (L.) Pall.	Shop	June, August	Cardiovascular system

peptides in camel milk. Camel's peptide hormone, insulin, does not form coagulum in the acids environment of the stomach like the insulin of other mammals and has a good potential and helps in the reduction of insulin requirement in type I diabetic patients [17]. Regarding the fat content, it should note that the average diameter of fat globules in camel milk is three times less than that in buffalo milk. It indicates a high state of dispersion of fat in milk and is more digestible for humans [18].

Analysis of the dispersion of the values found for component composition among camel milk samples proposed influence of various factors such the health status, herd management practices, environmental conditions, and food supply. All mentioned factors are interconnected and probably food supply plays the most important role and can explain the particular richness of camel milk.

The obtained data of a poll of owners of camels and shepherds revealed that camels are grazed in extensive territories from March to October feeding on the wild-growing plants and constantly moved from one place to another. Plant diversity of available fodder flora, growing in the investigated period, showed that the fodder base consists of around 300 plants. Table 2 shows plants in the main diet of camels on seasons. Analysis of plant species revealed that 30 plants are widely used in traditional medicine.

Table 3 shows the wild-growing herbs with healing properties in the food supply of camels. The presented plants cover a wide range of medicinal properties which are applied for the treatment of the cardiovascular diseases, diseases of the digestive tract, respiratory, urogenital and hematologic systems, and others, since ancient time in traditional medicine. Among them are *Artemisia terrae-albae* Krasch., *Salsola richteri* (Moq.) Kar. ex Litv., *Smirnowia turkestana* Bunge, *Ferula foetida* (Bunge) Regel, *Alhagi pseudalhagi* (Bieb.) Fisch., *Halostachys belangeriana* (Moq.) Botsch. which are included in the main diet and that one makes more than 80% of the food supply which are eaten by camels (Figs. 3, 4, and 5). The historical experience of application of these plants in traditional medicine is confirmed by many investigations which are directed on the discovery of the bioactive compounds. Some phytochemicals with helpful cardiovascular effects have been isolated from *Ferula* species [19]. *Alhagi pseudalhagi* (Bieb.) Fisch. is used as a remedy for rheumatic pains, various types of gastrointestinal discomforts, urinary tract diseases, and liver diseases [20]. Aqueous extract of *Cynodon dactylon* (L.) Pers. exerted its good capability for wound healing activity [21]. Immunomodulatory and antioxidant activities were found by using *Artemisia vulgaris* L. [22, 23]. The medicinal properties of other presented plants in Table 3 were also described in our previous studies [11, 12]. These plant species and their bioactive agents with therapeutic properties could be secreted in milk and milk-based products. It can be seen as one of the points of the health benefit of camel milk [24]. On the other hand, these plants can have an influence on the health

Fig. 3 *Ammodendron conollyi* Bunge ex Boiss. blooms in April and fructifies in May. Picture taken in May 2017, in Kyzylkum Desert. In traditional medicine, it is used for a treatment of respiratory system. Roots of sand acacia have traditionally been used by the local population to color wool by yellow. Wood is used as fuel and this plant is a good anchor for sand

Fig. 4 *Ferula foetida* (Bunge) Regel, blooms in April–May and fructifies from May to June. Picture taken in June 2017, in Kyzylkum Desert. Ferula foetida (Bunge) Regel has an application as a remedy against the gastrointestinal tract and respiratory system problems in traditional medicine. By interview of healers, it was revealed the milled young ferula shoots and its mix with acidic milk are used to treat tumors and syphilis. Alcohol tincture of ferula resin and emulsions are used in the treatment of asthma, convulsions, and nervous diseases.

status of camels, and therefore, on the composition of camel milk as well.

Conclusion

The results of the current study showed the particular richness of camel milk in protein and fat content. Analysis of plants in main diet of camels revealed the presence of the wild-growing plants with medicinal properties. This finding suggests that the healing benefit of camel milk can be connected with content of the various protective proteins and secretion of the bioactive compounds from plants with medicinal properties via

Fig. 5. *Smirnowia turkestana* Bunge. The plant blooms between April and May, a period of fruiting between May and June. The plant was photographed in May 2017, on the sands of Kyzylkum. In traditional medicine, Smirnowia turkestana Bunge is used as a remedy for treatment of urogenital and respiratory system

food. Undoubtedly, other factors such as the geographical origin, physiological stage, and seasonal variations have an influence on the composition of camel milk and its properties.

Camel milk and its based products have a long-time tradition as a dairy food with healing properties in Uzbekistan. More investigations are still required for understanding the healing benefit of camel milk on human. The above reported information suggests a good perspective in development of the food market in Uzbekistan based on camel milk.

Abbreviation
AOAC: Association of Official Analytical Chemists

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VVP contributed 50% of the work. OKK contributed 30% of the work. GJA contributed 10% of the work. EBM contributed 10% of the work. All authors read and approved the final manuscript.

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Competing interests
The authors declare that they have no competing interests.

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