

Article

Ethnobotanical Assessment of the Diversity of Wild Edible Plants and Potential Contribution to Enhance Sustainable Food Security in Makkah, the Kingdom of Saudi Arabia

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Abstract

Wild edible plants contribute significantly to food security, environmental protection, cultural heritage preservation, economic diversification, and the development of communities. In this paper, we present an inaugural ethnobotanical investigation of the traditional knowledge on wild edible plant species from Makkah, Kingdom of Saudi Arabia. Ethnobotanical fieldwork was conducted in Makkah from January to February 2025. Ethnobotanical data pertaining to wild edible plants were collected from 102 informants through free listing, semi-structured interviews, field observations, and a survey of the market. The data were analyzed based on descriptive statistics, the relative frequency of citation, preference ranking, and priority ranking. Forty-one out of one hundred and eighty-four wild plants were gathered and recognized as wild edible plant species belonging to twenty-one families. *Poaceae* showed the greatest species diversity, comprising five plant species (12%). *Phoenix dactylifera* L. is the most common wild edible plant. Notably, 11 of the 41 wild edible plants identified in this study had never been reported in the Kingdom of Saudi Arabia before. Wild edible plants are currently threatened by several anthropogenic sources in the research region, including overgrazing, fuel wood collection, and the repeated use of multiple species. Therefore, to ensure sustainable future usage, wild food plants must be used carefully and should be the subject of targeted conservation efforts from all stakeholders.



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1. Introduction

Ethnobotany is the study of the close relationships among people and plants. This encompasses flora utilized for construction, sustenance, medicine, and other economic applications [1–3]. Undomesticated plants containing at least one edible component, such as a root, leaf, or fruit, are called wild edible plants (WEPs) [4,5]. These plants thrive naturally in their native environments without human interference [6]. They are widely used as a primary source of subsistence in many regions globally [7,8]. In addition, a number of studies indicate that WEPs, as opposed to agricultural crop foods, have better nutritional content required for healthy body growth [9,10]. In addition to their nutritional importance, people are now more conscious of the medical advantages of WEPs [11,12]. Globally, rural communities rely on WEPs for food security [13]. Food security refers to people's ability to achieve their fundamental daily nutritional needs in order to live a decent and healthy life [14,15]. By the year 2030, the Goals for Sustainable Development proposed by the United Nations seek to advance sustainable agriculture, end hunger, and ensure food security [16–18].

An international concern in recording ethnobotanical data on underutilized wild edible food sources has led many ethnobotanists to concentrate their research on wild food plants in recent decades [3,19]. Indigenous knowledge is the body of information that native people in a given place have gathered throughout time. In order to maintain long-term relationships with nature, indigenous populations have consistently refined their understanding of traditional plant utilization and resource management [20]. Traditional knowledge about WEPs is in danger of disappearing when habitats, value systems, and natural surroundings change. Wild food plant knowledge is widely declining, particularly among urban inhabitants and young people. This knowledge must therefore be systemically recorded in order to preserve it and its potentially great worth for future generations [21].

The Kingdom of Saudi Arabia (KSA) is home to over 2250 species, making it a significant source of biodiversity [22–24]. It encompasses a variety of natural environments, like rocky and sandy deserts, meadows, wadis (wet riverbeds or river valleys that contain water only after a lot of rain), mountains, and salt pans [25–27]. Xerophytes, which are related mostly to ecological conditions, make up the majority of the plant life in KSA. Vegetation is almost exclusively found in wadi channels (broad, sloping channels) inside desert regions; this system is often referred to as a “run-off desert.” [27]. Makkah is situated in the Wadis between Saudi Arabia’s western mountain range [28]. It is known for its diverse range of plant species, such as *Amaranthus viridis* L., *Sonchus oleraceus* L. and *Limeum obovatum* Vicary, and its high species diversity [27,29,30]. Makkah is home to over 184 species across 125 genera and 44 families [24]. These plants were discovered to share traits with Irano-Turanian and Saharo-Arabian flora [24,31]. In desert ecosystems, the main site of biodiversity is wadi vegetation [27,32]. However, a number of factors are currently endangering the biodiversity of the country. Climate change, which includes rising temperatures and falling precipitation, is one of the biggest dangers [33–36]. Over the past few decades, KSA has experienced rising daytime and nighttime temperatures [37]. Temperature increases in KSA are expected to reach 48 °C, which is the highest point of climate change in the Middle East. Additionally, the whole country is experiencing low precipitation [38]. Currently, the domestic food supply in the Kingdom of Saudi Arabia falls well short of what is needed to meet local demand. Up to 80 percent of the nation’s food needs are met by imports [39,40]. Climate change, a heavy reliance on food imports, water scarcity, and a reduction in vegetation diversity as a result of habitat loss, environmental disturbances, and fragmentation are considered to be factors that contribute to threats to overall food security [27,41,42].

Recent ethnobotanical research conducted in Makkah has yielded comprehensive information on medicinal plants [43,44]. On the other hand, local knowledge and practices regarding wild edible plant (WEP) species in Makkah are not documented. According to [27], numerous original vegetation regions within the study area in of Wadi Al-Sharaea in Makkah have been either naturally or intentionally destroyed. Therefore, it is imperative that ethnobotanical knowledge about WEP species in Makkah be gathered and recorded before it is permanently lost. For this reason, the current study intends to (1) identify and document ethnobotanical data on wild edible plants, including indigenous knowledge from the Makkah; (2) evaluate the most preferred and extensively utilized WEPs in the study regions, which may provide a foundation for conservation and nutritional assessment; (3) compare the WEPs of the research regions with those from earlier publications in KSA for potential new food species; and (4) determine the main threats for edible wild plants and establish suitable plans of action and strategies to preserve these plants in Makkah, KSA.

2. Materials and Methods

2.1. Study Area

According to Figure 1, KSA is situated between 16°22' and 32°14' N, 34°29' and 55°40' W. Makkah is located in the western part of KSA, with the coordinates 21°26' N and 39°46' E. It is situated between wadis in the hilly area of western KSA [24]. Makkah is home to about 2,427,924 inhabitants. This study was conducted in three neighboring sites to the east of Makkah city: Al-Sharaya, 21°28'40" N and 39°57'14" E, Al-Tarwiyah 21°28'46" N and 39°57'48" E, and Al Rashidiya 21°29'01" N and 39°58'59" E (Figure 1). Al-Sharaya occupies 3.68 km², Al-Tarwiyah occupies 4.34 km² and Al Rashidiya occupies 5.83 km². These are lowland areas and are situated 432 m above sea level.

The study area has a tropical and arid climate. The amount of rainfall in Makkah has a direct impact on the size and growth of the vegetation. In general, January, February, April, August, and September are the wettest months of the year, with the highest rainfall. When the temperature drops between November and February, the mean monthly rainfall rises, while when the temperature rises between April and October (excluding April, August, and September), the mean monthly rainfall falls [45]. According to studies on Makkah's floristic composition and vegetation, the two most prevalent families are the Poaceae family, which includes 31 species, and the Fabaceae family, encompassing 24 species. The predominant species in the study area are those that are typical of arid subtropical environments such as *Calotropis procera* (Aiton) W.T.Aiton and *Aerva javacica* (Burm.fil.) Juss. The floristic elements of Makkah comprise Saharo-Arabian (27.70%), Irano-Turanian (17.91%), and Sudano-Zambezian (16.22%) elements [24].

2.2. Data Collection

The methodologies and procedures established by Martin [1] were employed to gather ethnobotanical information. This study employed established methodologies in ethnobotanical research to document local knowledge of WEPs through free listing and semi-structured interviews and field observations adhering to the guidelines of [1]. Semi-structured interviews covered ethnobotanical information about WEPs, including common names, edible parts, growing characteristics and habitats, methods of eating, threats, and additional use. To gather the data, a pre-made questionnaire was employed. It was approved by Umm Al-Qura University's Biomedical Research Ethics Committee (HAPO-02-K-012-2024-12-2423). Prior to the formal interview, the study's aims were clearly outlined to the relevant informants and verbal or informed consent was solicited and acquired. Permanent residents who agreed to participate in the study were selected as participants. Targeted sampling was used to select informants who use WEPs [43]. The entire field study was carried out in accordance with the International Society of Ethnobiology. Ethnobotanical fieldwork was conducted for a duration of four weeks in Makkah from January to February 2025. Ethnobotanical data regarding WEPs was obtained from 102 informants through semi-structured interviews and free listing, adhering to the guidelines proposed by [1]. According to [46], saturation in free listing can happen once 15 or 20 informants have been interviewed. Therefore, interviews were stopped when a saturation of information was reached. Subsequent to data collection, the data were systematically arranged according to the research topics.

2.3. Collection and Identification of Plant Specimens

Most of the voucher specimens were collected during the field survey. In instances where this was impracticable, they were acquired from local stores. Collection numbers were allocated, and the specimens were pressed for future identification. Plant identification was conducted at the herbarium of Umm Al-Qura University utilizing herbarium specimens of

the Flora of KSA [47]. Voucher specimens, including herbarium samples, dried plant parts, and pictures, were deposited in the herbarium of Umm Al-Qura University. The scientific names of plants, families and nomenclature adhere to the guidelines described by [48].

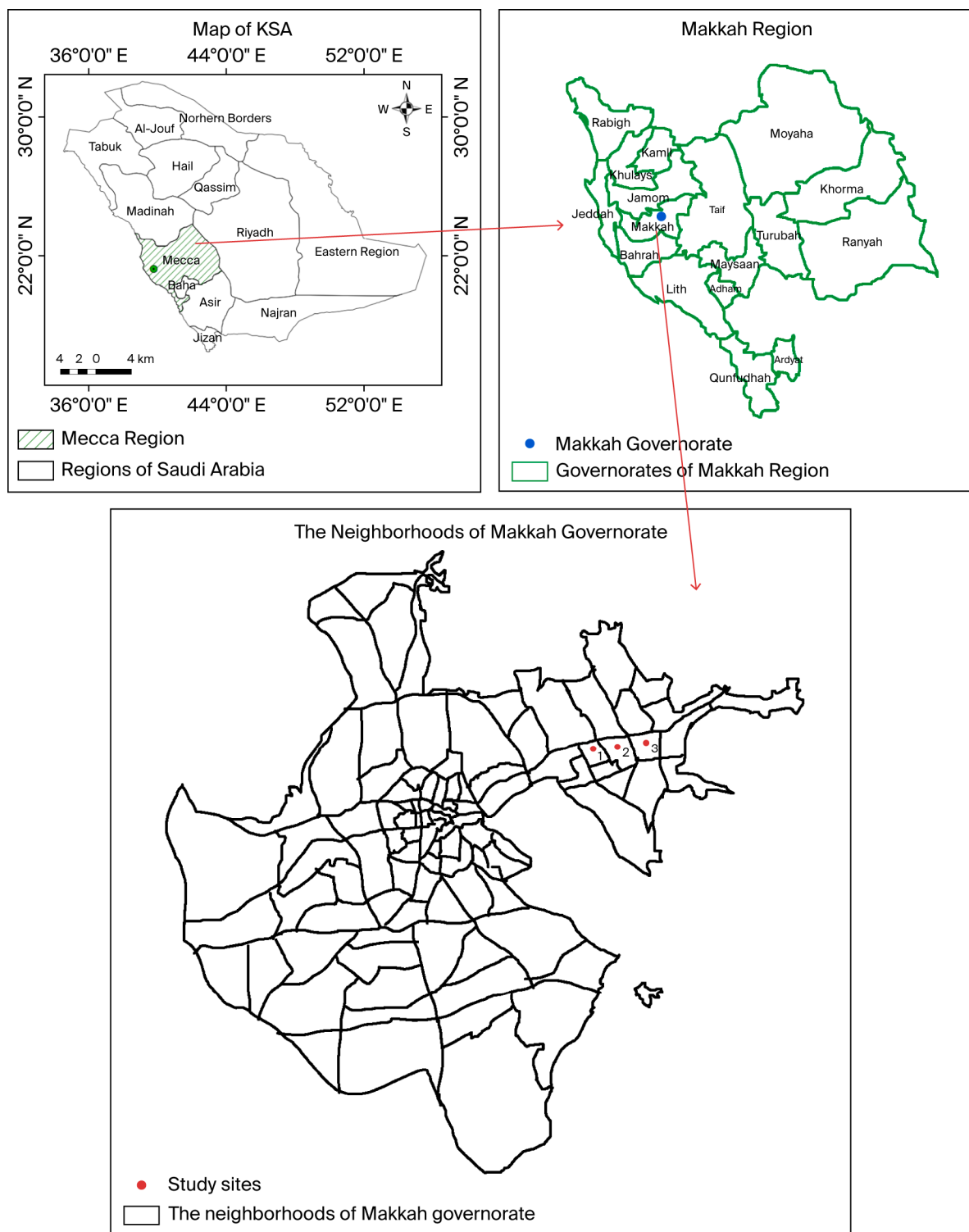


Figure 1. Map of KSA [43] showing the Makkah region and study sites.

2.4. Data Analysis

The collected information was analyzed using descriptive statistics. To summarize and describe the data of WEPs, percentages and frequencies (F) were computed using Microsoft

Excel spreadsheet software. The relative frequency of citation (RFC) was calculated to assess the frequency of use of specific species. In the formula used, $(RFC = FC/N)$ N stands for the total number of survey participants and FC is the number of respondents that described a specific wild edible plant. The more significant and valuable a plant is in the area, the higher its RFC value, which ranges from 0 to 1. The FC value of each wild edible plant was used to signify its relevance, allowing all WEPs cited in the important survey to be ordered in order of importance [49].

2.5. Preference Ranking

Preference ranking of the WEPs was performed according to the work of Martin [1] and Cotton [50]. Ten key informants provided values ranging from 1 to 10, which were then added up, and the average was calculated to discover which one was preferred over the others. The eight most popular wild edible plants were presented to the informants for the preference rating exercise, and they were ranked by sweetness. The plant with the least sweet taste received a rating of 1, while the WEP thought to have the sweetest taste received the maximum value of 10. The overall score for each species was used to determine preference classification. By aggregating the number provided by each informant, the overall order of preferences was determined.

2.6. Threat Rankings by Priority

Ten key informants ranked the five main dangers to these plants according to their level of harmful impacts in order to determine their preference [1,50]. Threats were given ratings ranging from 1 to 5. The threat with the least degree of destructive effects received a rating of 1, while the threat with the highest degree of destructive effects received the maximum value of 5. To determine the most pertinent factors, the sum of the values supplied by each key informant was calculated.

2.7. Comparative Studies on Literature Reviews

A systematic literature review was performed to evaluate the documented knowledge of Saudi Arabian WEPs. Data collected locally was contrasted with data from research performed in KSA, bordering nations, regional countries, African countries, and Asian countries. In both Arabic and English, the terms “ethnobotany,” “wild edible plants,” “wild food plants,” or similar expressions were used, without any limitations with regard to the publication date. Any studies that solely reported antibacterial activity for WEPs without referencing local knowledge sources were removed. Methods for documenting explicit knowledge, the collection of herbarium specimens, the literature utilized for their identification, and their deposition in herbaria were quality criteria employed to identify rigorous literature sources [43]. The names from the chosen literature were verified against the plant list to ascertain recognized plant names, family classifications, botanical species, and applications. The purpose of this was to find the new wild plants in the area that are being used as food for the first time [51–54].

3. Results and Discussion

3.1. Wild Edible Plant Knowledge Distribution Among Sociodemographic Groups

Interviews were conducted with 102 local informants. The study shows that, even with 102 participants, The study was contributed with novel data on plant use. It investigated differences in knowledge about WEPs among the sociodemographic groups in the study area (Table 1). In Makkah, WEPs were used by both genders. However, women were more knowledgeable about WEPs and their use, with a predominance of 76% compared to 24% of men. Women listed 151 WEPs, while men listed 34 WEPs. This female preponderance can be

explained by the fact that women have become familiar with WEPs through their cooking, homemaking, and family health responsibilities. The results of other ethnobotanical studies are supported by these findings [43].

Table 1. Informants' sociodemographic attributes.

Variable	Category	Number of Informants	Percentage	Number of Plants Listed	Average Number of Plants Listed
Gender	Female	78	76%	151	1.94
	Male	24	24%	34	1.42
Age	20–25	19	19%	37	1.95
	26–30	7	7%	15	2.14
	31–35	17	17%	31	1.82
	36–40	13	13%	26	2
	41–45	11	11%	14	1.27
	46–50	12	12%	26	2.17
	51–55	7	7%	8	1.14
	56–60	11	11%	15	1.36
	61–65	1	1%	1	1
	71 and older	4	4%	12	3
Marital status	Single	27	26%	53	1.96
	Married	68	67%	113	1.66
	Widowed	4	4%	14	3.5
	Divorced	3	3%	5	1.67
Education	Illiterate	10	10%	23	2.3
	Primary education	6	6%	6	1
	Secondary education	26	25%	36	1.36
	Undergraduate	60	59%	117	1.95

To determine the extent to which botanical knowledge is passed from the elderly to the youth, or whether there a significant gap in indigenous knowledge of wild edible plants between young people and elderly. The ages of the participants were chosen to range from 20 and 71 and older. Although the number of informants aged between 20 and 25 (19 informants) was greater than the number of informants who were aged 71 and older (4 informants), the average number of plants listed by informants who were 71 and older (3) was greater than the average number of plants listed by informants who were between 20 and 25 (1.95). Education level was found to be linked to the ages of the informants. Younger informants reported having an undergraduate education, while older informants were illiterate. Although the number of informants with an undergraduate education (60; 59% informants) was greater than the number of informants who were illiterate (10; 10% informants), the average number of plants listed by informants who were illiterate (2.3) was greater than the average number of plants listed by informants with an undergraduate education (1.95). This means there is a significant gap in indigenous knowledge of WEPs between young people and the elderly. Because they possess a large portion of the oral tradition's ancestral knowledge, the oldest respondents pass along more

trustworthy information. Therefore, there is a lack of knowledge of WEPs among young individuals, which might be explained by their propensity for canned or fast food. These results support the findings of previous studies [43].

3.2. Taxonomic Diversity of Wild Edible Plants

The plant species in the study area are generally diverse. Twenty-one families and forty-one beneficial WEP species were gathered and identified (Table 2). The *Poaceae* family exhibited the greatest species diversity, comprising five plant species (12%), followed by *Asteraceae* and *Brassicaceae*, each with four species (10%), and *Lamiaceae* with three species (7%). All other families were represented by two WEP species or less (Figure 2). In the current study area, *Poaceae* is the most dominant WEP family. This might be because *Poaceae* is the largest family in KSA, composed of 286 species [55]. Unlike other studies conducted around the world, in southern Yemen, the *Apocynaceae* family was predominant among plant species [56]; in northwest Pakistan, the most prominent families were *Rosaceae* [57]; and in western Ethiopia, the family *Rubiaceae* was found to be the dominant family [58]. *Anacardiaceae* and *Tiliaceae* were identified as the predominant families in other investigations [59,60]. This variance may be associated with the availability and accessibility of flora, in addition to the cultural inclinations of the studied society [3,61].

Table 2. WEPs listed with their scientific name, families, local names, edible parts, mode of preparation, mode of utilization, voucher specimen, additional uses and frequency (F), and relative frequency of citation. Plants not documented in KSA are indicated in bold.

Scientific Name	Family	Local Name	Part (s) Used	Mode of Preparation	Mode of Utilization	Voucher Specimen	Additional Uses	F	RFC
<i>Allium baeticum</i> Boiss.	<i>Amaryllidaceae</i>	Korath	Leaves	Fresh, ripe, and uncooked	Eaten raw	EPM-33	-	4	0.04
<i>Allium vinicolor</i> Wendelbo	<i>Amaryllidaceae</i>	Basal	Bulbs	Fresh, ripe, and uncooked	Eaten	EPM-4	-	1	0.01
<i>Apium graveolens</i> L.	<i>Apiaceae</i>	Korfuss	Stems and leaves	Fresh, ripe, and uncooked	Eaten raw	EPM-37	-	4	0.04
<i>Avena byzantina</i> K. Koch	<i>Poaceae</i>	Shoofan	Seeds	Dried, ground seeds, and cooked	Eaten as bread	EPM-23	-	17	0.17
<i>Beta vulgaris</i> L.	<i>Amaranthaceae</i>	Shamandar	Roots	Fresh, ripe, and uncooked	Eaten as salad and with food	EPM-13	Medicine; natural dye	8	0.08
<i>Citrullus colocynthis</i> (L.) Schrad.	<i>Cucurbitaceae</i>	Handhal	Seeds	Dried, cooked	Munching	EPM-11	Medicine	1	0.01
<i>Cucumis melo</i> L.	<i>Cucurbitaceae</i>	Shammam	Fruits	Fresh, ripe, and uncooked	Fruit eaten	EPM-25	-	1	0.01
<i>Cuminum cyminum</i> L.	<i>Apiaceae</i>	Kamun	Seeds	Dried, infusion, ground seeds	Eaten with salad and food; drunk as a hot beverage	EPM-34	Medicine	1	0.01
<i>Cymbopogon schoenanthus</i> (L.) Spreng.	<i>Poaceae</i>	Athkhar	Leaves	Dried, decoction	Eaten with bread and dates; drunk as a hot beverage	EPM-1	Medicine	3	0.03
<i>Eruca vesicaria</i> subsp. <i>sativa</i> (Mill.)	<i>Brassicaceae</i>	Jerjeer	Leaves	Fresh, ripe, and uncooked	Eaten as salad	EPM-8	Medicine	3	0.03
<i>Ficus carica</i> L.	<i>Moraceae</i>	Teen	Fruits	Fresh, ripe, and uncooked	Fruit eaten	EPM-7	Medicine	12	0.12
<i>Ficus palmata</i> Forssk.	<i>Moraceae</i>	Hamat	Fruits	Fresh, ripe, and uncooked	Fruit eaten	EPM-9	Medicine	2	0.02
<i>Glebionis coronaria</i> (L.) Tzvelev	<i>Asteraceae</i>	Oghowan	Stems	Fresh, ripe, and uncooked	Eaten raw	EPM-14	Medicine	1	0.01
<i>Hibiscus sabdariffa</i> L.	<i>Malvaceae</i>	Karkadah	Flowers	Dried, infusion	Eaten with salad and food; drunk as a hot beverage	EPM-27	Medicine, Natural dye	2	0.02
<i>Hyphaene thebaica</i> (L.) Mart.	<i>Arecaceae</i>	Doom	Fruits	Fresh, ripe, and uncooked	Eaten fresh pericarp of the fruit	EPM-40	Construction, forage, shade, thatch, furniture, brooms and ornamental.	3	0.03
<i>Lactuca serriola</i> L.	<i>Asteraceae</i>	Khas	Leaves	Fresh, ripe, and uncooked	Eaten as salad	EPM-38	-	1	0.01
<i>Lepidium sativum</i> L.	<i>Brassicaceae</i>	Rashad	Leaves	Fresh, ripe, and uncooked	Eaten with salad and food	EPM-17	Medicine	2	0.02
<i>Leptadenia pyrotechnica</i> (Forssk.) Decne.	<i>Apocynaceae</i>	Markh	Leaves	Dried, cooked	With food	EPM-36	Medicine, Animal fodder	3	0.03
<i>Malva neglecta</i> Wallr.	<i>Malvaceae</i>	Khoppaizah	Leaves	Dried, cooked	Eaten with food	EPM-12	-	2	0.02

Table 2. Cont.

Scientific Name	Family	Local Name	Part (s) Used	Mode of Preparation	Mode of Utilization	Voucher Specimen	Additional Uses	F	RFC
<i>Matricaria aurea</i> (Loefl.) Sch. Bip.	Asteraceae	Baboonig	Flowers	Dried, infusion	Eaten with salad and food; drunk as a hot beverage	EPM-2	Medicine	2	0.02
<i>Mentha longifolia</i> (L.) L.	Lamiaceae	Habag	Stems and leaves	Fresh, ripe, and uncooked; infusion	Eaten as a salad; drunk as a hot beverage	EPM-39	Medicine	2	0.02
<i>Nigella sativa</i> L.	Ranunculaceae	Habat Albarakah	Seeds	Dried and uncooked	With food	EPM-31	Medicine	1	0.01
<i>Ocimum basilicum</i> L.	Lamiaceae	Rehan	Leaves	Fresh, ripe, and uncooked	Eaten with salad and food	EPM-18	Medicine; ornamental	6	0.06
<i>Olea europaea</i> L.	Oleaceae	Zaitoon	Fruits	Fresh, ripe, and uncooked	Fruit eaten	EPM-20	Medicine	6	0.06
<i>Opuntia ficus-indica</i> (L.) Mill.	Cactaceae	Birshumi	Fruits	Fresh, ripe, and uncooked	Fruit eaten	EPM-3	-	2	0.02
<i>Origanum syriacum</i> L.	Lamiaceae	Zatar	Leaves	Dried leaves	Eaten with salad and food	EPM-19	Medicine	9	0.09
<i>Panicum turgidum</i> Forssk.	Poaceae	Dukhn	Seeds	Dried, ground, seeds and cooked	As bread	EPM-41	Animal fodder; thatch	16	0.16
<i>Phoenix dactylifera</i> L.	Arecaceae	Tamir	Fruits	Fresh, ripe, and uncooked	Fruit eaten	EPM-5	Construction, forage, shade, thatch, furniture, brooms and ornamental.	20	0.2
<i>Portulaca oleracea</i> L.	Portulacaceae	Rejlah	Leaves	Fresh, ripe, and uncooked	Eaten as salad and with food	EPM-16	-	19	0.19
<i>Prunus arabica</i> (Oliv.) Meikle	Rosaceae	Lwz	Fruits	Fresh, ripe, and uncooked	Eaten raw	EPM-35	-	7	0.07
<i>Pulicaria incisa</i> (Lam.) DC.	Asteraceae	Shay Aljabl	Stems and leaves	Dried; infusion	Eaten with salad and food; drunk as a hot beverage	EPM-24	Medicine	2	0.02
<i>Raphanus raphanistrum</i> L.	Brassicaceae	Khاردال	Seeds	Dried, ground seeds, and cooked	Eaten with salad and food	EPM-22	-	2	0.02
<i>Raphanus sativus</i> L.	Brassicaceae	Fijel	Roots	Fresh, ripe, and uncooked	Eaten raw	EPM-30	-	1	0.01
<i>Rubus sanctus</i> Schreb.	Rosaceae	Toot	Fruits	Fresh, ripe, and uncooked	Fruit eaten	EPM-6	Medicine; natural dye	6	0.06
<i>Rumex nervosus</i> Vahl	Polygonaceae	Atrah	Leaves	Fresh, ripe, and uncooked	Eaten raw	EPM-29	Medicine	1	0.01
<i>Saccharum spontaneum</i> L.	Poaceae	Qasab	Stems	Fresh, ripe, and uncooked	Eaten raw; drunk as juice	EPM-32	-	1	0.01
<i>Sesamum indicum</i> L.	Pedaliaceae	Sumsum	Seeds	Dried; cooked as oil	With food	EPM-28	Medicine	1	0.01
<i>Sorghum bicolor</i> (L.) Moench	Poaceae	Thorah	Seeds	Dried, ground seeds, and cooked	As bread	EPM-15	Animal fodder	1	0.01
<i>Suaeda maritima</i> (L.) Dumort.	Amaranthaceae	Hamid	Leaves	Fresh, ripe, and uncooked	Eaten raw	EPM-10	Medicine	3	0.03
<i>Tamarindus indica</i> L.	Fabaceae	Tamur-hendi	Fruit	Fresh, ripe, and uncooked	Eaten with food	EPM-26	Medicine	1	0.01
<i>Ziziphus spina-christi</i> (L.) Desf.	Rhamnaceae	Seder	Fruits	Fresh, ripe, and uncooked	Fruit eaten	EPM-21	Medicine	6	0.06

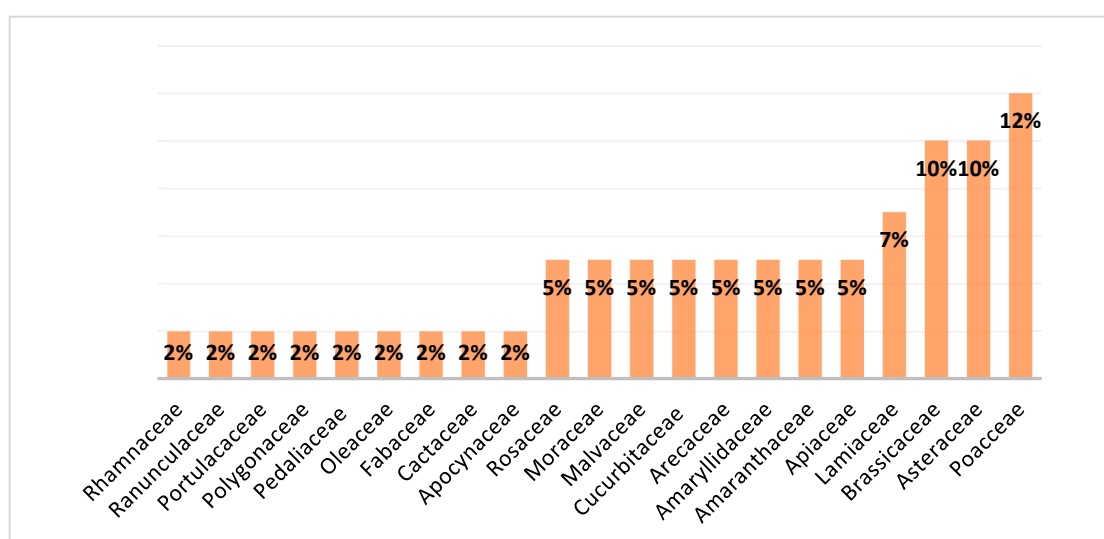


Figure 2. Percentage of wild edible plants species in each family.

Forty-one WEP species were identified and collected in the present study region. This result is close to the 43 species of WEPs documented by [5] in Ensaro, Ethiopia. Conversely, the quantity of WEPs recorded in the study area significantly exceeded that of other regions; for instance, Uganda reported 27 WEP species [62].

Some of the WEPs used in Makkah are medicinal plants. Medicinal plants cited in this study include *Cuminum cyminum*, *Hibiscus sabdariffa*, *Lepidium sativum*, *Matricaria aurea*, *Nigella sativa* and *Ziziphus spina-christi* (Table 2). The widespread usage of food plants as remedies by urban populations may be due to the plants' easy accessibility. The Mediterranean medical tradition also places a strong emphasis on medicinal foods [43].

Every culture on Earth has unique cultural, social, and dietary traditions and customs that invariably evolve based on their ecological characteristics, economic and social status, and cultural practices. The dietary habits that parents teach their kids are among such traditions. The consumption of dates is one of the eating customs in Saudi society. In the current study area, *Phoenix dactylifera* (date palm) is the most dominant wild edible plant. This might be because it is part of an ancestral tradition that many people continue to follow and uphold, and it is a part of society's customs and traditions. Dates are one of the most important main ingredients in many traditional dishes in KSA. The Kingdom of Saudi Arabia possesses a wealth of legacies, traditions and ancient customs, including an extensive heritage of food habits. One such food habit is the typical Saudi breakfast. It may include eating dates with Saudi coffee; however, dates with Saudi coffee (traditional drink) may be savored at any time of the day [63,64]. The nutritious date palm fruits are a fundamental component of the food and culture in KSA, frequently ingested during the Rutab and Tamer phases [65]. Date palm fruits possess substantial carbohydrate content (sugars, 44–88%), protein (2.3–5.6%), fat (0.2–0.5%), 15 salts and minerals, vitamins, and a significant dietary fiber proportion (6.4–11.5%). Dates can be regarded as an exemplary food, offering a diverse array of necessary nutrients and significant health advantages [66]. The Kingdom of Saudi Arabia is the world's second-largest producer and exporter of dates, producing around 1.5 million tons per year. The nutrient-rich fruits of the date palm significantly enhance food security on global as well as local scales [65]. This is a result of its substantial nutritional value and cost-effectiveness as an energy and nutrient source [56,67–69]. According to ecological characteristics, the maturation and ripening of date palm fruit occur in dry and hot climatic conditions, rendering it perfect for desert and semiarid areas [65,70,71].

3.3. Edible Parts of Wild Edible Plants

Numerous edible parts of wild plants have been reported in the current research region. Seven distinct components of WEPs were identified (Figure 3). This indicates the diversity of consumable parts of wild flora in Makkah. Of the edible parts, leaves constituted the most commonly ingested portion of WEPs, accounting for (29%), followed by fruits (27%) and seeds (20%; Table 2 and Figure 3). This result is in accordance with other research findings [72]. The least frequently consumed parts of WEPs are bulbs (2%). Among the documented WEPs, several possess multiple edible parts, including stems and leaves (Figure 3). For instance, the stems and leaves of *Apium graveolens* L. are both edible (Table 2). This outcome aligns with findings from prior research conducted in various areas [58,73] of multiple edible parts of a single plant. Reports indicate that leaves constitute a significant portion of WEPs commonly consumed globally [5,74]. Leaves are favored due to their extended growing season, unique flavor, and broad availability, rendering vegetable plants among the most popular selections [72]. Conversely, fruits may be favored due to their sweetness and elevated sugar content [5,75]. Furthermore, this preference may be attributed to the convenience of ingesting fruits in their raw, unprocessed state [58].

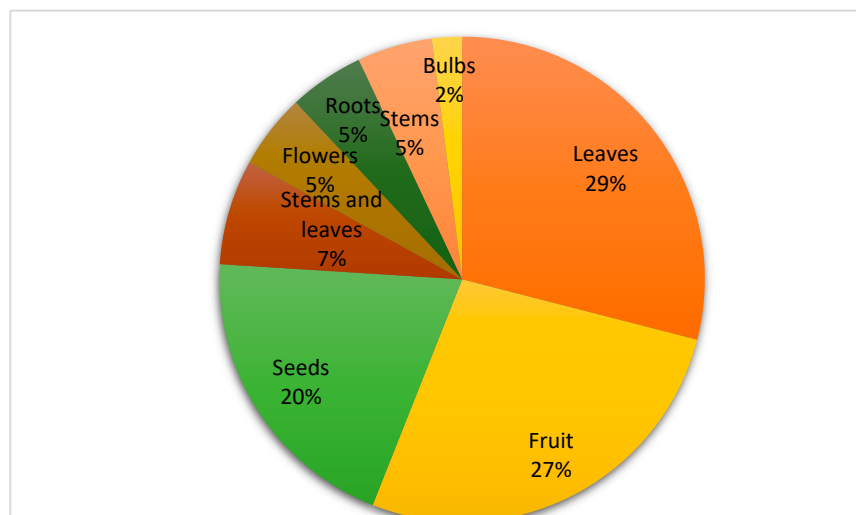


Figure 3. Edible parts of wild edible plants in Makkah, KSA.

3.4. Methods of Consuming Edible Wild Plants

Most of the WEPs were eaten fresh, ripe, and uncooked (63%) and did not require any form of preparation, whereas a smaller percentage was consumed dried (37%) and needed to be prepared beforehand. For example, seeds of *Sorghum bicolor*, *Avena byzantina*, and *Panicum turgidum* were used as ground seeds and cooked as bread. Moreover, seeds of *Raphanus raphanistrum* and *Cuminum cyminum* were used as ground seeds and cooked as spices. In addition, flowers of *Matricaria aurea* and *Hibiscus sabdariffa* and stems and leaves of *Pulicaria incisa* and *Mentha longifolia* were used as infusions, which were then ingested as a hot beverage. This inclination towards fresh consumption corresponds with global research findings [76–81]. The popularity of fresh fruits is attributed to their convenience, palatable flavor, and essential nutritional benefits [7,76]. The plants that were dried and preserved for future use included *Cymbopogon schoenanthus*, *Matricaria aurea*, *Citrullus colocynthis*, *Malva neglecta*, *Sorghum bicolor*, *Origanum syriacum*, *Raphanus raphanistrum*, *Avena byzantina*, *Pulicaria incisa*, *Hibiscus sabdariffa*, *Sesamum indicum*, *Nigella sativa*, *Cuminum cyminum*, *Leptadenia pyrotechnica*, and *Panicum turgidum*. In addition to increasing their availability, this storage capacity improves local communities' food security [76].

3.5. Wild Edible Plant Life Form

The wild edible plants in the research region demonstrate varying lifespans and growth patterns. Twenty-one species (51%) of WEPs are annuals, and twenty species (49%) are perennial. It is worth noting that the majority of the KSA plants are annuals (50–60%) [55]. Out of the reported WEPs in the current study, most plant species were therophytes (22 species (45%)), followed by Phanerophytes (8 species (20%)), hemicryptophytes (6 species (15%)), and chamaephytes (4 species (10%)), whereas geophytes made the smallest contribution, with only 1 species (2%; Figure 4). In the current study, wild edible herbs were dominant. According to a previous study conducted by [24] in Makkah, the most prevalent life forms are therophytes. In addition, the majority of plants in the KSA (71.02%) are herbs. Studies around the world, in Yemen [56], China [61], Şırnak [82], Ethiopia [7,83], Nepal [84], and India, also identified herbs as the dominant form of WEPs [85]. On the other hand, trees and shrubs are the most common types of wild edible plants, according to other ethnobotanical research. For example, research by [86,87] showed that the most prevalent growth pattern is that of shrubs. Similar research in Ethiopia [76], Guatemala [88], and Uganda [62] cited trees as the dominant form of WEPs. The discrepancies in these

findings might be ascribed to differences in the sorts of WEP species and the local culture of a specific region [5,13,61], and to agroecological conditions [61,76].

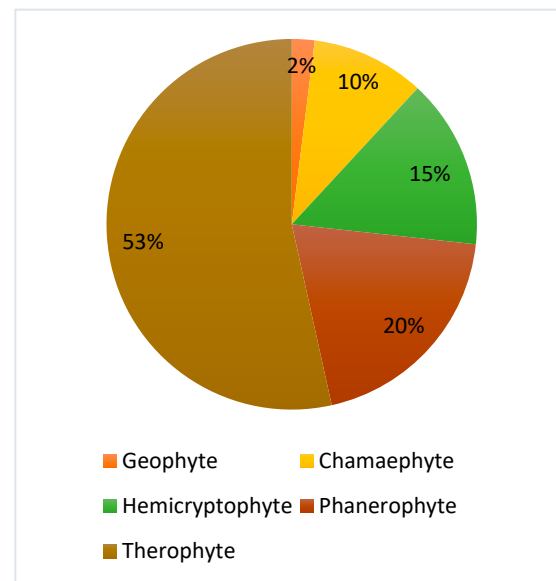


Figure 4. Life form of wild edible plants in Makkah, KSA.

3.6. Additional Applications for Edible Wild Plants

A wide variety of WEPs are used by the local communities for purposes other than food intake. Only thirteen species (32%) of the forty-one WEPs that were documented were used exclusively as food. There were several uses reported for the remaining 28 species (68%; Table 2). Common applications included traditional medicines (24 species), animal fodder, furniture, natural dye, ornamental and thatch (3 species each), and brooms, construction, forage, and shade (2 species each; Figure 5). Notably, *Phoenix dactylifera* and *Hyphaene thebaica* possessed more than six distinct uses beyond edibility, including construction, forage, shade, thatch, furniture, brooms, and ornamental applications (Table 2). Date palms are a multipurpose crop in addition to being a food source. For instance, they may also be used in construction, animal feed production, roofing, fencing, and basketry [71,89,90]. The present study demonstrates an impressive range of applications for WEPs that surpass their nutritional worth, which is consistent with results from additional research carried out in China [91], Ethiopia [76], and Uganda [62]. In the study area, the use of edible wild plants as medicine is widespread, which is consistent with findings from ethnomedicinal and pharmaceutical studies conducted in the study area [43,44,92–95]. Similar findings were reported in Ethiopia [58], Morocco [96], Brazil [97] and India [98]. The substantial quantity of documented WEPs employed for medicinal purposes highlights their essential contribution to human health and welfare, emphasizing the global acknowledgment of wild edibles as crucial resources for therapeutic use [76,99,100].

3.7. Preference Ranking of Wild Edible Plants

Ten key informants participated in a preference rating to assess ten widely used WEPs based on a number of criteria, including accessibility, availability, cultural importance, taste, and potential for revenue creation. The informants gave the chosen plants ratings ranging from 1 to 10, with 10 denoting the most preferred WEP and 1 denoting the least preferred. The findings indicated that *Phoenix dactylifera*, *Panicum turgidum*, and *Prunus arabica* were placed first, second, and third, respectively (Table 3). The preference ranking's numbers show the diversity in WEP usage across community members and represent unique viewpoints. The fruits of *Phoenix dactylifera* were the most highly rated among all the tested

plants. This might be because dates are one of the most important main ingredients in many traditional dishes. Nutritious date palm fruits are a fundamental component of the food and culture in KSA [65]. In addition, dates can provide a diverse array of necessary nutrients and significant health advantages [66]. In addition to dates, *Panicum turgidum* is the main ingredient in one of the most important traditional dessert dishes. *Prunus arabica* comes in third due to its popular use as a supplemental food and its pleasant taste. Preference ranking draws attention to how important particular WEPs are in regional diets. Communities' nutritional results and dietary variety can be improved by encouraging the consumption of these favored species. Preference ranking offers important information on which WEPs the community values most. In order to preserve local biodiversity, conservation initiatives can give priority to certain species and guarantee their preservation and sustainable management. The involvement of key informants in the rating process highlights the importance of local conservation knowledge. Involving people in the process of identifying and managing preferred WEPs can improve conservation efforts and promote natural resource stewardship [76].

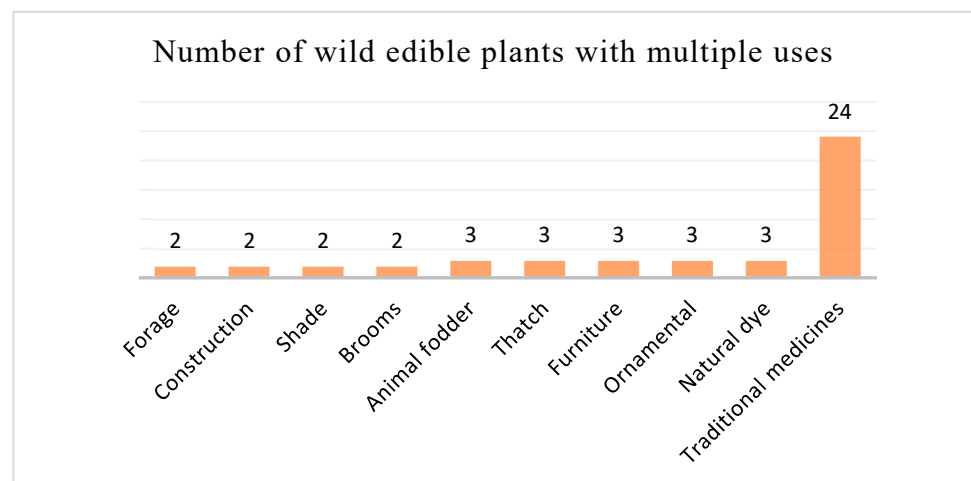


Figure 5. Additional uses of wild edible plants.

Table 3. Preference ranking of WEPs used in Makkah, KSA.

Plant Species	Key Informants (1 to 10)										Sum	Rank
	1	2	3	4	5	6	7	8	9	10		
<i>Phoenix dactylifera</i>	10	10	10	10	10	10	10	10	10	10	100	1st
<i>Panicum turgidum</i>	8	10	9	8	8	8	8	8	10	9	86	2nd
<i>Prunus arabica</i>	5	7	10	9	10	10	10	10	9	5	85	3rd
<i>Ficus carica</i>	6	10	9	6	5	10	10	8	8	9	81	4th
<i>Avena byzantine</i>	9	9	5	4	10	5	9	9	8	6	74	5th
<i>Origanum syriacum</i>	8	4	5	9	10	8	7	6	8	8	73	6th
<i>Beta vulgaris</i>	10	5	5	7	4	8	7	6	7	8	67	7th
<i>Portulaca oleracea</i>	4	5	8	5	1	3	8	7	7	8	56	8th

3.8. Wild Edible Plant Threats and Conservation

Ten key informants participated in a priority rating process that further clarified the most urgent risks to these resources (Table 4). The availability of WEPs is decreasing due to a number of factors. In the research region, WEPs face five main threats. These are urban expansion, overgrazing, fuelwood, multiple use of WEPs and climate change. Overgrazing

was viewed as the primary threat, followed by fuel wood collection; the repeated use of multiple species, especially of useful plants (medicinal, edible, forage plants); urban expansion; and climate change. The top-ranked threats are primarily attributed to a surplus population of people or a surplus of wild animals, which led to livestock grazing in randomly managed agricultural practices, in addition to the use of firewood and charcoal for heating and home cooking, the use of these resources in folk medicine and traditional industries, and the population influx from rural areas to urban areas searching for better services. Therefore, in order to preserve these plants and the related indigenous knowledge for the next generation, they need to be used wisely and given special attention by all relevant agencies [58]. According to [27], numerous original vegetation regions within the study area in of Wadi Al-Sharaea in Makkah had been either naturally or intentionally destroyed. The survival of plant species at the research location was mostly influenced by anthropogenic causes. According to other researchers [63,83,101], the main danger to WEPs is human activity. Furthermore, climate change and fluctuation in the area made the threats worse. A number of factors are currently endangering the nation's biodiversity. Climate change, which includes rising temperatures and falling precipitation, is one of the biggest dangers [33–36]. Food availability, access, and supply stability are all impacted by climate change [36].

Table 4. Ranking of threats to the conservation of wild edible plants by priority in Makkah, KSA.

Major Threats	Key Informants (1 to 10)										Sum	Rank
	1	2	3	4	5	6	7	8	9	10		
Overgrazing	5	5	4	5	5	5	5	4	4	5	47	1st
Fuel wood collection	4	3	5	4	3	4	3	3	5	3	37	2nd
The repeated use of multiple species	3	2	3	3	4	2	1	5	3	4	30	3rd
Urban expansion	1	4	1	1	2	3	4	1	2	2	21	4th
Climate change	2	1	2	2	1	1	2	2	1	1	15	5th

Local populations suggest a number of strategies for the future management of WEPs in order to improve sustainable food security in KSA. First and foremost, recording traditional knowledge about using indigenous wild plants as sustenance would help them to preserve the related indigenous knowledge for future generations. The second proposed strategy is establishing campaigns to raise awareness. The third pertains to the domestication of edible wild plants for household gardens and the creation of nurseries for seedlings of wild food plants, which will facilitate on-site conservation.

3.9. Comparative Study

This is the first ethnobotanical survey of WEPs conducted in Makkah. Compared to the traditional knowledge of other global locations, the indigenous species in Makkah are unique to the local traditional knowledge on WEPs. In order to identify new species that are employed only in the research area and to determine the degree of knowledge dissemination among these countries, the WEPs recorded in this study are compared with ethnobotanical literature from KSA, neighboring countries, regional countries, African countries, and Asian countries. The results of the comparative study are displayed in Tables 5 and 6. In general, this comparison showed that 31 common species were reported to be used in KSA, and in neighboring countries including (Yemen and Oman), regional countries, African countries, Asian countries, and Arab countries. Thirty edible species identified in the study area are also used for traditional purposes in other KSA regions, according to a comparison with ethnobotanical literature (Table 5). It has also been discovered

that six edible species present in the research area are also utilized in traditional ways in neighboring countries (Yemen and Oman; Table 6). Shared WEPs that are used in Oman include *Portulaca oleracea* and *Ziziphus spina-christi*. Those that are used in Yemen include *Ficus palmata*, *Lactuca serriola*, *Opuntia ficus-indica*, *Portulaca oleracea*, *Rumex nervosus*, and *Ziziphus spina-christi*. Additionally, *Rumex nervosus* is employed in nearby nations, albeit with distinct portions. While the study area uses the leaves of *Rumex nervosus* as sustenance, Yemen uses the plant's flower nectar for the same purpose [56]. Due to their proximity and shared flora, heritage, and inherited practices, Yemen and Makkah, Saudi Arabia, have very similar traditional applications of WEPs.

Table 5. Novel WEPs for Makkah and similar WEPs used in other KSA regions based on the literature review.

Novel WEPs Makkah (11 Species)	WEPs Used in Other KSA Regions (30 Species)		
<i>Allium baeticum</i>	<i>Apium graveolens</i> [52,53]	<i>Lepidium sativum</i> [53]	<i>Raphanus sativus</i> [53]
<i>Allium vinicolor</i>	<i>Avena byzantine</i> [53]	<i>Malva neglecta</i> [53]	<i>Rubus sanctus</i> [53]
<i>Cuminum cyminum</i>	<i>Beta vulgaris</i> [53]	<i>Matricaria aurea</i> [53]	<i>Rumex nervosus</i> [53]
<i>Cymbopogon schoenanthus</i>	<i>Citrullus colocynthis</i> [53]	<i>Mentha longifolia</i> [53]	<i>Sesamum indicum</i> [53]
<i>Glebionis coronaria</i>	<i>Cucumis melo</i> [53]	<i>Nigella sativa</i> [53]	<i>Sorghum bicolor</i> [53]
<i>Leptadenia pyrotechnica</i>	<i>Eruca vesicaria</i> subsp. <i>sativa</i> [52,53]	<i>Ocimum basilicum</i> [53]	<i>Suaeda maritima</i> [53]
<i>Opuntia ficus-indica</i>	<i>Ficus carica</i> [53]	<i>Olea europaea</i> [53,54]	<i>Tamarindus indica</i> [53]
<i>Panicum turgidum</i>	<i>Ficus palmata</i> [52–54]	<i>Origanum syriacum</i> [53]	<i>Ziziphus spina-christi</i> [51,53]
<i>Prunus arabica</i>	<i>Hibiscus sabdariffa</i> [53]	<i>Phoenix dactylifera</i> [51,53]	
<i>Raphanus raphanistrum</i>	<i>Hyphaene thebaica</i> [51,53,54]	<i>Portulaca oleracea</i> [53]	
<i>Saccharum spontaneum</i>	<i>Lactuca serriola</i> [53]	<i>Pulicaria incisa</i> [53]	

Table 6. Similar WEPs used in neighboring countries (Yemen and Oman; 6 WEPs) and other Asian and African countries (5 WEPs).

Same WEP Used in Neighboring Countries (Yemen and Oman)	Same WEP Used in Other Asian and African Countries
<i>Ficus palmata</i> Yemen [56]	<i>Ficus palmata</i> Pakistan [102]; Ethiopia [103]
<i>Lactuca serriola</i> Yemen [56]	<i>Lactuca serriola</i> L. Turkey [104]; Libya [105]
<i>Opuntia ficus-indica</i> Yemen [56]	<i>Opuntia ficus-indica</i> Algeria [106]; Ethiopia [103]; Libya [105]
<i>Portulaca oleracea</i> Yemen [56]; Oman [107]	<i>Portulaca oleracea</i> Jordan [108]; Palestine [74]; Lebanon [109]; Iraq [110]; Turkey [104]; Egypt [111]; Libya [105]; Morocco [111]; Sudan [112]; Somalia [113]
<i>Rumex nervosus</i> Yemen [56]	<i>Ziziphus spina-christi</i> Soqatra [114]; Angola [115]; Ethiopia [7]; Libya [105]; Egypt [111]; Sudan [77]; Palestine [74]; Tunisia [116]; Morocco [117]
<i>Ziziphus spina-christi</i> Yemen [56]; Oman [107]	

Based on the research that is currently available, there is little available ethnobotanical data for WEPs in Arab nations. Studies with a large survey were conducted in Libya [105]; Jordan [108]; Palestine [74]; Lebanon [109]; Iraq [110]; Egypt [111]; Morocco [111,117]; Sudan [77,112]; Somalia [113] and Tunisia [116]. However, significant variation was observed in the kind of plants employed compared to these Arab nations. Even though Arab nations share many linguistic and cultural traits with the KSA, they differ greatly in terms of geography and climate. Because of this, there are notable distinctions between the flora of Makkah and that of the Arab nations. Consequently, there are only four species of common WEPs that are known to be used in Arab nations. These include Libya (three WEPs, *Lactuca serriola*, *Opuntia ficus-indica*, *Portulaca oleracea*), Palestine, Egypt, Morocco, and Sudan (two species for each, *Portulaca oleracea*, *Raphanus raphanistrum*); and Jordan,

Lebanon, Iraq, and Somalia (one species for each; *Portulaca oleracea*) and Tunisia (one species, *Raphanus raphanistrum*; Table 6).

Other Asian and African countries showed the low number of shared WEPs recorded in Makkah, including Pakistan (one species) *Ficus palmata*, Turkey (two species) *Lactuca serriola* and *Portulaca oleracea*, Ethiopia (three species) *Ficus palmata*, *Opuntia ficus-indica*, and *Ziziphus spina-christi* (Table 6). *Ziziphus spina-christi* and *Portulaca oleracea* are commonly utilized in numerous surrounding and regional nations, as mentioned (Tables 5 and 6). Their high nutritional value, proximate composition, and energy content may be the cause of this [56].

3.10. Novel Ethnobotanical Findings

To evaluate the uniqueness of the WEPs found in this study, a comparison with prior studies on WEPs in KSA, neighboring countries including (Yemen and Oman), regional countries, African countries, Asian countries, and Arab countries was carried out. This investigation yields a number of novel results that support the current corpus of information regarding WEPs in the study area. It is noteworthy that 11 of the 41 WEPs detected in this study have never been documented in KSA; these are indicated in bold in (Tables 2 and 5). Additionally, 10 of the 41 WEPs detected in this study have never been documented in neighboring countries (including Yemen and Oman), regional countries, African countries, Asian countries, or Arab countries; these are indicated in bold in (Tables 2 and 6). The identification of 11 new species of WEPs expands the KSA's inventory of WEPs and emphasizes the significance of conducting more research into the rich plant diversity of the nation. This study highlights the potential to bolster local food security by recording new applications and species of newly identified edible plants, hence diversifying diets and enhancing nutrition in local communities.

Our findings indicate that the local population in Makkah has substantial indigenous knowledge on WEPs. This is demonstrated by the substantial variety of novel native wild edible species. The documented WEPs are a significant component of the historical, biological legacy, and cultural identity of KSA. Consequently, they are crucial for safeguarding and revitalizing Indigenous knowledge, culture, and identity. Furthermore, these plants are crucial to people's food security, particularly in times of food scarcity brought on by a variety of factors. For example, during the COVID-19 pandemic, the prevalence of using edible plants in Taif-KSA increased [118]. Additionally, the public's health benefits from these wild plants. For instance, one of the most often mentioned salients utilized by Makkah women for respiratory, gynecological, endocrine, and nutritional purposes is *Cuminum cyminum* [43]. *Cymbopogon schoenanthus* was also used by Makkah women to treat urinary, digestive, and neurological conditions [43]. Furthermore, wild plants are essential for supporting ecosystems and ensuring ecological stability and balance in KSA [119]. In light of the serious issues of food insecurity and climate change, incorporating WEPs into the diet has far wider implications for environmental sustainability. It may also reduce agricultural footprints and facilitate the transition to more sustainable food systems [120].

4. Conclusions

This is the inaugural ethnobotanical investigation of traditional knowledge of WEP species in Makkah, KSA. The study presents findings on 41 native WEP species consumed by local people in Makkah, KSA. Local inhabitants in the study area have a robust connection with WEP species, utilizing them for nutritional purposes as part of their traditional culture. In addition, multiple WEP species were found to be used as traditional medicines, animal fodder, furniture, natural dye, for ornamental and thatching purposes, as well as in brooms, construction, forage, and shade. Therefore, WEPs necessitate prudent utilization and specific conservation efforts from all stakeholders to ensure their sustainable use

in the future. This study suggests a number of strategies for the future management of WEPs that could be used to improve sustainable food security in KAS. First and foremost, recording traditional knowledge related to using indigenous wild plants as sustenance would help with the preservation of related indigenous knowledge for future generations. The second proposed strategy involves creating campaigns to raise awareness. The third involves the domestication of edible wild plants for household gardens and the creation of nurseries for seedlings of wild food plants, which would facilitate on-site conservation. Moreover, the documented WEPs must be validated by additional research on their toxicity assessment, nutritional analysis, antioxidant activity, and phytochemical composition. In conclusion, WEPs are precious resources in KSA that may support sustainable community development, guarantee food security, and safeguard the environment.

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Informed Consent Statement: Before a formal interview was conducted, verbal or prior informed consent was sought and obtained from the individual informants concerned, who were clearly briefed about the objectives of the study.

Data Availability Statement: All data are included in the article.

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Conflicts of Interest: The author declares no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

KSA	Kingdom of Saudi Arabia.
WEPs	Wild edible plants.
WEP	Wild edible plant.
F	Frequencies.
RFC	Relative frequency of citation.

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