




Identification and frequency of consumption of wild edible plants over a year in central Tunisia: a mixed-methods approach

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Abstract

Objective: To identify wild plants used as food and assess their frequency of consumption over a year in a region of Tunisia where agriculture is undergoing a major transformation from smallholder farming to an intensive high-input agricultural system.

Design: Qualitative ethnobotanical study followed by a survey of women's frequency of consumption of wild plants conducted using FFQ at quarterly intervals.

Setting: Sidi Bouzid governorate of central Tunisia.

Participants: Mixed-gender group of key informants (n 14) and focus group participants (n 43). Survey sample of women aged 20–49 years, representative at governorate level (n 584).

Results: Ethnobotanical study: thirty folk species of wild edible plants corresponding to thirty-five taxa were identified by key informants, while twenty folk species (twenty-five taxa) were described by focus groups as commonly eaten. Population-based survey: 98% of women had consumed a wild plant over the year, with a median frequency of 2 d/month. Wild and semi-domesticated fennel (*Foeniculum vulgare* Mill. and *Anethum graveolens*) was the most frequently consumed folk species. Women in the upper tertile of wild plant consumption frequency were more likely to be in their 30s, to live in an urban area, to have non-monetary access to foods from their extended family and to belong to wealthier households.

Conclusions: In this population, wild edible plants, predominantly leafy vegetables, are appreciated but consumed infrequently. Their favourable perception, however, offers an opportunity for promoting their consumption which could play a role in providing healthy diets and mitigating the obesity epidemic that is affecting the Tunisian population.

Keywords
Wild edible plants
Ethnobotany
Consumption
FFQ
Nutrition
Tunisia

The importance of biodiversity for ensuring sustainable human and environmental health is well recognized^(1–3). The loss of biodiversity could pose a threat to the quality and sustainability of human diets⁽⁴⁾. The Cross Cutting Initiative on Biodiversity for Food and Nutrition, adopted in 2006 by the Convention on Biological Diversity with

the partnership of the FAO and Bioversity International, made a strong statement in this regard: ‘Without urgent action that directly engages the environmental, agricultural, nutrition and health communities, biodiversity and the positive options offered by domesticated and wild biodiversity for addressing food security, nutrition deficiencies and the emerging burden of non-communicable diseases will be lost’⁽⁵⁾. In response, the FAO, with the support of experts,

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developed indicators to document scientific work on biodiversity for nutrition in terms of food composition and food consumption^(6,7). On these occasions, the importance of documenting the consumption of wild and neglected or underutilized foods was emphasized.

At the turn of the century, Grivetti and Ogle⁽⁸⁾ underlined the importance of wild plants for meeting the dietary requirements of populations around the globe because the so-called 'edible weeds' are often rich in micronutrients and bioactive substances. The authors noted that the scientific literature produced on wild edible plants in the fields of cultural studies, nutrition and food composition remained scattered and that interdisciplinary approaches were lacking. The value of traditional food systems for health and well-being, of which wild harvested foods are an important component, was emphasized by Kuhnlein⁽⁹⁾. The consumption of wild plants is an important feature of traditional Mediterranean diets^(10,11). Consumption of wild foods can serve 'as a buffer against hunger' in difficult times while trading of these foods can complement farmers' income⁽¹²⁾. Termote *et al.*⁽¹³⁾ argue that consumption of wild foods can reduce the cost of local diets in Kenya while increasing their nutrient adequacy. Burlingame *et al.*⁽¹⁴⁾ and studies cited by Bioversity International⁽³⁾ showed that the nutritional value of wild and indigenous foods is often higher than that of their cultivated counterparts, but some authors have expressed concerns regarding the presence of antinutritional or toxic components in wild edible plants⁽¹⁵⁾.

In their review, Penafiel *et al.*⁽¹⁶⁾ noted that most research on biodiversity and human nutrition was 'conducted by botanists and agronomists and received less attention from nutritionist and health scientists'. Many studies reviewed by Powell *et al.*⁽¹⁷⁾ reported the contribution of wild foods to dietary diversity, but a more limited number documented their contribution to diets in terms of provision of nutrients. The paucity of studies investigating linkages between wild food biodiversity and nutrition is due to methodological difficulties in measuring the contribution of wild foods to nutrient intakes. The most common difficulty is the taxonomic identification of wild edible plants, which is rarely done during food and nutrition surveys. It requires the competence of a botanist. Other difficulties are due to the shortcomings of standard dietary assessment instruments to capture the intake of foods for which the period of availability is often not precisely known. Studies based on the 24 h recall and weighed or observed records usually employ a short recall/recording period, which leads to missing consumption of wild plants available outside the period of recall; these methods cannot provide a comprehensive assessment of the consumption of wild foods over time. FFQ, because they are retrospective, do not suffer from this limitation, but require prior identification of wild foods for inclusion in questionnaires, otherwise their consumption will be ignored. It is therefore crucial, in preparation for food and nutrition surveys, to gather preliminary information on wild edible plants in

order to make methodological choices and develop survey instruments that will ensure an accurate and comprehensive representation of intakes from these foods.

The present study is part of the interdisciplinary MEDINA research programme on 'Promoting sustainable food systems in the Mediterranean for good nutrition and health'⁽¹⁸⁾. The Tunisian component of the project seeks to investigate the relationship between women's nutrition and food consumption patterns, their implication in agriculture and their use of local agrobiodiversity in a rural region of the centre of the country⁽¹⁹⁾. Consumption of wild plants has not been documented previously in a quantitative manner in Tunisia. Because it was noted incidentally during a previous survey investigating micronutrient deficiencies that wild plants were consumed by the population⁽²⁰⁾ (J El Ati, unpublished results), it was hypothesized that they could represent a valuable source of nutrients. It was therefore decided to explore the consumption of wild plants to be able to estimate their importance in women's diets. The objectives of the present study were: (i) to identify the wild edible plants consumed by the population that have potential to provide essential nutrients; (ii) to determine their habitats, seasonal availability and food uses in order to develop an adapted dietary assessment tool; and (iii) to assess their frequency of consumption by women of childbearing age. Aromatic and medicinal uses of wild plants were not included in the scope of the study because their potential contribution to nutrient intakes was deemed to be low⁽²¹⁾.

Methods

Study area

The studies were carried out in the Sidi Bouzid governorate, situated in central Tunisia. The governorate was the starting point of the so-called Jasmine Revolution of 2011, which led to the establishment of a democratic government. In the 1960s, Sidi Bouzid was an essentially rural area where traditional extensive pastoralism was practised. The development of irrigation by the public sector led to the growth of fruit and vegetable production for export to Tunis, the capital city, and to foreign countries. Since the early 1980s, public investment in irrigation has stalled and private investment in intensive agriculture is being promoted. The region is at a turning point where traditional smallholder agriculture, while still predominant, is gradually being marginalized by the development of large farms practising deep-drilling into aquifers, consequently impairing smaller farms' access to water resources⁽²²⁾. According to the 2014 census, the governorate has a population 429 912, of which 73 % is rural⁽²³⁾. Agriculture is the major employment sector. The level of employment of women is low (24 %), but almost half is in agriculture⁽²³⁾.

Administratively, the governorate is divided in twelve delegations and 111 districts. The climate is Mediterranean

with mild winters and hot and dry summers. Average rainfall is 350 mm/year concentrated during the months of September–May⁽²⁴⁾.

The Centre-West region of Tunisia where the Sidi Bouzid governorate is located is characterized by a prevalence of overweight and obesity among adult women that is lower than the national average (25 % in the Centre-West *v.* 37 % at national level among women aged 35–70 years)⁽²⁵⁾. However, the prevalence of anaemia among women of childbearing age, mostly due to iron deficiency, is slightly higher than the national average (31 *v.* 26 % at national level)⁽²⁶⁾. Other micronutrient deficiencies do not appear to be highly prevalent⁽²⁰⁾.

Ethical clearance

The project was approved by the Tunisian National Council of Statistics (visa 08/2014). Oral informed consent was obtained from persons interviewed for the ethnobotanical study and written consent was provided by participants in the food consumption survey.

Qualitative ethnobotanical study

Wild plants are defined by the FAO⁽²⁷⁾ as ‘plants or plant species [...] that grow spontaneously in self-maintaining populations in natural or semi-natural ecosystems and can exist independently of direct human action’.

The regional government agricultural development commission (*Commissariat régional de développement agricole*), the personnel of the female extension services unit (*Unité féminine de vulgarisation*) and territorial extension services (*Cellules territoriales de vulgarisation*) provided contacts and support to identify key informants and to organize focus group discussions. The qualitative study was carried out in March and April 2014 and complemented in February 2015. It took place in seven delegations of the governorate comprising 69 % of the population (delegations of Sidi Bouzid Est, Sidi Bouzid Ouest, Jelma, Ouled Haffouz, Souk Jdid, Regueb and Meknassy). For security reasons at the time of the study, delegations of the south-western part of the governorate were not visited.

Key informant interviews

Fourteen interviews were carried out with personnel of the *Commissariat régional de développement agricole* and the *Unité féminine de vulgarisation* and with farmers identified by them, and with persons encountered during roadside stops (agricultural labourers and persons collecting wild plants). The informants were ten men and four women with various levels of education (engineers, technicians and persons with no formal education). Key informants were asked to list wild plants that were currently consumed in the Sidi Bouzid governorate and identify them *in situ* where possible. Samples of wild edible plants were collected during field trips to farms, rangeland and riverbeds.

Wild food collection and identification

One hundred and fourteen samples of wild edible plants were collected. Photographs of the plants were taken *in situ* and a photographic guide was developed. The samples were put in presses and brought back to the herbarium of the National Agronomy Institute of Tunis, where voucher specimens were deposited in a MEDINA project herbarium. Recommendations by Nesbitt *et al.*⁽²⁸⁾ for plant identification and nomenclature were followed. Formal identification by an ethnobotanist was based on the *Flore de Tunisie*^(29–31). The names of plants were updated on the basis of Le Floc’h *et al.*⁽³²⁾ and The Plant List website⁽³³⁾.

Focus group discussions

Two questionnaires were developed for focus group discussions: one relevant to ethnobotanical information (names of foods, habitat, calendar of availability, collection and trends in perceived abundance since the 1990s) and the other on food uses (parts of the plants used, mode of consumption and culinary preparations where relevant, home processing, marketing, perceived value and inconveniences).

Seven mixed-gender focus group discussions were organized by the *Unité féminine de vulgarisation* and *Cellules territoriales de vulgarisation* personnel. The focus group discussions took place in the office of the *Cellules territoriales de vulgarisation* or in the countryside (farm, natural reserve) and lasted 2–3 h. Some participants brought samples of wild plants that they commonly consumed.

After the purpose of the study was explained by the research team, participants were asked to list the wild plant species, i.e. folk species, that they use as food (‘free listing’⁽³⁴⁾). Once the list was established, the questionnaires were used to structure the discussions, which were conducted in Arabic and were facilitated by the research team. The number of participants in focus group discussions varied from four to twelve. Among a total of forty-three participants, thirty-three were women. Participants’ ages ranged from 17 to 70 years and their level of education varied from no formal education to university studies.

Market visits

All wild edible plants sold on the weekly and daily markets of Sidi Bouzid and on the weekly market of Souk Jdid were recorded in April 2014 and February 2015.

Quantitative survey to determine frequency of wild plant consumption by women

Women aged 20–49 years were randomly selected from the governorate population through a stratified three-stage sampling procedure: the sample was stratified by delegation; thirty-six districts (clusters) were selected with probability proportional to size. In each cluster, twenty households were chosen randomly, and one woman was selected from each chosen household.



The women were interviewed four times, at 3-month intervals, from November 2014 to October 2015. Data on their sociodemographic characteristics and that of their households were collected, as well as their involvement in agriculture and livestock-rearing and non-monetary access to foods from an extended family orchard or garden or family livestock. An asset-based wealth index was computed by principal components analysis using variables pertaining to housing characteristics and ownership of appliances, as described in Traissac *et al.*⁽²⁵⁾.

FFQ of consumption of wild plants were developed using the structure of the validated national FFQ of Tunisia⁽³⁵⁾. For each period, a list of wild edible plants was established on the basis of the ethnobotanical study results, using the list of wild plants described by the focus group participants as commonly consumed and their seasonal availability. The number of wild plants inquired about in the FFQ varied across seasons. For each wild edible plant, different plant parts were included where relevant. Consumption was recorded as dishes or other forms of consumption (e.g. snack, salads). The total number of wild edible plant items was forty, sixty-four, seventy and thirty-nine in the autumn, winter, spring and summer FFQ, respectively. The FFQ asked about consumption retrospectively over the previous 3 months, thus the four rounds of survey covered an entire year of wild plant consumption. Frequency of consumption was assessed based on a set of nine frequency choices for consumption ranging from 'never' to 'every day'. An open question was included at the end of the FFQ for recording the consumption of previously unlisted wild plants. The photographic guide was shown to respondents to ensure correct identification of the foods.

The consistency between the ethnobotanical information and the consumption frequency data was examined in order to ensure a triangulation of the information, in particular regarding the comprehensiveness of the wild plant food lists of the FFQ.

Data analysis

Notes were taken by the research team during focus group meetings. An inductive thematic approach, with literal coding, was used to analyse the data⁽³⁶⁾. After each focus group meeting, fact sheets were developed for each wild edible plant using paper copies. Fact sheets from the various focus groups were compiled manually into a summary sheet of concordant information for each wild edible plant. Divergent information or opinions were also recorded with an indication of who expressed them (e.g. gender and age of the persons).

EpiData software version 3.1 was used for data entry of the wild plant frequency of consumption survey (EpiData Association, Odense, Denmark, 2008). Quality checks and double entry were performed. Because consumption frequencies did not follow a normal distribution, non-parametric tests (Wilcoxon signed-rank tests) were used

for comparisons. Multinomial logistic regression was used to analyse the associations between individual and household characteristics (independent variables) and tertiles of wild plant consumption frequency over the year (dependent variables). Variables with *P* values less than 0.20 in the univariate analysis were selected for the multivariate model. Odds ratios were computed. In the final model, a variable was considered significant when the *P* value was less than 0.05. Analyses were performed using with survey data procedures (surveymeans, surveyfreq and surveylogistic) of the SAS statistical software package (version 9.4).

Results

Ethnobotanical study

All key informants and focus group participants knew and had consumed wild plants. In both the key informant interviews and the focus group discussions the first use of wild plants that was mentioned was medicinal use, which was not investigated in the present study.

Wild edible plants mentioned by key informants

The key informants listed thirty folk species of wild edible plants and one species of wild fungus as being consumed currently in the Sidi Bouzid governorate.

Taxonomic identification of wild plants

Thirty-five wild edible plants were formally identified, one *Gymnosperm* and thirty-four *Angiosperms* (thirty-one *Dicotyledoneae* and three *Monocotyledoneae*). These species belong to twenty-nine genera grouped in twelve families. The most represented families were *Asteraceae* and *Brassicaceae* with thirteen and seven species, respectively. The fungus is a desert truffle, *Terfezia boudieri* Chatin. The vernacular and scientific names of the wild edible plants and fungus are presented in the online supplementary material.

Focus group discussions

The focus group discussions provided detailed information on twenty folk species of wild plants reported by participants to be commonly consumed as food in the governorate (Table 1). These plants had all been mentioned by the key informants.

Ethnobotanical information. Most of the wild edible plants mentioned were vegetables, with two exceptions: the fruit of a shrub, jujube (*Ziziphus lotus* (L.) Lam.), and the seeds of a tree (*Pinus halepensis* Mill.).

Vernacular names of wild edible plants. A few wild edible plant species had more than one vernacular name (overdifferentiation) and conversely distinct botanical species were designated under the same vernacular name (underdifferentiation), which explains the discrepancy between the number of folk species and the number of species formally identified (Table 1).

A single vernacular name, *barra*, is used for three distinct taxa of wall-rocket. These taxa were identified as


Table 1 Wild edible plants commonly consumed according to focus group discussions, Sidi Bouzid governorate, Tunisia, 2014

Botanical family	Scientific name	Vernacular name	English name	Plant part consumed	Period of availability	Consumption mode/preparations	Remark
Alliaceae	<i>Allium baeticum</i> Boiss.	<i>korath</i>	wild leek	leaves, bulb, flowers	January to March	<i>kesra</i> bread, couscous, <i>kneff</i> , stuffed tripe	abundance decreasing
	<i>Allium roseum</i> L.	<i>yazoul, gazoul, azoul</i>	wild garlic	leaves, bulb flowers	November to April March and April	couscous, <i>kneff</i> *, rice dish, <i>kesra</i> † bread couscous, rice dish	abundance decreasing
Amaranthaceae	<i>Beta macrocarpa</i> Guss.	<i>selg arbi</i>	wild swiss chard	leaves	December to March	couscous, stew, soup	abundance decreasing
Apiaceae	<i>Anethum graveolens</i> L. and <i>Foeniculum vulgare</i> Mill.	<i>besbes arbi</i>	dill and fennel	young leaves seeds	February to June June	<i>kneff</i> , couscous, rice dish, stuffed tripe <i>bsissa</i> ‡, infusion	wild and semi-domesticated abundance increasing
Asphodeliaceae	<i>Asphodelus tenuifolius</i> Cav.	<i>tazia</i>	onionweed	leaves	December to March	couscous	
Asteraceae	<i>Centaurea bimorpha</i> Viv.	<i>boulaâlaâ, b'laâlaâ</i>		leaves	December to April	couscous, <i>kneff</i>	abundance decreasing
	<i>Cynara cardunculus</i> L.	<i>khorchof</i>	wild cardoon	leaf petiole and rachis	all year	couscous, stew	abundance stable
	<i>Launaea quercifolia</i> L. and <i>Launaea nudicaulis</i> L.	<i>zarset azouza</i>		leaves	January to March	raw	abundance decreasing
	<i>Onopordum arenarium</i> (Desf.) Pomel and <i>Silybum eburneum</i> Coss. & Durieu	<i>bokk</i>	cotton thistle milk thistle	collar, stalk capitulum seeds	November to August	couscous, stew raw <i>bsissa</i>	abundance stable
	<i>Scolymus hispanicus</i> Desf.	<i>bouhaliba, holliba</i>	Spanish oyster thistle	base of stem	December to March	couscous, stew	abundance decreasing
	<i>Scorzonera undulata</i> subsp. <i>undulata</i> Vahl	<i>chtel, guiz</i>		leaves flowers fleshy root	January to March April and May March to June	raw, couscous, <i>kneff</i> raw raw	
	<i>Sonchus oleraceus</i> L.	<i>tifef</i>	common sow thistle	leaves, young stalks	January to March	raw	
Brassicaceae	<i>Brassica tournefortii</i> Gouan.	<i>lebsen</i>	Asian mustard	young leaves	December to March	raw, couscous, <i>kneff</i>	
	<i>Diplotaxis eruroides</i> L. and <i>Diplotaxis harra</i> Forssk. and <i>Diplotaxis muralis</i> subsp. <i>simplex</i> L.	<i>harra</i>	wall-rocket	leaves	September to April	couscous, stew, <i>kneff</i> , soup, salad (raw)	
	<i>Atriplex halimus</i> L.	<i>g'taf</i>	Mediterranean saltbush	leaves	winter and spring	couscous, <i>kneff</i>	
Malvaceae	<i>Malva aegyptia</i> L.	<i>khobizza</i>	malva	leaves	December to April	stew	
Pinaceae	<i>Pinus halepensis</i> Mill.	<i>zgougou</i>	Aleppo pine seeds	seeds	November to April	<i>assida</i> dessert	wild and domesticated
Polygonaceae	<i>Rumex roseus</i> var. <i>eu tingitanus</i> L.	<i>homidha (jbal)</i>	dock	leaves	January to May	raw	
	<i>Rumex roseus</i> var. <i>lacirus</i> L.	<i>homidha</i>					
Rhamnaceae	<i>Ziziphus lotus</i> (L.) Lam.	<i>n'bag</i>	jujube	fruit (drupe)	August and September	raw (fresh or dried)	

**kneff* is a vegetarian couscous where the vegetable is mixed with the semolina.

†*kesra* is a traditional flatbread made with durum wheat.

‡*bsissa* is a mixture of cereals (usually ground durum wheat) and legumes with spices (fennel, fenugreek or cumin seeds), used as a beverage (with water or milk, and sugar or honey) or as a paste (with added olive oil).



Diplotaxis muralis subsp. *simplex* L. and *Diplotaxis barra* Forssk. (*barra* with yellow flowers) and *Diplotaxis eruroides* L. (*barra* with white flowers). The vernacular name *besbes arbi* corresponds to two taxa, *Anethum graveolens* L., i.e. dill, which is sub-spontaneous and cultivated in this area, and *Foeniculum vulgare* Mill., which is spontaneous. The key informants and focus group participants did not distinguish dill and wild fennel as separate species. They distinguished *besbes arbi* ('Arab' fennel) from *besbes souri* ('introduced' fennel) which is cultivated (*Foeniculum vulgare* var. *azoricum* Mill.).

Habitat and calendar of availability. Wild edible plants were described as ubiquitous, found in and around cultivated fields and on uncultivated land, rangelands, roadsides and along riverbeds. Their period of availability depends on the species and the plant parts used (Table 1). Wild plants consumed as young sprouts or leaves are generally available from November to April or until June if rains are abundant. Their period of maximum availability is during February and March. As soon as the plants bloom, leaves become tough and are no longer consumed. The jujube fruit matures during the summer (August and September). Fennel seeds mature in June and Aleppo pine seeds during the winter and early spring.

Wild edible plant collection. Wild edible plants were reported to be gathered by men and women, as well as by adolescents and children, except those that are thorny such as wild cardoon (*Cynara cardunculus* L.) and cotton and milk thistle (*Onopordum arenarium* (Desf.) Pomel and *Silybum eburneum* Coss. & Durieu), which were harvested only by adults. Women were more likely to gather wild edible plants than men.

Trends in perceived abundance. The abundance of most wild edible plants depends on water resources, either from rainfall or irrigation. In comparison with the 1990s, six species were said to be currently less abundant (Table 1). Focus group participants said this was due to the adoption of modern farming practices (mechanized tilling, weeding and use of herbicides). In contrast fennel has become more abundant, due to the development of irrigation and domestication.

Food uses. All focus group participants said wild plants were commonly consumed in the Sidi Bouzid governorate except three young university graduate women who declared consuming them very infrequently. The most frequently consumed wild plants are vegetables, i.e. wild fennel, wall-rocket, wild swiss chard (*Beta macrocarpa* Guss.), malva (*Malva aegyptia* L.), cotton and milk thistle, wild cardoon, and two allium species (*Allium baeticum* Boiss. & *Allium roseum* L.).

Various plant parts are consumed (Table 1). For example, four different parts of cotton and milk thistle are eaten at different stages of maturity of the plant: the collar, tender stalks and capitulum are eaten as vegetables, while the seeds are used as a spice.

Mode of consumption and culinary preparations. The fresh leaves, capitulum, flowers or roots of some wild

vegetables are eaten raw (Table 1). For example, *Rumex roseus* var. *lacirus* L. leaves (*bomidba*) and the fleshy root of *Scorzonera undulata* subsp. *undulata* Vahl (*guiz*) are often eaten at the site of collection, directly off the plant as a snack. Wall-rocket (*barra*) is used raw in salads.

The majority of wild plants, however, are eaten cooked as part of main meal dishes, such as couscous, vegetable stews, rice dishes and thick soups. Wild plants are used in couscous in the same way as cultivated vegetables (carrots, courgettes, pumpkin, cabbage, onion, potatoes, etc): vegetables and meat are cooked separately from the semolina and are served on top of it. In contrast, *kneff* is a vegetarian couscous dish where the wild plant is the main vegetable and is mixed with the semolina. Fennel leaves are often used for the preparation of *kneff*. Thick pasta-based soups include wild swiss chard. Wild leek (*Allium baeticum* Boiss.) leaves and bulb are incorporated in the traditional flatbread, *kesra*. Fennel and cotton and milk thistle seeds are used as spices in a traditional cereal and legume preparation, *bsissa*, which is made into a beverage or a paste, also containing olive oil, sugar and other optional ingredients. Aleppo pine seeds (*zgougou*) are used to prepare a dessert (*assida*) eaten during the celebration of the birth of the Prophet (Mawlid).

Home processing. Wild vegetables are seldom processed for preservation, except wall-rocket which is dried or sometimes frozen. Seeds are dried and stored. The jujube fruit is eaten fresh or dried. Dried jujube has been used in times of food insecurity in the past: in the 1940s, as a replacement or complement to barley flour in *bsissa*.

Marketing. Focus group participants declared that four wild edible plants are sold in markets: wild fennel, wild swiss chard, wall-rocket and onionweed (*Asphodelus tenuifolius* Cav.). Wild fennel and wild swiss chard were said to be affordable. During visits to the Sidi Bouzid weekly market, the research team observed the presence of some wild edible plants that focus group participants said were not sold on markets, i.e. wild cardoon, malva and wild leek.

Perceived values of wild edible plants. Wild edible plants are mostly valued for their taste. Fennel, *besbes arbi*, and wall-rocket, *barra*, were the preferred wild plants according to focus group participants. *Besbes arbi*, which has become very popular, was described as more flavourful than *besbes souri*. When they grow near or in irrigated plots wild edible plants were said to be less tasty. They were considered as healthy, containing vitamins and being 'good for cholesterol'. Cooking with wild plants is considered as part of the local food tradition. None of the wild edible plants were described as foods consumed only by the poor.

Inconveniences. The major inconvenience mentioned by focus group participants was the short duration of the season of availability of wild leafy vegetables. Some wild edible plants are difficult to harvest and clean because they are thorny (wild cardoon, cotton and milk thistle).

Women's frequency of consumption of wild plants

Respondent characteristics

Among the 720 women initially included in the sample, ninety-five were lost to follow-up and forty-one had missing information for some of the variables. After exclusion for missing information, 584 women with complete information were available for analysis (response rate of 81 %).

Mean age of the women was 35.3 (SE 0.4) years. Most of the women were married (76.9 %) and had children (mean parity of 2.7 (SE 0.1)). Only 13.7 % had received secondary or university-level education and 35.2 % reported having a professional occupation. More than half of the women declared being involved in agricultural activities or livestock-rearing (63.0 %). A majority of women had non-monetary access to foods from an extended family orchard (86.0 %), a vegetable garden (52.1 %) or from family livestock (71.4 %).

Consumption of wild plants

Almost all women (98.3 %) reported consuming at least one wild plant over the year (Table 2). Consumption of twenty-four folk species of wild plants and one fungus was recorded. Since the wild fungus was considered by the women as a plant, it is included in the frequency of consumption results (Table 2). The median frequency of consumption of folk species was 2.27 d/month. Over the year, the median diversity of folk species consumed by women was 4 (range 0–17).

Fennel, *besbes arbi*, was the most often consumed plant: 78.2 % had eaten it with a median frequency of consumption of 0.98 d/month. Women mostly consumed the leaves and very seldom the seeds of fennel. The second most often consumed wild plant was wall-rocket, *barra*: 67.2 % had eaten it with a median frequency of consumption of 0.81 d/month. Aleppo pine seeds and wild swiss chard were consumed by more than 40 % of women. Five other folk species of wild plants were consumed by a range of 10–30 % of women, while sixteen were consumed by less than 10 %. Four wild edible plants and one fungus that had been listed by key informants but not described as commonly consumed by focus groups were eaten by a small percentage of women (Table 2).

Frequency of consumption of wild plants was highest in winter, followed by autumn, spring and summer (Table 3). Consumption of fennel was observed during all seasons compared with wall-rocket, which was mostly eaten during the winter and spring. Aleppo pine seeds were consumed during the winter and jujube in autumn.

Women used a variety of recipes for the two most frequently consumed wild plants, fennel and wall-rocket. Ninety-two per cent of those who ate fennel prepared it as *kneff*. They also used fennel in rice dishes (16 % of consumers), in couscous (10 %) or with innards (4 %). In contrast, they used wall-rocket mainly in couscous (77 % of consumers), and less often as *kneff* (33 %),

in stews (14 %) and seldom ate it raw as a salad (4 %). Aleppo pine seeds were almost exclusively consumed as *assida* for the celebration of the Mawlid.

Sociodemographic characteristics associated with wild plant consumption

Results of the multinomial logistic regression analysis are presented in Table 4. Several variables were associated with a higher frequency of consumption of wild plants: women's age between 30 and 38 years and having non-monetary access to products from a family vegetable garden were associated with the middle and upper tertiles of frequency of consumption. Urban residence, belonging to the wealthier households and having access to products of the family livestock were associated with the upper tertile of frequency of consumption. The women's level of education, professional occupation and involvement in agricultural or livestock-rearing activities were not significantly related to the frequency of consumption of wild plants.

Discussion

Ethnobotanical study

Conducting an ethnobotanical study is a necessary preliminary phase for the study of the contribution of wild foods to diets. Our study followed the methodological steps described in the *Guidelines on Assessing Biodiverse Foods in Dietary Intake Surveys*⁽³⁷⁾ for documenting local foods with the purpose of adapting a dietary assessment instrument to capture the contribution of food biodiversity to nutrition. In our study, key informants and *in situ* collection identified thirty folk species of wild edible plants corresponding to thirty-five taxa, while focus group participants described twenty folk species (twenty-five taxa) as being commonly consumed. Most of these plants were leafy vegetables.

In the ethnobotanical literature, we found only one study of consumption of wild vegetables in Tunisia⁽³⁸⁾, conducted in three governorates (Kairouan, Siliana and Le Kef) which are more northern than Sidi Bouzid: Ben Ismail reported the consumption of twenty-five wild vegetables, eight of which were mentioned in our study under the same vernacular and scientific names and three taxa belonging to the same genera but different species. The most popular wild edible plant in our study, fennel, was not reported in that study⁽³⁸⁾. The botanical literature of Tunisia reported more taxa used as food: Le Floc'h⁽³⁹⁾ inventoried sixty-six wild taxa used as food in southern Tunisia. He mentions species that were also inventoried by Cuenod⁽²⁹⁾ and Potier-Alapetite^(30,31) as being present in the flora of Sidi Bouzid but were not reported in our study. It is possible that some wild edible plants are no longer found or consumed in the Sidi Bouzid governorate.

Several species of wild edible plants reported in our study by focus group participants were consumed in other

Table 2 Percentage of women consuming folk species of wild edible plants over the year and frequency of consumption (*n*584), Sidi Bouzid governorate, Tunisia, 2014–2015

	Vernacular name	English name	Total sample			Consumers only	
			%	Median*	P25–P75	Median*	P25–P75
All folk species of wild edible plants			98.2	2.27	1.02–4.45	2.34	1.07–4.52
<i>Anethum graveolens</i> L. & <i>Foeniculum vulgare</i> Mill.	<i>besbes arbi</i>	dill and fennel	78.2	0.61	0.04–1.43	0.98	0.50–3.12
<i>Diplotaxis erucoides</i> L. & <i>Diplotaxis harra</i> Forssk. & <i>Diplotaxis muralis</i> subsp. <i>simplex</i> L.	<i>harra</i>	wall-rocket	67.2	0.16	0.00–0.72	0.81	0.50–2.38
<i>Pinus halepensis</i> Mill.	<i>zgougou</i>	Aleppo pine seeds	49.8	0.00	0.00–0.08	0.50	0.50–0.50
<i>Beta macrocarpa</i> Guss.	<i>selg arbi</i>	wild swiss chard	43.0	0.00	0.00–0.53	1.60	0.50–4.99
<i>Ziziphus lotus</i> (L.) Lam.	<i>n'bag</i>	jujube	30.3	0.00	0.00–0.14	0.66	0.51–1.54
<i>Allium roseum</i> L.	<i>yazoul</i>	wild garlic	19.8	0.00	0.00–0.00	0.76	0.50–0.98
<i>Cynara cardunculus</i> L.	<i>khorchof</i>	wild cardoon	19.1	0.00	0.00–0.00	0.59	0.50–2.34
<i>Onopordum arenarium</i> (Desf.) Pomel & <i>Silybum eburneum</i> Coss. & Durieu	<i>bokk</i>	cotton & milk thistle	12.0	0.00	0.00–0.00	0.85	0.50–2.32
<i>Allium baeticum</i> Boiss.	<i>korath</i>	wild leek	11.3	0.00	0.00–0.00	0.57	0.50–0.93
<i>Malva aegyptia</i> L.	<i>khobizza</i>	malva	9.4	0.00	0.00–0.00	0.50	0.50–0.68
<i>Sonchus oleraceus</i> L.	<i>tifef</i>	common sow thistle	7.8	0.00	0.00–0.00	0.81	0.50–2.00
<i>Rumex roseus</i> var. <i>eu tingitanus</i> L. & <i>Rumex roseus</i> var. <i>lacirus</i> L.	<i>homidha</i>		7.7	0.00	0.00–0.00	0.50	0.50–0.60
<i>Brassica tournefortii</i> Gouan.	<i>lebsen</i>	Asian mustard	7.2	0.00	0.00–0.00	0.50	0.50–0.65
<i>Launaea quercifolia</i> L. & <i>Launaea nudicaulis</i> L.	<i>zarset azouza</i>		7.1	0.00	0.00–0.00	0.50	0.50–0.63
<i>Capparis spinosa</i> L.	<i>kabbar</i>	caper	5.8	0.00	0.00–0.00	0.79	0.50–2.10
<i>Eruca sativa pinnatifida</i> Desf.	<i>harra't bell</i>	rocket	5.7	0.00	0.00–0.00	0.50	0.50–0.93
<i>Terfezia boudieri</i> Chatin.	<i>terfes</i>	desert truffle	3.4	0.00	0.00–0.00	0.50	0.50–0.95
<i>Podospermum laciniatum</i> subsp. <i>decumbens</i> L.	<i>telma</i>		3.0	0.00	0.00–0.00	0.50	0.50–1.59
<i>Eruca sativa</i> subsp. <i>longirostis</i>	<i>bortom</i>	rocket	2.5	0.00	0.00–0.00	0.75	0.50–0.92
<i>Atriplex halimus</i> L.	<i>g'taf</i>	Mediterranean saltbush	2.4	0.00	0.00–0.00	0.50	0.50–0.70
<i>Centaurea bimorpha</i> Viv.	<i>boulaâlaâ</i>		2.3	0.00	0.00–0.00	0.50	0.50–0.50
<i>Scorzonera undulata</i> subsp. <i>undulata</i> Vahl	<i>chtel, guiz</i>		2.1	0.00	0.00–0.00	0.50	0.50–0.74
<i>Asphodelus tenuifolius</i> Cav.	<i>tazia</i>	onionweed	1.3	0.00	0.00–0.00	0.50	0.50–0.67
<i>Emex spinosa</i> L.	<i>bazzoul nâaja</i>	devil's thorn	0.8	0.00	0.00–0.00	0.61	0.50–1.43
<i>Scolymus hispanicus</i> Desf.	<i>bouhaliba</i>	Spanish oyster thistle	0.2	0.00	0.00–0.00	0.50	0.50–0.50

P25–P75, first and third quartile of consumption frequency per month.

*Median frequency (number of days) of consumption per month.

Table 3 Percentage of women consuming folk species of wild edible plants, seven most consumed species, and frequency and diversity of consumption across seasons (n=584), Sidi Bouzid governorate, Tunisia, 2014–2015

	Autumn			Winter			Spring			Summer		
	%	Median*	P25–P75	%	Median*	P25–P75	%	Median*	P25–P75	%	Median*	P25–P75
All folk species of wild edible plants	73.9	2.27 ^a	0.00–4.33	91.6	2.78 ^b	0.80–6.47	73.7	0.92 ^a	0.00–4.42	24.4	0.00 ^d	0.00–0.00
<i>Anethum graveolens</i> L. & <i>Foeniculum vulgare</i> Mill. (dill and fennel)	54.3	0.23 ^a	0.00–2.45	56.6	0.14 ^b	0.00–1.14	49.0	0.00 ^c	0.00–0.50	12.6	0.00 ^d	0.00–0.00
<i>Diptotaxis erucoides</i> L. & <i>harra</i> Forsk & <i>murialis</i> subsp. simplex L. (wall-rocket)	18.0	0.00 ^a	0.00–0.00	54.2	0.10 ^b	0.00–0.82	36.4	0.00 ^a	0.00–0.34	4.8	0.00 ^c	0.00–0.00
<i>Pinus halepensis</i> Mill. (Aleppo pine seeds)	5.5	0.00 ^a	0.00–0.00	47.7	0.00 ^b	0.00–0.27	1.0	0.00 ^c	0.00–0.00	0.5	0.00 ^c	0.00–0.00
<i>Beta macrocarpa</i> Guss. (wild swiss chard)	0.3	0.00 ^a	0.00–0.00	33.4	0.00 ^b	0.00–0.68	27.5	0.00 ^c	0.00–0.14	0.0	0.00 ^a	0.00–0.00
<i>Ziziphus lotus</i> (L.) Lam. (jujube)	25.4	0.00 ^a	0.00–0.02	4.4	0.00 ^{b,c}	0.00–0.00	0.8	0.00 ^c	0.00–0.00	5.1	0.00 ^b	0.00–0.00
<i>Allium roseum</i> L. (wild garlic)	1.9	0.00 ^a	0.00–0.00	14.3	0.00 ^b	0.00–0.00	11.3	0.00 ^b	0.00–0.00	0.0	0.00 ^a	0.00–0.00
<i>Cynara cardunculus</i> L. (wild cardoon)	4.9	0.00 ^{a,b}	0.00–0.00	12.7	0.00 ^{a,b}	0.00–0.00	11.6	0.00 ^a	0.00–0.00	1.8	0.00 ^b	0.00–0.00
Diversity of folk species consumed		0.56 ^a	0.00–1.29		1.96 ^b	0.87–3.34		0.95 ^c	0.00–2.24		0.00 ^d	0.00–0.00

P25–P75, first and third quartile of consumption frequency per month.

^{a,b,c,d}Median values within a row with unlike superscript letters were significantly different as tested with Wilcoxon signed-rank tests ($P < 0.05$).

*Median frequency (number of days) of consumption per month and median diversity of consumption of folk species (number of different species) per season.

circum-Mediterranean countries (Albania, Cyprus, Egypt, Greece, Italy, Lebanon, Morocco and Spain): *Foeniculum vulgare* Mill., *Cynara cardunculus* L., *Allium baeticum* Boiss., *Beta macrocarpa* Guss., *Sonchus oleraceus* L., *Scolymus hispanicus* Desf., and different species belonging to the same genera of *Malva*, *Diptotaxis*, *Rumex* and *Ziziphus*^(11,40–45). Wild fennel, *Foeniculum vulgare* Mill., one of the preferred wild edible plants in our study, was recorded in all of these countries except Albania. While a large number of wild edible plants were described in these countries, researchers noted that knowledge of these foods was declining and as most of their key informants were elderly, they predicted that traditional knowledge on wild edible plant gathering and use would not be passed on to younger generations^(40,43). In effect, among the focus group participants of our study, we noted that young educated women expressed limited interest in consumption of wild plants.

The cited circum-Mediterranean studies reported a large variety of culinary preparations of wild plants but some similarities across countries, for instance the preference for consuming cooked wild plants⁽⁴⁰⁾. In Morocco, wild plants were used in couscous⁽⁴⁴⁾. Some of the recipes reported in our study were also noted by Ben Ismail⁽³⁸⁾, for example couscous, soups and rice dishes. In Tunisia, these recipes can be prepared with cultivated or wild vegetables. The recipes using cultivated vegetables are included in the Tunisian national FFQ⁽³⁵⁾. In contrast, *kneff* prepared with wild vegetables seems to be a recipe specific to Sidi Bouzid.

While in several studies respondents considered wild vegetables as foods consumed in situations of food insecurity^(44,46) or as famine foods⁽⁴⁷⁾, we noted only positive perceptions of wild edible plants – they were described as tasty and healthy – apart from the difficulty in harvesting thorny wild plants and the short duration of the season. In Sidi Bouzid wild edible plants are not culturally devalued and are not regarded as food for the poor.

A limitation of the study was the definition we used for wild edible plants which appeared to be problematic in some cases: certain wild plants are both spontaneous and cultivated. Powell *et al.*⁽¹⁷⁾ caution against dichotomization of wild *v.* cultivated plants. For example, the vernacular name *besbes arbi*, or Arab fennel, designates two species: *Anethum graveolens* L., which can be cultivated, and *Foeniculum vulgare* Mill., which is spontaneous. The focus group participants did not distinguish these two species when they were sold on the Sidi Bouzid market.

Women's frequency of consumption of wild plants

To our knowledge, ours is the first published survey of the consumption of wild plants covering an entire year. Results of the survey were consistent with some but not all of the qualitative ethnobotanical information collected.

Table 4 Association between women's frequent consumption of folk species of wild edible plants and sociodemographic characteristics (n584), Sidi Bouzid governorate, Tunisia, 2014–2015

	Univariate analysis*						Multivariate analysis†					
	Middle tertile‡ (n 193)			Upper tertile‡ (n 194)			Middle tertile‡ (n 193)			Upper tertile‡ (n 194)		
	OR	95 % CI	P value	OR	95 % CI	P value	OR	95 % CI	P value	OR	95 % CI	P value
Women's characteristics												
Age (years)												
20–29	1.00	Ref.	–	1.00	Ref.	–	1.00	Ref.	–	1.00	Ref.	–
30–38	2.17	1.11, 4.26	0.03	1.90	1.00, 3.62	0.12	2.33	1.12, 4.87	0.01	1.95	1.00, 3.80	0.04
39–49	1.50	0.78, 2.87	0.97	1.70	0.88, 3.30	0.47	1.34	0.62, 2.88	0.65	1.49	0.66, 3.37	0.83
Marital status (married)	0.91	0.60, 1.40	0.68	1.38	0.80, 2.37	0.25	–	–	–	–	–	–
Parity	1.00	0.92, 1.11	0.89	1.05	0.91, 1.22	0.49	–	–	–	–	–	–
Professional occupation (yes)	0.97	0.48, 1.93	0.92	1.45	0.86, 2.45	0.16	0.81	0.39, 1.69	0.57	1.00	0.55, 1.82	0.99
Implication in agricultural or livestock-rearing activities (yes)	1.04	0.80, 1.36	0.77	1.01	0.51, 1.98	0.98	–	–	–	–	–	–
Level of education												
No schooling	1.00	Ref.	–	1.00	Ref.	–	1.00	Ref.	–	1.00	Ref.	–
Primary	0.87	0.54, 1.38	0.94	0.70	0.44, 1.01	0.02	0.70	0.43, 1.13	0.85	0.62	0.34, 1.12	0.18
Secondary and university	0.73	0.35, 1.53	0.49	1.12	0.62, 2.02	0.22	0.44	0.21, 0.95	0.08	0.66	0.35, 1.26	0.45
Household characteristics												
Area of residence (urban)	1.32	0.95, 1.84	0.10	1.47	0.80, 2.75	0.22	1.46	0.93, 2.27	0.10	1.90	1.02, 3.54	0.04
Access to food coming from a family orchard (yes)	0.94	0.45, 1.93	0.86	1.01	0.54, 1.90	0.97	–	–	–	–	–	–
Access to food coming from family livestock (yes)	1.29	0.86, 1.95	0.22	1.88	1.20, 2.94	0.01	1.52	0.94, 2.46	0.09	1.97	1.27, 3.03	0.00
Access to food coming from a family garden (yes)	1.41	1.01, 1.98	0.04	3.10	1.80, 5.32	0.00	1.37	1.02, 1.84	0.04	2.82	1.57, 5.05	0.00
Asset-based wealth index												
Lower tertile	1.00	Ref.	–	1.00	Ref.	–	1.00	Ref.	–	1.00	Ref.	–
Middle tertile	1.36	0.81, 2.29	0.86	1.19	0.79, 1.80	0.21	1.58	0.86, 2.89	0.67	1.27	0.83, 1.96	0.43
Upper tertile	1.71	0.96, 3.05	0.14	2.21	1.37, 3.54	0.00	2.07	1.04, 4.14	0.08	2.16	1.33, 3.50	0.00

Ref, referent category.

*Variables with P value less than 0.20 were selected for the multivariate analysis (shown in bold font).

†OR with P value less than 0.05 were considered significant (shown in bold font).

‡The referent category is the lower tertile of frequency of consumption of wild plants over the year.

The comprehensiveness of the list of wild edible plants included in the FFQ is corroborated by the qualitative study results: the women mentioned having consumed only four foods that were not listed in the FFQ and consumption frequencies of these foods were low. These foods had been mentioned and identified by the key informants but were regarded as not commonly consumed by the focus group participants.

The survey confirmed that consumption of wild plants is common in the Sidi Bouzid governorate, as almost all women reported consuming a wild plant at least once during the year, but consumption frequency was low, with a median occurrence of 2 d/month. Only four wild plant foods were consumed by more than 40% of women, which were three leafy vegetables and seeds of a tree. Moreover, the women consumed a limited diversity of folk species (median of four different species over the year).

A gap between knowledge of wild foods and actual consumption, observed in our study, was noted by several authors in sub-Saharan African countries^(46,48,49). In some studies, the observed discrepancy between knowledge and consumption could be due, in part, to a short recall period, but this is not the case in our study. Diminishing availability of wild edible plants, described by focus groups for some plants as a consequence of the development of intensive agriculture in Sidi Bouzid, is observed in many different contexts⁽¹²⁾. Urbanization and integration in market economies are also often cited as factors that accelerate the decline in use of wild edible plants because acquisition of vegetables from markets has replaced gathering in the wild^(12,43). That could be the case in Sidi Bouzid, where cultivated vegetables have become widely available in local markets.

The case of fennel, however, shows that local marketing can also be an opportunity for maintaining the use of wild edible plants. In Sidi Bouzid, fennel, the most frequently consumed wild plant, is both a wild and semi-domesticated plant. Women were able to access it in several ways: gathering it themselves, obtaining it from family networks who gathered it or acquiring it from local markets, which explains why both urban and rural women consumed it.

Conclusion

Our research, combining a qualitative study and a population-based survey, was a first attempt to assess the importance of wild edible plants in the diets of women of the Sidi Bouzid governorate of Tunisia. Further research is underway for investigating the nutrient composition of these foods and of dishes that comprise them, and to assess their contribution to nutrient intakes.

In the context of the nutrition transition that is affecting the population of Tunisia, the consumption of wild plants, predominantly leafy vegetables, could play a significant role in mitigating the obesity epidemic and could

contribute to providing healthy diets to the population. The favourable perception of wild edible plants observed in the context of this research offers an opportunity for promoting their consumption. Because the agricultural system of the governorate is changing rapidly, with the development of large high-input farms producing for export that will decrease the availability of wild edible plants, research on their nutrition contribution should be a priority and policy makers should be alerted to the potential importance of preserving and promoting this food resource.

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Supplementary material

To view supplementary material for this article, please visit <https://doi.org/10.1017/S1368980019003409>



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Appendix

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