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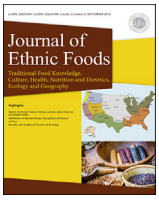

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Original article

Honey in traditional cuisine of Uzbekistan and analysis of melliferous flora of Karakalpakstan

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ABSTRACT

Background: Honey and honey based-products have a long tradition as a food source in Uzbekistan. The melliferous flora is one of the main resources for honey production. In this study, we present a review of some honey-based foods made in Uzbekistan and on the current state of the wild melliferous flora of Karakalpakstan, which is located in the northwestern part of Uzbekistan. This is the first such statistical study in a region in Uzbekistan after nearly 30 years.
Methods: Field studies were carried out between 2013 and 2015. The melliferous plants were collected on territory of Karakalpakstan. More than 450 samples of plants have been collected from this region.
Results: According to the literature, in 1978, there were 68 species of melliferous plants belonged to 32 genera of 19 families. In this study on the territory of Karakalpakstan, we found 206 species of wild vascular plants, which belonged to 134 genera of 46 families, that have commercial value for beekeeping. Among the 206 species of wild melliferous plants identified, 196 species are considered to have medicinal properties. An analysis of 13 leading families containing five or more types of melliferous plants showed that these families comprise 72.05% of the total melliferous flora.
Discussion: The obtained data on the sequence of flowering of wild melliferous plants show that the vegetation period starts from March. After June, the bees start to collect honey from the cultivated species. These data suggest that the melliferous flora of Karakalpakstan has a fairly powerful resource base, which with a right approach can help us to get dozens of tons of high-quality, environmentally friendly honey, catering to all needs of Uzbekistan.

1. Introduction

Honey is a healthy foodstuff used for improving human nutrition and boosting immunity. The composition and source of honey provide information about its biochemical properties. The biochemical content of honey has been investigated in many studies [1–3]. In recent years, there has been an increasing interest in utilizing natural antioxidants in human diet due to the possible negative effects of the synthetic food additives on human health [4–7].

Honey and honey-based products have a long tradition as a food source in Uzbekistan. Since ancient times, in the East, honey was considered as God's gift and used as a prophylactic food for treating many diseases. The most well-known honey-based foods are the so-called East sweets (e.g., *kozinaki*, *halva*, *chak-chak*, and others). *Kozinaki* is prepared by frying caramelized peanuts or sunflower seeds in honey (Fig. 1). Soft sesame *halva* is made from sugar syrup, honey, egg whites, and sesame seeds. Solid sesame *halva* is made from pulled sugar, which is repeatedly stretched to give it a white or other color, depending on the place it is prepared (Fig. 2). *Chak-chak* is made from unleavened dough cut and rolled into hazelnut-sized balls, which are then deep-fried in oil. Optionally, hazelnuts or dried fruits are added to the mixture. The fried balls are stacked in a mound in a special mold and drenched with hot honey. After

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Fig. 1. *Kozinaki* is made by frying caramelized peanuts or sunflower seeds in honey.

Fig. 2. Solid *halva* (Samarkand city, Uzbekistan). Sesame *halva* is made from sugar syrup, honey, egg whites, and sesame seeds.

Fig. 3. *Chak-chak* is made from unleavened dough cut and rolled into hazelnut-sized balls, which are then deep fried in oil. The fried balls are stacked in a mound in a special mold and drenched with hot honey. If the dough is fried as noodles, *chak-chak* is called *bukhara kalawa* (Uzbekistan).

cooling and hardening, *chak-chak* may be optionally decorated with hazelnuts and dried fruits. If the dough is fried as noodles, *chak-chak* is called *bukhara kalawa* (Fig. 3). Because of the addition of honey, which has antibacterial and preserving properties, one of the main features of these desserts is that the taste and quality of these products can be preserved for up to 3 months at room temperature. This is very convenient and useful, especially during periods of hot weather.

The first and the complete description of honey was given by Abu Ali ibn Sino (980–1037). He was born in the territory of Uzbekistan, near Bukhara city. He wrote 456 books, among which 62 were on medical topics. According to him, honey is the most valuable product with medicinal properties and one of the most important means of prolonging life. In his fundamental work *Canon of Medicine*, he provides around 150 recommendations for using honey, either in its pure form or mixed with various food ingredients. Honey can be mixed with dried fruits, such as a dried apricots or dried grapes, as well as with different nuts and seeds, such as *Amygdalus bucharica* L. *Amygdalus communis* L., *Armeniaca vulgaris* Lam., *Juglans regia* L., *Pistacia vera* L., either separately or all mixed together. Such products are not only tasty dishes, but also have disease-preventive properties and help us to perform normal daily activities during periods of lack of vitamins, especially during the early spring period. The combination of honey with vegetables (e.g., beet, pumpkin) has strong medicinal and disease-preventive properties, especially those related to the respiratory system.

In this regard, it should be also noted that honey bee (*Apis*) has a long and close relationship with humans. Traditional studies have suggested that the center of origin for *Apis* was Asia, the region that has the largest number of living species [8,9]. The hive and the honey produced by these species have fascinated and nourished human populations and civilization for millennia and the honey bee has been intricately woven into most cultures. Naturally, once domesticated, honey bees were actively moved as part of human migrations, and eventually their pollination services became recognized and held in equal importance to the honey harvested as a food and medicine.

Nowadays, the main breed of honey bee in Uzbekistan is *Apis mellifera carpathica*. One of the important biological features of carpathian bees is their peaceful behavior. This bee is winter hardy, which allows them to successfully come back from a long dormant period in a moderate zone. Families of this breed differ in intensive spring development. Bees collect honey from flowers of all plants, from weak to strong, and in all seasons.

Honey is known to be rich in both enzymatic and nonenzymatic antioxidants, including glucose oxidase, catalase, ascorbic acids, flavonoids, phenolic acids, carotenoid derivatives, organic acids, Maillard reaction products, amino acids, and proteins. The geographical and botanical origins have a great influence on the biochemical composition of honey and consequently on its biological properties [10–12].

According to the literature, the flora of Uzbekistan contains more than 1,000 species of melliferous plants [13,14]. However, the last statistical analysis was performed almost 30 years ago (1978) [13], and since then many things have changed. The population of the country has increased by almost two times. Besides, in these 30 years, a large number of new residential buildings and industrial facilities have been built, the network of roads and railways has expanded significantly, and vast areas of land have experienced desertification. In addition, salinization of soils associated with the drying up of the Aral Sea has been observed. Thus, examining the current state of the wild melliferous flora of Uzbekistan is the purpose of this study.

2. Materials and methods

The Republic of Karakalpakstan is located in the northwestern part of Uzbekistan, occupying about 37% of its area. It occupies an area of 167,100 km^2 and has a population totaling 1,704,000. Karakalpakstan is mostly deserted and is located near the Aral Sea, in

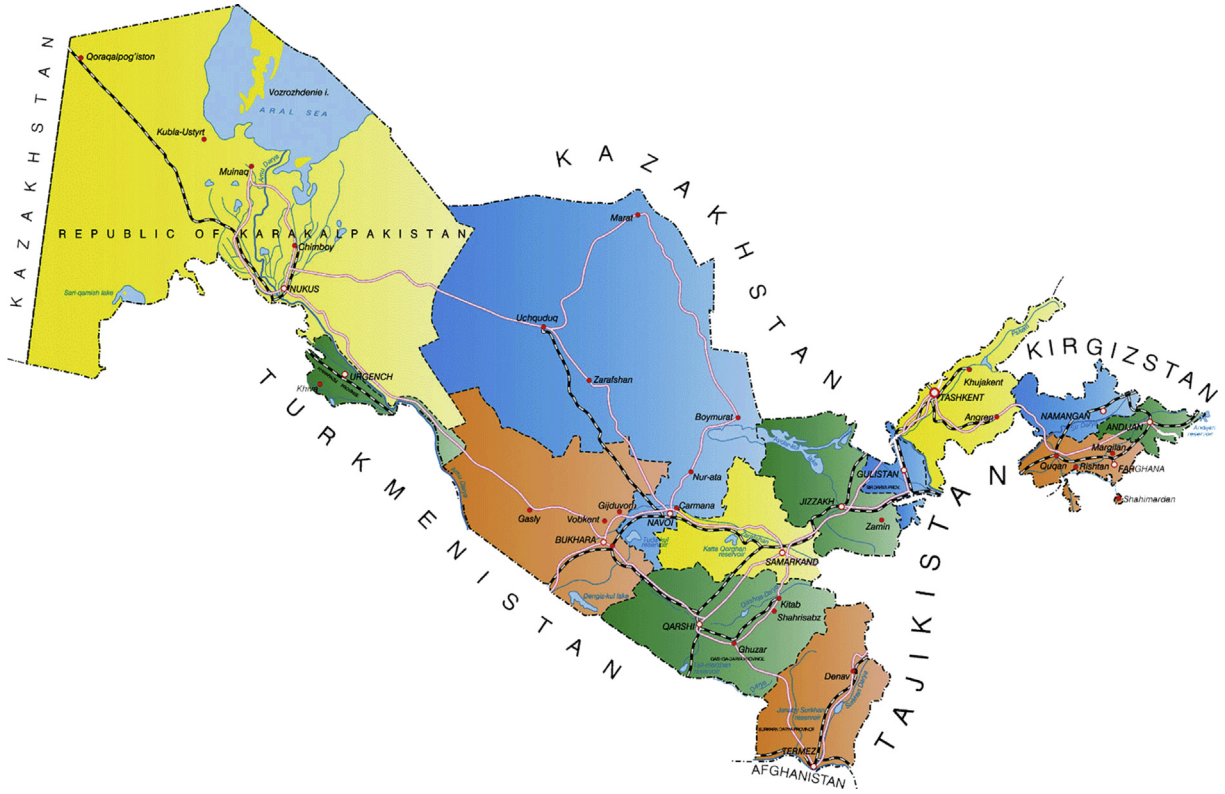

Fig. 4. Karakalpakstan occupies the whole northwestern region of Uzbekistan. It occupies an area of 167,100 km^2 and has a population totaling 1,704,000. Karakalpakstan is mostly deserted and is located near the Aral Sea, in the lowest part of the Amu Darya basin.

the lowest part of the Amu Darya basin. It is surrounded by deserts—The Kyzyl Kum desert on the East and the Kara Kum desert on the South (Fig. 4).

Field studies were carried out between 2013 and 2015. The melliferous plants were collected on the territory of Karakalpakstan, which is economically valuable in terms of the availability of large areas occupied by vegetation, the presence of access roads, wells, etc. More than 450 samples of plants have been collected from this region, and these are stored as herbarium specimens in the Central Herbarium of the Institute of the Gene Pool of Flora and Fauna in the Uzbekistan Academy of Sciences and Research Institute of Natural Sciences, Karakalpakstan branch of the Academy of Sciences of Uzbekistan.

3. Results

The total biomass of plants, and all parts thereof, including specific substances that occur as a result of their primary and secondary metabolism, represents a renewable natural resource. Plants serve multiple purposes, primarily as a natural source of nutrients, and indirectly for the many other needs of the human population. Flora is a collection of all plant species of an area. Plants of the Uzbekistan flora act as sources of medicinal substances and chemical compounds, food for people and animals, and source of seed and planting material, oil, etc. Almost all types of fruit trees, a large number of medicinal plants, and many vegetable plants are important sources of honey production. According to the literature, there are about 1,110 species of plants in Karakalpakstan [15]. However, wild melliferous plants are not studied enough, and thus, only fragmentary information is available so far. According to Yerzhepov [16], there are 68 species of melliferous plants belonging to 32 genera of 19 families.

During this study on the territory of Karakalpakstan, we found 206 species of wild vascular plants belonging to 134 genera of 46 families that have commercial value for beekeeping. Among these 206 species of melliferous plants, 196 are considered medicinal. The medicinal applications of some plants were described in our previous work [17]. Results of the analysis of 13 leading families containing five or more types of melliferous plants, which constitute 72.05% of the total melliferous flora, are presented in Table 1.

In this analysis, 11 genera of 10 families comprise 57 species. The mass of these species constitute 27.49% of the total number of melliferous plants in the study region (Table 2).

As the table shows, a majority of melliferous plants belong to *Artemisia* L.—*A. annua* L., *A. diffusa* Krasch. ex Poljak., *A. juncea* Kar. & Kir., *A. terrae-albae* Krasch., *A. tournefortiana* Reichenb., and *A. turanica* Krasch. These species cover a large area and play an

Table 1
Leading families of the melliferous flora of Karakalpakstan.

No.	Families	Genera	Species	%
1	Asteraceae Dumort.	19	33	16
2	Fabaceae Lindl.	16	29	14
3	Brassicaceae Burnett	18	27	13.1
4	Polygonaceae Juss.	3	8	3.86
5	Tamaricaceae Link	1	8	3.86
6	Poaceae Barnhart	7	7	3.38
7	Salicaceae Mirb.	2	6	2.9
8	Rosaceae Juss.	4	6	2.9
9	Caryophyllaceae Juss.	2	5	2.41
10	Zygophyllaceae R.Br.	2	5	2.41
11	Convolvulaceae Juss.	2	5	2.41
12	Cuscutaceae Dumort.	1	5	2.41
13	Lamiaceae Lindl.	4	5	2.41
	Total	81 (60.4%)	149 (72.3%)	72.05

Table 2
Generic range of melliferous plants.

No.	Families	Genera	Species	%
1	Asteraceae Dumort.	*Artemisia* L.	9	4.34
2	Tamaricaceae Link	*Tamarix* L.	8	3.86
3	Brassicaceae Burnett	*Strigosella* Boiss.	5	2.41
4	Polygonaceae Juss.	*Calligonum* L.	5	2.41
5	Cuscutaceae Dumort.	*Cuscuta* L.	5	2.41
6	Fabaceae Lindl.	*Astragalus* L.	5	2.41
		Alhagi Hill	4	1.93
7	Convolvulaceae Juss	*Convolvulus* L.	4	1.93
8	Plantaginaceae Juss.	*Plantago* L.	4	1.93
9	Salicaceae Mirb.	*Salix* L.	4	1.93
10	Zygophyllaceae R. br.	*Zygophyllum* L.	4	1.93
	Total	11 (8.14%)	57 (27.66%)	27.5

important role in beekeeping. Only one species, *Artemisia serotina* Bunge, is rare for this region.

Other important plants are species of the genus *Tamarix* L., which are ubiquitous and have significant reserves of biomass. In addition, the following species play a significant role in beekeeping: *Ferula foetida* (Bunge) Regel, *Alhagi canescens* (Regel) Shap., *Alhagi pseudalhagi* (Bieb.) Fisch., *Acroptilon repens* (L.) DC., *Cichorium intybus* L., *Convolvulus arvensis* L., *Convolvulus hamadae* (Vved.) V. Petrov, *Capsella bursa-pastoris* (L.) Medik., *Malva neglecta* Wallr., *Capparis herbacea* Willd., *Ammodendron conollyi* Bunge, *Ammothamnus lehmannii* Bunge, *Centaurea squarrosa* Willd., *Strigosella grandiflora* (Bunge) Botsch., *Isatis violascens* Bunge, *Isatis minima* Bunge, and *Glycyrrhiza glabra* L. [18] (Figs. 5–8).

The flower of each plant species is a unique combination of shape, size, color, odor, and other characteristics, which aid in attracting pollinators. Although there exists a mutual relationship between these plants and the pollinators (bees), they have different interests: the plants want to ensure successful reproduction through pollination, which leads to the formation of the next generation in the form of seeds, while the animals feed on these plants for feeding itself or their offspring. This mutual relationship developed during the evolution of glands secreting nectar (nectaries). The pollinators exchange pollen between individuals of the same species, which allows the plants to fertilize and transfer genetic materials, thereby giving the offspring a greater adaptive capacity.

The phenology of flowering, nectar production, and pollen supply in a particular area depend on the presence of the vegetation type and the length of the flowering period of the available plant species. Besides, the type of vegetation depends on the physicochemical characteristics of soil (pH, chemical composition, drainage, etc.), climatic conditions (minimum and maximum daily and seasonal temperature, air humidity, precipitation), and other factors.

One of the main reasons for the rich biodiversity can also be explained by the altitudinal zonation of a relief where each high-rise belt is represented by unique climate and weather conditions, soils, and various other factors supporting the growth of plants. In Uzbekistan, the deserts, steppes, and mountains adjoin among themselves. Vegetation cover adapted to drought climates grows in deserts and steppes. Along the coasts of rivers and lakes, the riparian forest is widespread. Mountains have a very rich biodiversity. It is possible to identify several levels/areas on which a unique flora grows. The difficult reliefs of mountains and its slopes with various expositions, each of which receive varying levels of illumination and are exposed by wind of varying intensity and humidity, have a strong impact on the distribution of different plant species. In addition, the structure of soil, which is directly dependent on the steepness of slopes and altitudinal zonation, also substantially defines a diversity of a vegetable cover [19].

Fig. 5. *Alhagi pseudalhagi* (Bieb.) Fisch. plays a significant role in beekeeping in the region but suffers from development of virgin lands for agricultural purposes (neighborhood of Muinak city).

Fig. 6. *Capparis herbacea* Willd. plays a significant role in beekeeping in the region (neighborhood of Nukus city).

Fig. 7. *Ferula foetida* (Bunge) Regel is ubiquitous and has a significant role in beekeeping in the Ellikkala region of Karakalpakstan.

Fig. 8. *Ammodendron conollyi* Bunge is a ubiquitous plant in Kyzylkum desert that is used for beekeeping.

The data obtained on the sequence of flowering of wild melliferous plants show that the vegetation period starts from March (Table 3). After June, the bees start to collect honey from the cultivated species, such as cotton (*Gossypium hirsutum* L.), clover (*Trifolium arvense* L.), apricot (*A. vulgaris* Lam.), jiyda (*Elaeagnus angustifolia* L.), and peach [*Prunus persica* (L.) Batsch].

By analyzing the dynamics of change of a vegetable cover of the Republic of Karakalpakstan over the last decades, it is possible to note a reduction in the areas of wild-growing thickets of the majority of plant species, especially *A. pseudalhagi* (Bieb.) Fisch. and *G. glabra* L. *A. pseudalhagi* (Bieb.) Fisch. suffers from development of virgin lands for agricultural purposes. Cotton crops occupy a majority of the planted area, and honey obtained from cotton flowers (*Gossypium arboreum* and *Gossypium herbaceum*) constitutes more than 50% of the total regional output. Honey from cotton is creamy with light amber color and has a mild, pleasant, flowery taste, without excessive acidity.

Table 3
Periods of plant flowering.

No.	Plant name	Period of flowering
1	*Populus nigra* L.	Mar–Apr
2	*Roemeria refracta* DC.	Mar–Apr
3	*Populus ariana* Dode	Mar–Apr
4	*Ferula foetida* (Bunge) Regel	Mar–Apr
5	*Ammodendron conollyi* Bunge	Apr–Jul
6	*Capparis herbacea* Willd.	Apr–Jul
7	*Karelinia caspia* (Pall.) Less.	Apr
8	*Halimodendron halodendron* (Pall.) Voss	Apr
9	*Fumaria vaillantii* Loisel.	Mar–Jun
10	*Elaeagnus turcomanica* N. Kozl.	May
11	*Elaeagnus oxycarpa* Schlecht.	May
12	*Alhagi pseudalhagi* (Bieb.) Fisch.	May
13	*Glycyrrhiza glabra* L.	May–Jun
14	*Medicago sativa* L.	May
15	*Althaea armeniaca* Ten.	Jun

During survey interviews, the natives of the study region said that they prefer the darker, more saturated honey. They believe that the darker honey has better healing properties than the lighter ones derived from such species as *Alhagi canescens* (Regel) Shap., *A. pseudalhagi* (Bieb.) Fisch., and *G. hirsutum* L. They suggest that the dark honey contains many biologically active substances, as it is collected from many different species of plants. Thus, honey is an important component of many drugs, dietary products, or cosmetics. Pure honey is used to treat coughs and colds. Furthermore, honey is used to prepare an ointment with other plant materials, which can be applied on various wounds as it has good antiseptic properties and prevents the growth of germs and bacteria. In addition, a mixture of honey, butter, and milk is used in the treatment of tuberculosis and other respiratory diseases.

4. Discussion

Our research on the flora and vegetation of Karakalpakstan has shown that this region has favorable conditions for beekeeping. The taste, color, and biochemical composition of the honey collected during different seasons will differ based on its origin. During different seasons, one melliferous herb is replaced by another, and therefore, the timing and place where these plants blossom play an important role in maximizing honey collection. It is necessary to maintain the areas with suitable conditions for honeybee colonization during the whole vegetation period, that is, from early spring to late fall. We also obtained some valuable information about the sequence of flowering of melliferous plants, which would allow beekeepers to appropriately arrange bee colonies (honeybee pasture) in the most favorable area (e.g., melliferous plants rich) to obtain honey and honey bee products of a good quality. Under the influence of weather conditions, plants change the flowering interval every year. Therefore, it will be necessary to collect multiyear data on the start and duration of a flowering phenophase of melliferous plants to make a phenological map of an area in detail.

The data obtained in this study suggest that honey collected from wild melliferous flowers has a good perspective in development of its production in Uzbekistan along with production of honey from cotton, which represents a uniflora honey. A variety of grades of honey are available that vary in their healing properties, which were described and tested since the ancient times and eventually became a traditional food. In this aspect, a particularly important fact is a need to preserve the environment that can sustain bee colonies. As one of the priorities in the field of environmental protection, especially melliferous flora, conservation and preservation of habitats and diversity of wild flora are suggested to improve numerical magnification and spatial expansion.

Thus, the wild melliferous flora of Karakalpakstan has a fairly powerful resource base, which with a right approach can help us to get dozens of tons of high-quality, environmentally friendly honey, catering to all needs of Uzbekistan.

Conflicts of interest

The authors have no conflicts of interest to declare.

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