

Research Article

The Beekeeping State and Inventory of Mellifero-Medicinal Plants in the North-Central of Morocco

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This study aims to determine the diversity of melliferous plants and to recognize the state of beekeeping in the Fez-Meknes region in Morocco. We conducted a questionnaire for beekeepers that set up their hives in the prefectures and provinces of the region, and we have studied the pharmacological evidence of the most preferred plants by beekeepers to assess its medicinal values. The results indicate that honey, bee pollen, bee bread, royal jelly, propolis, bee wax, bee venom, and bee queens are produced in this region with different percentages, and 102 plants belonging to 32 families were obtained in the inventory of melliferous plants; the most represented families were Asteraceae and Lamiaceae (13.73% each) followed by Rosaceae (8.82%). Among these 102 plants identified, 79 plants provide nectar and pollen for bees, 16 plants provide only pollen, 3 plants provide only nectar, 35 plants are resinous, and 6 plants provide honeydew for bees. The outcome of this study will contribute to the valuation of melliferous plants and help to establish a practical guide for the development of the beekeeping sector as an agricultural economic approach.

1. Introduction

Beekeeping is the art and science of breeding and caring for bees to exploit their products such as honey, bee pollen, bee bread, bee wax, bee venom, royal jelly, and the bee queens. It is a branch of agriculture that has been practiced for thousands of years by traditional methods, and it has evolved and modernized over the years [1]. Beekeeping is one of the essential pillars of agricultural development in Morocco, especially in the Fez-Meknes region where agriculture accounts for nearly half of the regional gross domestic product. The breed of bees that exists in Fez-Meknes is *Apis mellifera intermissa*; it is swarming with an aggressive behavior and is characterized by a good production of honey. This breed is famous for the overproduction of propolis, as well as enduring climate variations [2, 3]. In order to cover its nutritional and preventive needs, the bee collects substances including nectar, pollen, oil, and resin from plants that are highly attractive to them and also exudates of plant-sucking

insects to produce honeydew where the hive products are reflected through the quantity and quality of the pollinated plants. These melliferous plants vary from one area to another depending on the biotic, climatic, and ecological factors [4].

Bees search for melliferous plants not only in forests, grasslands, ruderal, and marshy vegetation but also in agrophytocenoses, such as orchards, vineyards, rapeseed, sunflower, and alfalfa crops, or in medicinal plant plantations and aromatics [5]. By pollinating melliferous plants, bees play a vital role in achieving plant fertilization and in conserving biodiversity. As pollinators, bees are useful as samplers of the environment in which they are conserved and have been used as bioindicators of ecosystem's health. Bees in search of food can cover up to eight kilometers of radii for pollen, nectar, and resinous plant substances [6]. Encouraging beekeeping means strengthening agriculture and thus helping people to become less vulnerable to poverty [7]. To establish a detailed mapping of melliferous plants in

Fez-Meknes, we conducted a questionnaire for professional beekeepers that set up their hives in the prefectures and provinces of the region. The objective of this study is to determine the richness of the Fez-Meknes region in melliferous plants and to highlight the state of beekeeping favoring the development and evolution of the bee sector.

2. Materials and Methods

2.1. Area of the Study. The region of Fez-Meknes is located in the northern center of Morocco (34° 02'00 "north, 500'00" west), integrating part of the Saïss plain alongside the mountain ranges of the Rif and the Middle Atlas, and it stretches over an area of 40.075 km² representing 5.7% of the national territory. It is geographically limited by the Tangier-Tetouan-Al Hoceima region in the north, the Rabat-Sale-Kenitra region in the west, the Oriental region in the east, the Beni Mellal-Khenifra region in the southwest, and the region of Drâa-Tafilelet in the South [8].

The Fez-Meknes region includes nine prefectures and provinces: the prefecture of Fez, the prefecture of Meknes, the province of Boulemane, the province of Sefrou, the province of Moulay Yacoub, the province of Taounate, the province of Taza, the province of El Hajeb, and the province of Ifrane (Table 1 and Figure 1).

Based on the information given by the beekeepers and the data described elsewhere [8–10], the predominant vegetation in Fez is *Olea europaea* L var. sativa (cultivated), *Ceratonia siliqua* L (cultivated), *Capparis spinosa* L (cultivated), *Myrtus communis* L (native), and *Silybum marianum* (L.) Gaertn (native); the predominant vegetation in Meknes is *Olea europaea* L var. sativa (cultivated), *Capparis spinosa* L (cultivated), *Silybum marianum* (L.) Gaertn (native), *Mentha* spp. (cultivated), and *Ammi visnaga* (L.) Lam (native); the predominant vegetation in Boulemane is *Bupleurum spinosum* Gouan (native), *Peganum harmala* L (native), *Thymus vulgaris* L (native), and *Rosmarinus officinalis* L (native); the predominant vegetation in Sefrou is *Prunus cerasus* L (cultivated), *Prunus domestica* L (cultivated), *Ceratonia siliqua* L (cultivated), *Olea europaea* L var. sativa (cultivated), *Ruta graveolens* L (native), and *Quercus ilex* L (native); the predominant vegetation in Moulay Yacoub is *Capparis spinosa* L (cultivated), *Olea europaea* L var. sativa (cultivated), *Myrtus communis* L (native), *Ammi visnaga* (L.) Lam (native), *Silybum marianum* (L.) Gaertn (native), and *Agave sisalana* Perrine (cultivated); the predominant vegetation in Taounate is *Olea europaea* L var. sativa (cultivated), *Crataegus monogyna* Jacq (native), *Ficus carica* L (cultivated), *Ceratonia siliqua* L (cultivated), *Matricaria chamomilla* L (native), *Origanum vulgare* L (native), and *Prunus domestica* L (cultivated); the predominant vegetation in Taza is *Olea europaea* L var. sativa (cultivated), *Ceratonia siliqua* L (cultivated), *Arbutus unedo* L (native), *Tetraclinis articulata* (Vahl) Mast (native), *Quercus ilex* L (native), *Pinus halepensis* Mill (native), *Quercus suber* L (native), *Cedrus atlantica* (Manetti ex Endl) (native), *Rosmarinus officinalis* L (native), *Globularia alypum* L (native), *Ziziphus lotus* (L.) Lam (native), and *Ditrichia viscosa* (L.) Greuter (native); the predominant

vegetation in El-Hajeb is *Ammi visnaga* (L.) Lam (native), *Myrtus communis* L (native), *Silybum marianum* (L.) Gaertn (native), *Thymus vulgaris* L (native), and *Crataegus monogyna* Jacq (native); and the predominant vegetation in Ifrane is *Thymus vulgaris* L (native), *Origanum vulgare* L (native), *Lavandula angustifolia* Mill (native), *Cedrus atlantica* (Manetti ex Endl) (native), and *Pinus halepensis* Mill (native).

2.2. Data Collection. In order to facilitate data collection for this study, 132 beekeepers were interviewed using a questionnaire focused on information about the beekeeper: gender, education level, age group, and duration of experience; information on the apiary: the number of hives, the amount of honey produced annually/hive, and other apicultural products provided by each beekeeper, as well as the prefecture or the province in the region Fez-Meknes preferred by the beekeeper for installing their apiary; and information on the honey plants that exist in each prefecture and province of the Fez-Meknes region: we asked beekeepers to give us a list of melliferous plants. Thus, we collected data on the information about the apicultural importance of each plant listed. The vernacular name of the plants was given by the beekeepers, and the scientific name was identified following Bellakhdar and Aafi et al. [11, 12].

Registration of all plant species observed by beekeepers was carried out throughout the year in the nine prefectures and provinces represented by the Fez-Meknes region. Each source has been identified by its vernacular name, scientific name, and botanical family. The average date of the flowering period of each plant and the apicultural value as a source of nectar and/or pollen, resin, and honeydew were recorded.

2.3. Data Analysis. Data were entered as codes in MS Windows Excel and then transferred to SPSS version 21 statistical analysis software.

3. Results and Discussion

3.1. Characterization of the Beekeeping Sector

3.1.1. Information on Beekeepers and Their Apiaries. Beekeeping in Morocco has experienced a very important development in recent years, thanks to the contribution of the Morocco Green Plan [3]. Therefore, many people approach this activity with different motivations and interests. The results of this survey illustrated in Figure 2 show that all interviewees are professional beekeepers and beekeeping is their main source of economic income. The bee hive products especially honey is marketed through traditional circuits (localized souks in production areas and others local outlets, urban markets, and roadsides in the production areas) and modern circuits (supermarkets, hotels and tourist camps, and electronic services). In addition, the household income of the surveyed beekeepers increases positively during the International Exhibition of Agriculture organized annually in Meknes, which gives a valuable opportunity for

TABLE 1: Climatic and geographical information of the Fez-Meknes region.

Locality name	Latitude (N)	Longitude (W)	Altitude (m)	Pluviometry (mm)	Temperature (°C)
Fez	33°52'22.86"	5°32'26.63"	410	1-78	9.9 to 27.2
Meknes	33°52'22.86"	5°32'26.63"	546	2-93	9.8 to 25.9
Boulemane	33°21'46.3"	4°43'48.3"	1752	9-60	3.2 to 22.1
Sefrou	33°49'49.89"	4°50'7.14"	823	2.4-62.7	9.2 to 26.3
Moulay Yacoub	34°5'14.81"	5°10'42.25"	238	1-85	6 to 36
Taounate	34°32'12.9"	4°38'23.53"	600	1-101	9.1 to 26.5
Taza	34°12'38.02"	3°59'52.97"	550	2-91	9.5 to 28.2
El-Hajeb	33°41'8.65"	5°22'4.02"	1000	4-106	7 to 24.5
Ifrane	33°31'22.1"	5°6'39.44"	1664	8-122	2.7 to 21.8

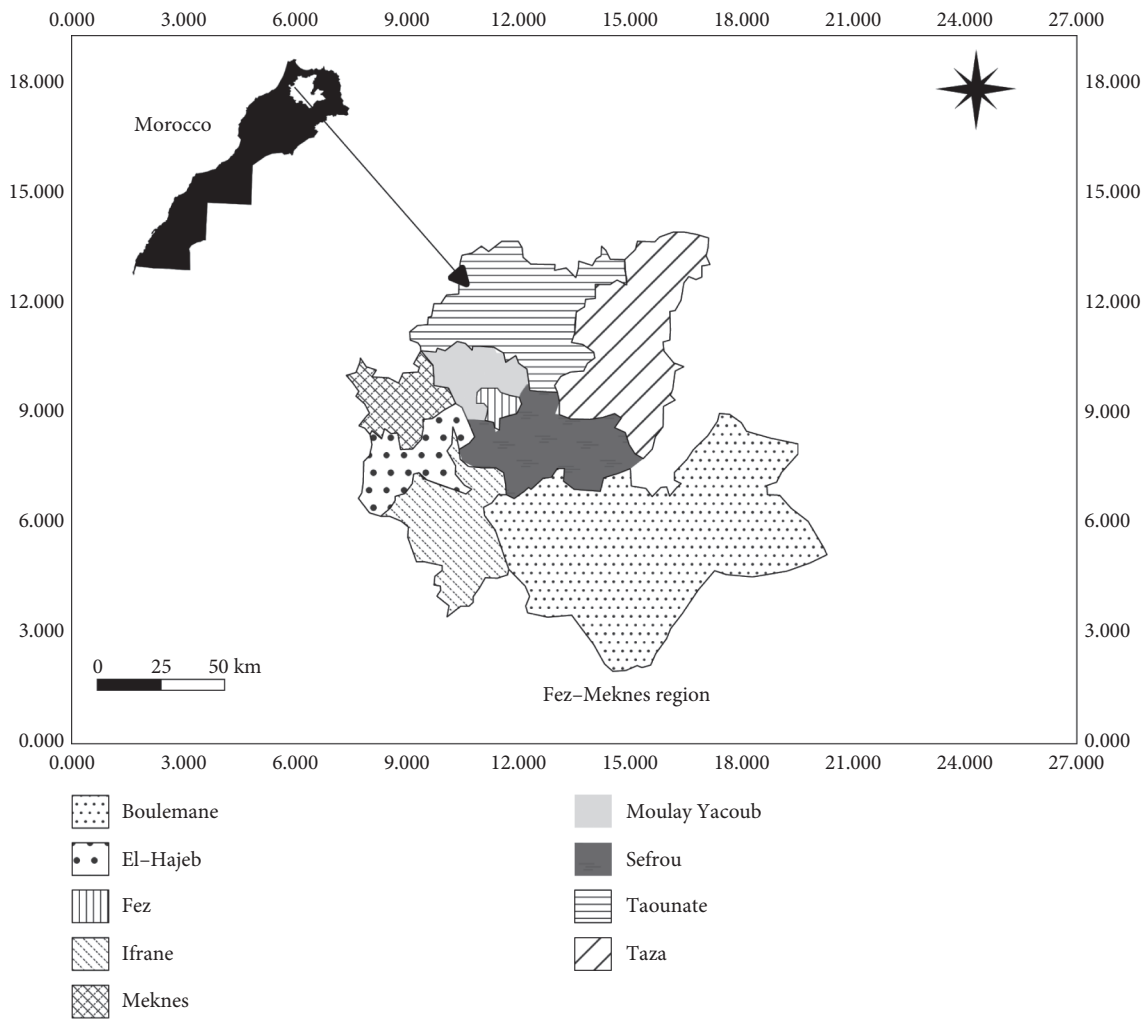


FIGURE 1: Map representation of area of the study.

the marketing of their products. Concerning the beekeepers gender, 98.48% is male and 1.52% is female, thus confirming a male predominance, which agrees with the results of Khabbach et al. [9] who showed that 90.9% of surveyed beekeepers in the pre-Rif region (Morocco) was male and only 9.1% was female, and this is because the beekeeping as a profession is relatively hard for women [13]. According to the opinion of the surveyed women in our study, the difficulty of beekeeping profession manifests mainly in the transhumance activity, which is done only at night and

requires a high physical effort. The age range of the beekeepers questioned is the following: 50% of beekeepers are between 40 and 60 years old, 39.39% between 20 and 40 years, and 10.61% older than 60 years.

The school-level of the beekeepers surveyed is as follows: 31.82% have a secondary education level followed by 22.73% who are unschooled, 21.21% have a university education, 13.64% have a primary education, and 10.61% have a level of college education. These results affirm the importance of the academic and intellectual level in the apicultural practice,

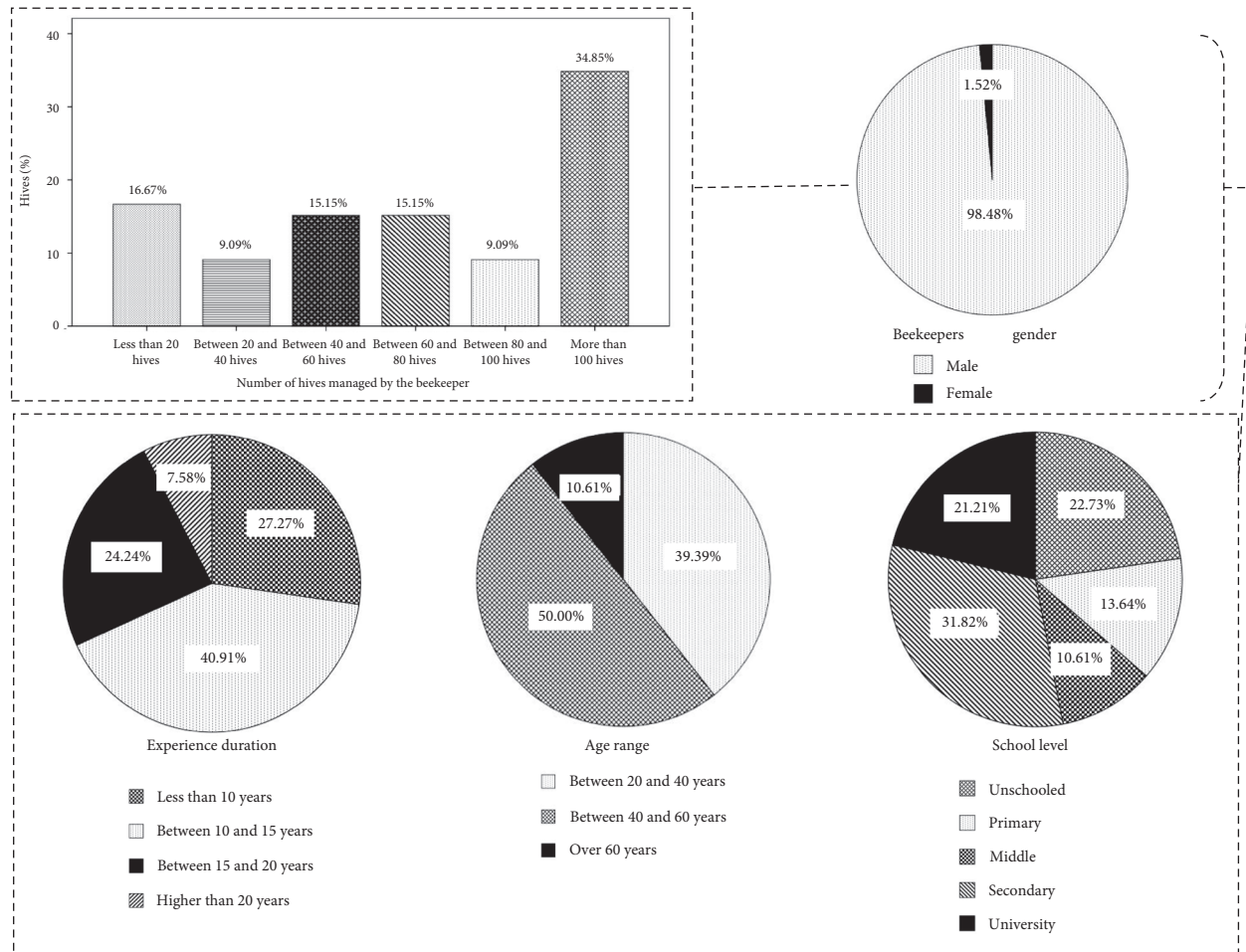


FIGURE 2: General information on beekeepers and their apiaries.

which requires a fundamental knowledge of melliferous flora and their relationship with environmental factors [14]. Concerning the years of experience in beekeeping, 40.91% of the beekeepers questioned have an experience between 10 and 15 years, 27.27% have an experience of less than 10 years, 24.24% of beekeepers have an experience between 15 and 20 years, and 7.58% of beekeepers have an experience more than 20 years. Concerning the number of hives in apiaries, 34.85% of the beekeepers surveyed manage apiaries made up of more than 100 hives, 16.67% have apiaries with fewer than 20 hives, 15.15% of beekeepers have apiaries made up of 40–60 hives, 15.15% of beekeepers have apiaries made up of 60–80 hives, 9.09% have between 80 and 100 hives, and 9.09% have an apiary made up of 20–40 hives. These results illustrate the region’s potential and its contribution to the national honey production.

3.1.2. The Preferred Locations by Beekeepers in the Fez-Meknes Region to Put Their Beehives. Regarding the location preferred by the beekeeper for the installation of hives in the Fez-Meknes region (Figure 3), 21.21% of beekeepers prefers Sefrou, 18.18% prefers Taza 12.12% prefers Taouinate, 12.12% prefers Boulemane, 12.12% prefers Meknes, 9.09% prefers Ifrane, 6.06% prefers El-Hajeb, 4.55% prefers Moulay

Yacoub, and 4.55% prefers Fez. The choice of the installation area was based on the climatic characteristics, the type of vegetation, and the increased market demand for certain types of monofloral honey such as carob (*Ceratonia siliqua* L), arbutus (*Arbutus unedo* L), oregano (*Origanum vulgare* L), and jujubier (*Ziziphus lotus* (L.) Lam) honeys.

3.1.3. Types of Bee Products Supplied by Beekeepers. Concerning bee products supplied by beekeepers (Figure 4) and (Table 2), 10.77% of beekeepers produced and marketed only honey, while 89.23% produced and marketed honey and other bee products by the following percentages: 83.30% bee wax, 63.60% fresh bee pollen, 43.90% propolis, 22.70% dry bee pollen, 15.20% bee queens production, 7.60% royal jelly, 4.50% bee venom, 3% fresh bee bread, and 0% dry bee bread.

Among the famously used hive products, honey is the one that leads the list; hence, it is known that the beekeeping sector is essentially interested in the production and marketing of honey, in the second position is the bee wax, a very high percentage of beekeepers who have been surveyed (83.30%) produce bee wax, and the majority of the production is for hive recycling purposes, in the third place, we find the fresh bee pollen, followed by propolis in fourth.

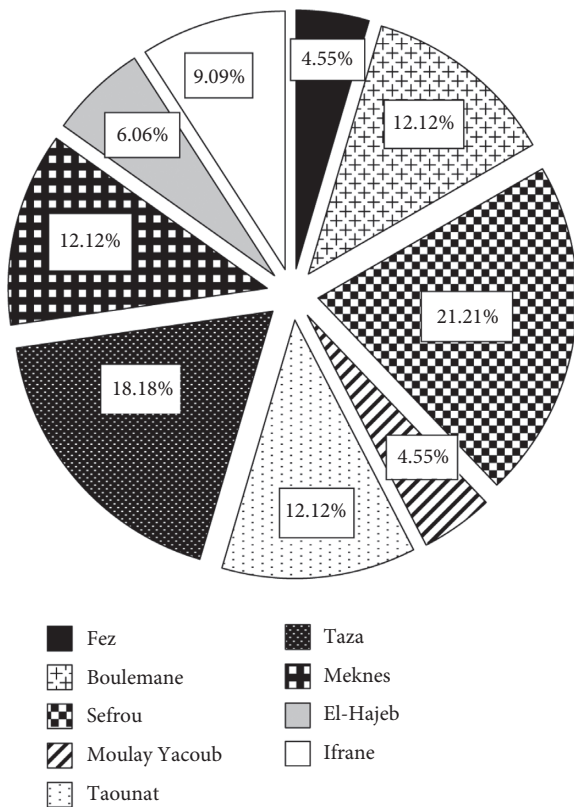


FIGURE 3: Distribution of beehive installation locations in the Fez-Meknes region.

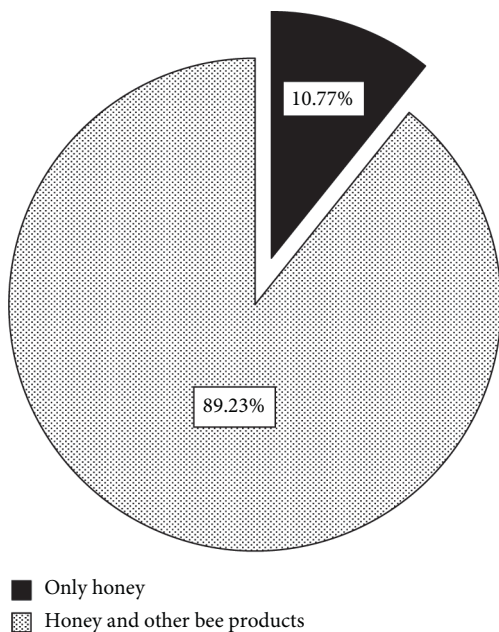


FIGURE 4: Percentages of honey and others bee hive production.

Since the surveyed population has a relatively high educational level, we observed that they are very well aware of the nutritional and therapeutic values of the other hive products such as bee pollen and especially fresh bee pollen, propolis,

royal jelly, bee bread, and bee venom, but these last three products are poorly produced in the Fez-Meknes region and even throughout the Moroccan territory due to the difficulties encountered in the production and harvesting of these products. For instance, the royal jelly implies the breeding of the queens and requires precise techniques to keep its therapeutic value, which is very sensitive to temperatures above 4°C [15]; similarly, for bee venom, that requires specific devices introduced to the entrance of the hive that cause a weak electric field and stimulates the bees to release the venom on the device [16]. Furthermore, the fresh bee bread is rarely produced in the region; the percentage of production is only 3%, and this is because most beekeepers do not master correctly its harvesting technique without destroying a part of the hive while doing so [17]. Moreover, the pharmacological benefits of this product are recently discovered, and it is still unknown to the public [18–21].

3.1.4. Annual Honey Production per Hive. Annual honey production per hive in Fez-Meknes is presented in Figure 5; the results indicate that 89.39% of apiaries produce less than 20 kg of honey per hive, 7.58% of apiaries produce between 20 kg and 40 kg of honey per hive, and 3.03% of apiaries produce between 40 kg and 60 kg of honey per hive. These findings show low honey production in the region; this may be due to *Varroa mites*’ infection and bee poisoning by insecticides and climatic changes [22–24].

3.2. Taxonomic Diversity of Melliferous Plants in the Fez-Meknes Region. The information obtained by the beekeepers from the bee’s foraging observations around the apiary made it possible to identify 102 melliferous plants belonging to 32 families (Figure 6). The most represented families in the established list of melliferous plants is the Asteraceae family with a percentage of 13.73% and Lamiaceae 13.73%, Rosaceae 8.82%, Apiaceae 7.84%, Rutaceae 6.86%, Fabaceae 5.88%, Cupressaceae 4.90%, Boraginaceae 4.90%, Cistaceae 2.94%, Fagaceae 2.94%, Moraceae 2.94%, Geraniaceae 1.96%, Papaveraceae 1.96%, and Pinaceae 1.96%. In a study published by Ennabili et al. (2000), the inventory of honey plants from the Mokrisset region (NW of Morocco) showed the presence of 78 species belonging to 35 families, and 48.7% of them corresponded to five families: Labiatae, Compositae, Rosaceae, Leguminosae, and Ericaceae [25]. In another study carried out in the central Rif region of Morocco, the most important taxa used by honeybees for nectar and/or pollen were *Ammi visnaga* (L.) Lam, *Mentha* spp., *Eucalyptus camaldulensis* Dehnh., *Rubus ulmifolius* Schott, *Cannabis sativa* L, various grasses, and *Cistus* spp. [26].

Among the plants listed, we found 28 trees, 26 shrubs and undershrubs, 46 herbaceous plants, and 2 bulbs. 79 of these plants are classified as nectariferous and polliniferous; hence, they supply bees with pollen and nectar. 16 are polliniferous and they supply bees with pollen only, 3 are nectariferous and they supply bees with nectar only, 35 are resinous and they supply bees with resin, and 6 are honeydew plants and they supply bees with honeydew [14].

TABLE 2: Types and percentages of bee hive production.

	Honey (%)	Fresh bee pollen (%)	Dry bee pollen (%)	Fresh bee bread (%)	Dry bee bread (%)	Royal jelly (%)	Propolis (%)	Bee wax (%)	Bee venom (%)	Production of bee queens (%)
The percentage of production	100	63.60	22.70	3	0	7.60	43.90	83.30	4.50	15.20

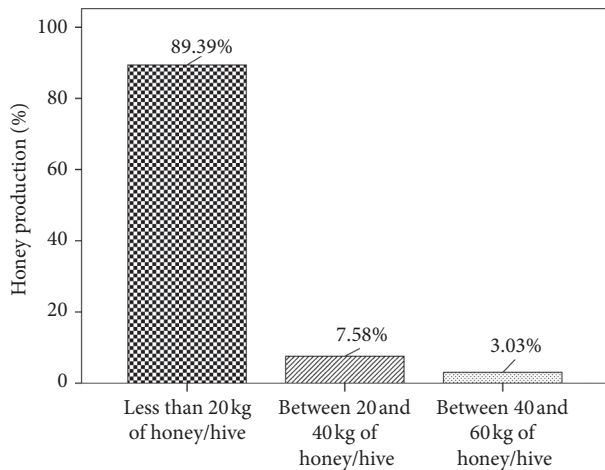


FIGURE 5: Annual honey production per hive.

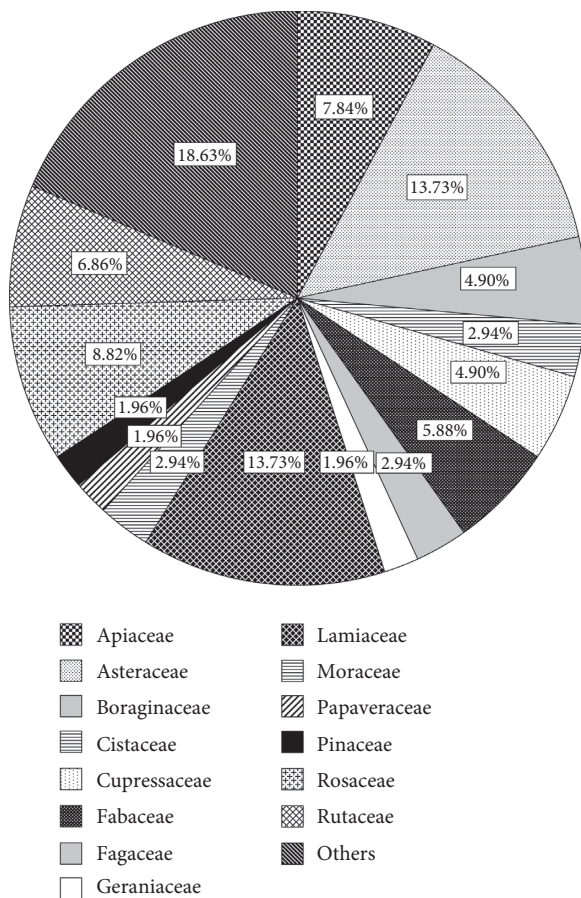


FIGURE 6: The most representative families of melliferous plants.

Sedentary beekeeping is the kind of beekeeping practiced by a traditional beekeeper or agri-beekeeper who leaves his hives in the same place and does not move them throughout the year. The bee’s harvest radius in this type of beekeeping does not exceed 2-3 kilometers. This limits the production of the apiary. On the other hand, pastoral or transhumant beekeeping aims to move hives from site to site from 50 km to 500 km depending on the rate of flowering in melliferous regions [3]. The flowering period of the plants mentioned in the list (Table 3) varies according to the species; it spreads over the whole year from January until December. All beekeepers interviewees in this study are professional, and these conditions favor transhumance practices for them.

Regarding the type of melliferous plants preferred by beekeepers for the installation of hives (Table 4), 100% of beekeepers prefer to install their hives near nectariferous plants because they know the importance of this type of plants for honey production. In addition to nectariferous plants, 83.30% of beekeepers also prefer polliniferous plants, while 25.80% prefer resinous plants, and only 6% of beekeepers prefer honeydew plants. From these results, we can see that the beekeepers of Fez-Meknes know the importance of polliniferous and resinous plants to bees, considering the role of pollen and propolis for hives and bees’ health, as well as for the marketing of these products in the region that are recently studied and consequently revealed to be rich in bioactive molecules with protective and therapeutic interest [10, 19, 27–29].

3.3. The Best Melliferous Plants and Their Medicinal Values. Regarding the opinion of beekeepers on the best vegetation that produce a good quality of propolis, most of them mentioned the following plants: *Pistacia lentiscus*, *Ferula communis*, *Populus alba*, *Pinus halepensis*, *Cedrus atlantica*, *Eucalyptus globulus*, *Ficus carica*, *Juniperus thurifera*, and *Tetraclinis articulata*. For the best nectariferous plants, the interviewed beekeepers cited the following plants: *Capparis spinosa*, *Calendula officinalis*, *Arbutus unedo*, *Ceratonia siliqua*, *Citrus* genus, *Bupleurum spinosum*, *Lavandula angustifolia*, *Lavandula multifida*, *Rosmarinus officinalis*, *Salvia officinalis*, and *Thymus vulgaris*. While for the good plants that provide the best pollen to bees, they have listed the following plants: *Capparis spinosa*, *Calendula officinalis*, *Prunus dulcis*, *Opuntia ficus-indica*, *Silybum marianum*, *Carthamus tinctorius*, *Centaureum erythraea*, and *Pelargonium odoratissimum*.

According to several studies, as shown in Table 5, the most preferred melliferous plants by beekeepers have a potent and large biological activities including antioxidant,

TABLE 3: Continued.

Type of plant	Family	Scientific name	Vernacular name	Flowering period												Beekeeping interest				Area of existence																					
				J	F	M	A	M	J	J	A	S	O	N	D	P	N	H	R	Taounate	My-yacoub	Fez	Meknés	Taza	Séfrou	El-hajeb	Ifrane	Boulemane													
Herbaceous plants	Apiaceae	<i>Pimpinella anisum</i> L	Habbathlawa																																						
	Asteraceae	<i>Achillea odorata</i> L	Šwihiya																																						
		<i>Anthemis pedunculata</i> Desf	Nouar eljenna																																						
		<i>Artemisia herba alba</i> Asso	Chih, izri, ifsi, ifssi																																						
		<i>Calendula officinalis</i> L	Jemra																																						
		<i>Cnicus benedictus</i> L	Holaiba																																						
		<i>Dittrichia viscosa</i> (L.) Greuter	Tirhla, magraman																																						
		<i>Anacyclus clavatus</i> (Desf.) Pers	Kra' ed-djaja																																						
		<i>Anacyclus pyrethrum</i> (L.) Link	Tignest; aoujdem																																						
		<i>Anacyclus radiatus</i> Loisel	Hallala																																						
		<i>Carthamus tinctorius</i> L	Laasfar																																						
	<i>Matricaria chamomilla</i> L	Babounj																																							
Herbaceous plants	Asteraceae	<i>Scolymus maculatus</i> L	Jarneij																																						
		<i>Scolymus hispanicus</i> L	Guernina																																						
		<i>Silybum marianum</i> (L.) Gaertn	Chouk																																						
	Boraginaceae	<i>Echium creticum</i> L	Lisân et-tûr																																						
		<i>Brassica napus</i> L	Colsa																																						
		<i>Diplotaxis harra</i> (Forssk.) Boiss	Lhara																																						
		<i>Eruca sativa</i> Mill	Bouhamou																																						
		<i>Sinapis arvensis</i> L	Moutarde																																						
	Fabaceae	<i>Medicago sativa</i> L	El fessa																																						
		<i>Ononis natrix</i> L	Fezaz																																						
		<i>Trifolium pratense</i> L	Nefla																																						
	Geraniaceae	<i>Centaurium erythraea</i> Rafn	Qessat lhayya																																						
		<i>Pelargonium odoratissimum</i> (L.) L'Hér	Elaetercha																																						
		Iridaceae	<i>Iris germanica</i> L	Elbouk																																					
			<i>Ajuga iva</i> (L.) Schreb	Chendkoura																																					
Lamiaceae	<i>Marrubium vulgare</i> L	Mriwa																																							
	<i>Mentha piperita</i> L	Naâna felfi																																							
	<i>Mentha pulegium</i> L	Flyou																																							
	<i>Mentha rotundifolia</i> L	Mchichtrou																																							
Herbaceous plants	Lamiaceae	<i>Mentha spicata</i> L	Naânaâ beldi																																						
		<i>Mentha viridis</i> L	Naânaâ																																						
		<i>Origanum majorana</i> L	Mardadouch																																						
		<i>Origanum vulgare</i> L	Zaâtar																																						
		<i>Malva sylvestris</i> L	Khobeyza																																						
	Papaveraceae	<i>Fumaria officinalis</i> L	Newar elhaya																																						
		<i>Papavers rhoeas</i> L	Belaaman																																						
		<i>Verbascum sinuatum</i> L	Slah lendar																																						
	Zygophyllacées	<i>Peganum harmala</i> L	Harmal																																						
	Bulb	Amaryllidaceae	<i>Narcissus tazetta</i> L	Twima																																					
		Liliaceae	<i>Urginea maritima</i> (L.) Baker	Elbessila																																					

Flowering period: J, January; F, February; M, March; A, April; M, May; J, June; J, July; S, September; N, November; D, December. Beekeeping interest: P, pollen; N, nectar; H, honeydew; R, resin.

TABLE 4: Type of plants preferred by beekeepers for the installation of hives.

Type of plants preferred	Nectariferous plants (%)	Polliniferous plants (%)	Resinous plants (%)	Honeydew plants (%)
Percentage	100	83.30	25.80	6

antidiabetic, anticancer, antifungal, anti-inflammatory, and diuretic effects. It has been previously reported that the medicinal properties of bee products are highly dependent on many factors, including their botanical origins [74]; in

fact, the diversity of their botanical sources gives them a wide range of pharmacological activities that can provide consumers a functional food product with therapeutic benefits.

TABLE 5: Review of the pharmacological evidence of the best melliferous plants existed in the Fez-Meknes region according to the beekeeper's opinion.

Type of plant	Scientific name	Pharmacological evidence
Resinous plants	<i>Cedrus atlantica</i> (Manetti ex Endl)	Antimicrobial effect [30]
	<i>Ferula communis</i> L	Antimicrobial and anticancer effects [31, 32]
	<i>Ficus carica</i> L	Antioxidant, antimicrobial, and anticancer effects [33, 34]
	<i>Eucalyptus globulus</i> Labill	Antioxidant, antifungal, and antimicrobial effects [35, 36]
	<i>Juniperus thurifera</i> L	Antioxidant and antibacterial effects [37, 38]
	<i>Pinus halepensis</i> Mill	Antioxidant and antibacterial effects [39, 40]
	<i>Pistacia lentiscus</i> L	Antioxidant, antidiabetic, and hepatoprotective effects [41, 42]
	<i>Populus alba</i> L	Antioxidant effect [43, 44]
	<i>Tetraclinis articulata</i> (Vahl) Mast	Antioxidant, antibacterial, anti-inflammatory, and cytotoxic effects [45–47]
	<i>Arbutus unedo</i> L	Antioxidant, antibacterial, anti-inflammatory, and antiaggregating effects [48–50]
Nectariferous plants	<i>Bupleurum spinosum</i> Gouan	Antioxidant effect [51]
	<i>Calendula officinalis</i> L	Healing and antimicrobial effects [52, 53]
	<i>Capparis spinosa</i> L	Antioxidant, hepatoprotective, and antidiabetic effects [54, 55]
	<i>Ceratonia siliqua</i> L	Antigenotoxic, antioxidant, antibacterial, and anticancer effects [34, 56, 57]
	<i>Citrus</i> spp	Antioxidant, vasodilator, antimicrobial, and antimutagen effects [58–61]
	<i>Lavandula angustifolia</i> Mill	Antioxidant effect [62]
	<i>Lavandula multifida</i> L	Anti-inflammatory effect [63]
	<i>Rosmarinus officinalis</i> L	Antihyperglycemic, antihyperlipidemic, and antioxidant effects [64]
	<i>Salvia officinalis</i> L	Antiproliferative effect [65]
	<i>Thymus vulgaris</i> L	Antioxidant and anti-inflammatory effects [66]
Polleniferous plants	<i>Carthamus tinctorius</i> L	Antioxidant effect [67]
	<i>Centaureum erythraea</i> Rafn	Antioxidant and antimicrobial effects [68]
	<i>Opuntia-ficus-indica</i> (L.) Mill	Diuretic, antioxidant, and anti-inflammatory effects [69, 70]
	<i>Pelargonium odoratissimum</i> (L.) L'Hér	Antifungal effect [71]
	<i>Prunus dulcis</i> (Mill.) D.A. Webb	Antioxidant, antiproliferative, antibacterial, and antidiabetic effects [72, 73]

4. Conclusion

The consensus of melliferous plants in the Fez-Meknes region made it possible to draw up an inventory of these plants and classify them according to the ingredients that they provide to the bee (nectar, pollen, resin, and honeydew) and the realization of a beekeeping calendar according to the flowering rhythms of each plant. The Fez-Meknes region offers great beekeeping potential, mainly due to the diversity of melliferous plants, allowing transhumance practices. An accompanying beekeeping policy is necessary to allow the optimal use of natural resources and a revitalization of this sector in order to improve the standards of living of the local population. This study contributes to the promotion of the field of beekeeping and to the valorization of the melliferous plants in the Fez-Meknes region.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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References

- [1] R. Kohsaka, M. S. Park, and Y. Uchiyama, "Beekeeping and honey production in Japan and South Korea: past and present," *Journal of Ethnic Foods*, vol. 4, no. 2, pp. 72–79, 2017.
- [2] P. de la Rúa Tarín, S. Radloff, R. Hepburn, and J. Serrano, "Do molecular markers support morphometric and pheromone analyses?: a preliminary case study in *apis mellifera* populations of Morocco," *Archivos de Zootecnia*, vol. 56, no. 213, pp. 33–42, 2007.
- [3] A. Moujanni, A. K. Essamadi, and A. Terrab, "L'apiculture au Maroc: focus sur la production de miel," *International Journal of Innovation and Applied Studies*, vol. 20, no. 1, pp. 52–78, 2017.
- [4] C. M. Koudegnan, T. M. Etorh, A. K. Guelly, K. Batawilla, and K. Akpagana, "Inventaire des taxons polliniques des miels de la zone guinéenne du Togo: cas des zones ecofloristiques IV et V," *European Scientific Journal*, vol. 8, no. 26, 2012.
- [5] M. Macukanovic-Jocic and S. Jaric, "The melliferous potential of apiflora of southwestern Vojvodina (Serbia)," *Archives of Biological Sciences*, vol. 68, no. 1, pp. 81–91, 2016.
- [6] A. A. Ayansola, B. Adedoyin Davies, and B. Adedoyin Davies, "Honeybee floral resources in Southwestern Nigeria," *Journal of Biology and Life Science*, vol. 3, no. 1, 2012.
- [7] R. Gupta, W. Reybroeck, J. Van Veen, and A. Gupta, "Beekeeping for poverty alleviation and livelihood security," *Technological aspects of Beekeeping*, vol. 1, 2014.
- [8] Direction générale des collectivités locales and Ministre de l'intérieur, Royaume du Maroc, "A région de Fès-Meknès: monographie générale," 2015, <http://www.region-fes-meknes.ma/publications/monographie-de-la-region-fes-meknes/>.

- [9] A. Khabbach, M. Libiad, and A. Ennabili, "Melliferous flora and apiculture in the pre-Rif of the province of Taza (North of Morocco)," *Luna Azul*, vol. 36, pp. 78–90, 2013.
- [10] A. Terrab, B. Valdés, and M. J. Díez, "Study of plants visited by honeybees (*Apis mellifera* L.) in the Central Rif Region (N. Morocco) using pollen analysis," *Grana*, vol. 44, no. 3, pp. 209–215, 2005.
- [11] J. Bellakhdar, *La pharmacopée marocaine traditionnelle. Médecine arabe ancienne et savoirs populaires*, Ibis Press, Paris, France, 1997.
- [12] A. Aafi, M. Ghanmi, B. Satrani, M. Aberchane, R. Ismaili My, and A. EL Abid, "Diversité et valorisation des principales plantes aromatiques et médicinales (PAM) de l'écosystème cédrarie au Maroc," *Cent. Rech. For.* vol. 16, 2011.
- [13] S. Maderson and S. Wynne-Jones, "Beekeepers' knowledges and participation in pollinator conservation policy," *Journal of Rural Studies*, vol. 45, pp. 88–98, 2016.
- [14] E. Melin, *Botanique Apicole*, Ecole Apic. Région Wallonne Inst. Bot. Univ. Liege Belgium, 2011.
- [15] A. N. K. G. Ramanathan, A. J. Nair, and V. S. Sugunan, "A review on royal jelly proteins and peptides," *Journal of Functional Foods*, vol. 44, pp. 255–264, 2018.
- [16] S. Zhang, Y. Liu, Y. Ye et al., "Bee venom therapy: potential mechanisms and therapeutic applications," *Toxicon*, vol. 148, pp. 64–73, 2018.
- [17] A. Urcan, L. Al Marghitas, D. S. Dezmirean, and O. Bobis, "Chemical composition and biological activities of bee bread-review," *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca Animal Science and Biotechnologies*, vol. 74, no. 1, 2017.
- [18] M. Bakour, N. S. Al-Waili, N. El Menyiy et al., "Antioxidant activity and protective effect of bee bread (honey and pollen) in aluminum-induced anemia, elevation of inflammatory makers and hepato-renal toxicity," *Journal of Food Science and Technology*, vol. 54, no. 13, pp. 4205–4212, 2017.
- [19] M. Bakour, Á. Fernandes, L. Barros, M. Sokovic, I. C. F. R. Ferreira, and B. Lyoussi, "Bee bread as a functional product: chemical composition and bioactive properties," *LWT*, vol. 109, pp. 276–282, 2019.
- [20] B. Podrižnik and J. Božič, "Maturation and stratification of antibacterial activity and total phenolic content of bee bread in honey comb cells," *Journal of Apicultural Research*, vol. 54, no. 2, pp. 81–92, 2015.
- [21] Z. Abouda, I. Zerdani, I. Kalalou, M. Faid, and M. T. Ahami, "The antibacterial activity of Moroccan bee bread and bee-pollen (fresh and dried) against pathogenic bacteria," *Research Journal of Microbiology*, vol. 6, pp. 376–384, 2011.
- [22] V. Dietemann, F. Nazzi, S. J. Martin et al., "Standard methods for varroa research," *Journal of Apicultural Research*, vol. 52, no. 1, pp. 1–54, 2013.
- [23] Y. Le Conte, M. Ellis et al., "Varroamites and honey bee health: can Varroa explain part of the colony losses?" *Apidologie*, vol. 41, no. 3, pp. 353–363, 2010.
- [24] A. Noureddine, S.-E. Doumandji, and N. Haddad, "Situation de l'apiculture en Algérie: facteurs menaçant la survie des colonies d'abeilles locales *Apis mellifera* intermissa," *Cahiers Agricultures*, vol. 21, pp. 235–241, 2012.
- [25] A. Ennabili, N. Gharnit, and E. El Hamdouni, "Inventory and social interest of medicinal, aromatic and honey-plants from Mokrisset region (NW of Morocco)," *Popular Music Research Today Revista online de Divulgación Musicológica*, vol. 19, pp. 57–74, 2000.
- [26] M. Bakour, M. d. G. Campos, H. Imtara, and B. Lyoussi, "Antioxidant content and identification of phenolic/flavonoid compounds in the pollen of fourteen plants using HPLC-DAD," *Journal of Apicultural Research*, vol. 59, no. 1, p. 35.
- [27] M. G. R. Campos, S. Bogdanov, L. B. de Almeida-Muradian et al., "Pollen composition and standardisation of analytical methods," *Journal of Apicultural Research*, vol. 47, no. 2, pp. 154–161, 2008.
- [28] D. M. Kasote, M. V. Pawar, S. S. Gundu et al., "Chemical profiling, antioxidant, and antimicrobial activities of Indian stingless bees propolis samples," *Journal of Apicultural Research*, vol. 58, no. 4, pp. 617–625, 2019.
- [29] S. Touzani, N. Al-Waili, N. El Menyiy et al., "Chemical analysis and antioxidant content of various propolis samples collected from different regions and their impact on antimicrobial activities," *Asian Pacific Journal of Tropical Medicine*, vol. 11, 2018.
- [30] B. M. Maya, A. Abedini, S. C. Gangloff, A. Kabouche, Z. Kabouche, and L. Voutquenne-Nazabadioko, "A new δ -tocotrienolic acid derivative and other constituents from the cones of *Cedrus atlantica* and their in vitro antimicrobial activity," *Phytochemistry Letters*, vol. 20, pp. 252–258, 2017.
- [31] F. Poli, G. Appendino, G. Sacchetti, M. Ballero, N. Maggiano, and F. O. Ranelletti, "Antiproliferative effects of daucane esters from *Ferula communis* and *F. arrigonii* on human colon cancer cell lines," *Phytotherapy Research*, vol. 19, no. 2, pp. 152–157, 2005.
- [32] F. Maggi, C. Cecchini, A. Cresci et al., "Chemical composition and antimicrobial activity of the essential oil from *Ferula glauca* L. (F. communis L. subsp. glauca) growing in Marche (central Italy)," *Fitoterapia*, vol. 80, no. 1, pp. 68–72, 2009.
- [33] A. M. Weli, A. A. M. Al-Blushi, and M. A. Hossain, "Evaluation of antioxidant and antimicrobial potential of different leaves crude extracts of Omani *Ficus carica* against food borne pathogenic bacteria," *Asian Pacific Journal of Tropical Disease*, vol. 5, no. 1, pp. 13–16, 2015.
- [34] N. Amessis-Ouchemoukh, S. Ouchemoukh, N. Meziant et al., "Bioactive metabolites involved in the antioxidant, anticancer and anticalpain activities of *Ficus carica* L., *Ceratonia siliqua* L. and *Quercus ilex* L. extracts," *Industrial Crops and Products*, vol. 95, pp. 6–17, 2017.
- [35] N. González, J. Elissetche, M. Pereira, and K. Fernández, "Extraction of polyphenols from and: experimental kinetics, modeling and evaluation of their antioxidant and antifungal activities," *Industrial Crops and Products*, vol. 109, pp. 737–745, 2017.
- [36] J. Hafsa, M. a. Smach, M. R. Ben Khedher et al., "Physical, antioxidant and antimicrobial properties of chitosan films containing *Eucalyptus globulus* essential oil," *LWT-Food Science and Technology*, vol. 68, pp. 356–364, 2016.
- [37] M. Manel, H. Nouzha, M. Rim et al., "Antibacterial and antioxidant activity of *Juniperus thurifera* L. leaf extracts growing in East of Algeria," *Veterinary World*, vol. 11, no. 3, pp. 373–378, 2018.
- [38] M. El Jemli, R. Kamal, I. Marmouzi, A. Zerrouki, Y. Cherrah, and K. Alaoui, "Radical-scavenging activity and ferric reducing ability of *Juniperus thurifera* (L.), *J. oxycedrus* (L.), *J. phoenicea* (L.) and *Tetraclinis articulata* (L.)," *Advances in Pharmacological Sciences*, vol. 2016, pp. 1–6, 2016.
- [39] N. Fekih, H. Allali, S. Merghache et al., "Chemical composition and antibacterial activity of *Pinus halepensis* Miller growing in West Northern of Algeria," *Asian Pacific Journal of Tropical Disease*, vol. 4, no. 2, pp. 97–103, 2014.
- [40] Z. Djerrad, L. Kadik, and A. Djouahri, "Chemical variability and antioxidant activities among *Pinus halepensis* Mill. essential oils provenances, depending on geographic variation

- and environmental conditions," *Industrial Crops and Products*, vol. 74, pp. 440–449, 2015.
- [41] C. Mehenni, D. Atmani-Kilani, S. Dumarçay, D. Perrin, P. Gérardin, and D. Atmani, "Hepatoprotective and antidiabetic effects of *Pistacia lentiscus* leaf and fruit extracts," *Journal of Food and Drug Analysis*, vol. 24, no. 3, pp. 653–669, 2016.
- [42] F. Mezni, A. Slama, R. Ksouri, G. Hamdaoui, M. L. Khouja, and A. Khaldi, "Phenolic profile and effect of growing area on *Pistacia lentiscus* seed oil," *Food Chemistry*, vol. 257, pp. 206–210, 2018.
- [43] D.-J. Kwon and Y.-S. Bae, "Phenolic glucosides from bark of *Populus alba* × *glandulosa* (Salicaceae)," *Biochemical Systematics and Ecology*, vol. 37, no. 2, pp. 130–132, 2009.
- [44] C. Alcalde-Eon, I. García-Estévez, J. C. Rivas-Gonzalo, D. Rodríguez de la Cruz, and M. T. Escribano-Bailón, "Anthocyanins of the anthers as chemotaxonomic markers in the Genus *populus* L. differentiation between *Populus nigra*, *Populus alba* and *Populus tremula*," *Phytochemistry*, vol. 128, pp. 35–49, 2016.
- [45] W. Rached, F. Z. Zeghada, M. Bennaceur et al., "Phytochemical analysis and assessment of antioxidant, antimicrobial, anti-inflammatory and cytotoxic properties of *Tetraclinis articulata* (Vahl) Masters leaves," *Industrial Crops and Products*, vol. 112, pp. 460–466, 2018.
- [46] A. Djouahri, B. Saka, L. Boudarene et al., "In vitro synergistic/antagonistic antibacterial and anti-inflammatory effect of various extracts/essential oil from cones of *Tetraclinis articulata* (Vahl) Masters with antibiotic and anti-inflammatory agents," *Industrial Crops and Products*, vol. 56, pp. 60–66, 2014.
- [47] M. El Jemli, R. Kamal, I. Marmouzi et al., "Chemical composition, acute toxicity, antioxidant and anti-inflammatory activities of Moroccan *Tetraclinis articulata* L.," *Journal of Traditional and Complementary Medicine*, vol. 7, no. 3, pp. 281–287, 2017.
- [48] M. E. A. Dib, H. Allali, A. Bendiabdellah, N. Meliani, and B. Tabti, "Antimicrobial activity and phytochemical screening of *Arbutus unedo* L.," *Journal of Saudi Chemical Society*, vol. 17, no. 4, pp. 381–385, 2013.
- [49] S. Mariotto, E. Esposito, R. Di Paola et al., "Protective effect of *Arbutus unedo* aqueous extract in carrageenan-induced lung inflammation in mice," *Pharmacological Research*, vol. 57, no. 2, pp. 110–124, 2008.
- [50] M. El Haouari, J. J. López, H. Mekhfi, J. A. Rosado, and G. M. Salido, "Antiaggregant effects of *Arbutus unedo* extracts in human platelets," *Journal of Ethnopharmacology*, vol. 113, no. 2, pp. 325–331, 2007.
- [51] R. Bencheraiet, A. Kabouche, Z. Kabouche, R. Touzani, and M. Jay, "Flavonol 3-O-glycosides from three Algerian *Bupleurum* species," *Records of Natural Products*, vol. 6, no. 2, 2012.
- [52] C. Nicolaus, S. Junghanns, A. Hartmann, R. Murillo, M. Ganzera, and I. Merfort, "In vitro studies to evaluate the wound healing properties of *Calendula officinalis* extracts," *Journal of Ethnopharmacology*, vol. 196, pp. 94–103, 2017.
- [53] E. Efstratiou, A. I. Hussain, P. S. Nigam, J. E. Moore, M. A. Ayub, and J. R. Rao, "Antimicrobial activity of *Calendula officinalis* petal extracts against fungi, as well as Gram-negative and Gram-positive clinical pathogens," *Complementary Therapies in Clinical Practice*, vol. 18, no. 3, pp. 173–176, 2012.
- [54] H. Kalantari, H. Forouzandeh, M. J. Khodayar, A. Siahpoosh, N. Saki, and P. Kheradmand, "Antioxidant and hepatoprotective effects of *Capparis spinosa* L. fractions and Quercetin on tert-butyl hydroperoxide- induced acute liver damage in mice," *Journal of Traditional and Complementary Medicine*, vol. 8, no. 1, pp. 120–127, 2018.
- [55] H. Vahid, H. Rakhshandeh, and A. Ghorbani, "Antidiabetic properties of *Capparis spinosa* L. and its components," *Biomedicine & Pharmacotherapy*, vol. 92, pp. 293–302, 2017.
- [56] A. Sassi, I. Bouhlel, N. Mustapha et al., "Assessment in vitro of the genotoxicity, antigenotoxicity and antioxidant of *Ceratonia siliqua* L. extracts in murine leukaemia cells L1210 by comet assay," *Regulatory Toxicology and Pharmacology*, vol. 77, pp. 117–124, 2016.
- [57] S. Meziani, B. D. Oomah, F. Zaidi, A. Simon-Levert, C. Bertrand, and R. Zaidi-Yahiaoui, "Antibacterial activity of carob (*Ceratonia siliqua* L.) extracts against phytopathogenic bacteria *Pectobacterium atrosepticum*," *Microbial Pathogenesis*, vol. 78, pp. 95–102, 2015.
- [58] P. Kang, K.-H. Ryu, J.-M. Lee, H.-K. Kim, and G. H. Seol, "Endothelium- and smooth muscle-dependent vasodilator effects of *Citrus aurantium* L. var. *amara*: focus on Ca²⁺ modulation," *Biomedicine & Pharmacotherapy*, vol. 82, pp. 467–471, 2016.
- [59] K.-I. Park, H.-S. Park, M.-K. Kim et al., "Flavonoids identified from Korean *Citrus aurantium* L. inhibit non-small cell lung cancer growth *in vivo* and *in vitro*," *Journal of Functional Foods*, vol. 7, pp. 287–297, 2014.
- [60] W. M. Otang and A. J. Afolayan, "Antimicrobial and antioxidant efficacy of *Citrus limon* L. peel extracts used for skin diseases by Xhosa tribe of Amathole District, Eastern Cape, South Africa," *South African Journal of Botany*, vol. 102, pp. 46–49, 2016.
- [61] T. Matsumoto, M. Koike, C. Arai et al., "Chemical structures and antimutagenic effects of unusual oximes from the peels of *Citrus limon*," *Phytochemistry Letters*, vol. 25, pp. 118–121, 2018.
- [62] N. Yadikar, K. Bobakulov, G. Li, and H. A. Aisa, "Seven new phenolic compounds from *Lavandula angustifolia*," *Phytochemistry Letters*, vol. 23, pp. 149–154, 2018.
- [63] S. Sosa, G. Altinier, M. Politi, A. Braca, I. Morelli, and R. Della Loggia, "Extracts and constituents of *Lavandula multifida* with topical anti-inflammatory activity," *Phytomedicine*, vol. 12, no. 4, pp. 271–277, 2005.
- [64] S. Selmi, K. Rtibi, D. Grami, H. Sebai, and L. Marzouki, "Rosemary (*Rosmarinus officinalis*) essential oil components exhibit anti-hyperglycemic, anti-hyperlipidemic and antioxidant effects in experimental diabetes," *Pathophysiology*, vol. 24, no. 4, pp. 297–303, 2017.
- [65] Y. Jiang, L. Zhang, and H. P. V. Rupasinghe, "Anti-proliferative effects of extracts from *Salvia officinalis* L. and *Salvia miltiorrhiza* Bunge on hepatocellular carcinoma cells," *Biomedicine & Pharmacotherapy*, vol. 85, pp. 57–67, 2017.
- [66] N. H. Habashy, M. M. Abu Serie, W. E. Attia, and S. A. M. Abdelgaleil, "Chemical characterization, antioxidant and anti-inflammatory properties of Greek *Thymus vulgaris* extracts and their possible synergism with Egyptian *Chlorella vulgaris*," *Journal of Functional Foods*, vol. 40, pp. 317–328, 2018.
- [67] R. Mandade, S. A. Sreenivas, and A. Choudhury, "Radical scavenging and antioxidant activity of *Carthamus tinctorius* extracts," *Free Radicals and Antioxidants*, vol. 1, no. 3, pp. 87–93, 2011.
- [68] J. Božunović, S. Živković, U. Gašić et al., "In vitro and in vivo transformations of *Centaureum erythraea* secoiridoid

- glucosides alternate their antioxidant and antimicrobial capacity,” *Industrial Crops and Products*, vol. 111, pp. 705–721, 2018.
- [69] M. Bakour, N. Al-Waili, R. El-Haskoury et al., “Comparison of hypotensive, diuretic and renal effects between cladodes of *Opuntia ficus-indica* and furosemide,” *Asian Pacific Journal of Tropical Medicine*, vol. 10, no. 9, pp. 900–906, 2017.
- [70] I. Ammar, M. Ben Salem, B. Harrabi et al., “Anti-inflammatory activity and phenolic composition of prickly pear (*Opuntia ficus-indica*) flowers,” *Industrial Crops and Products*, vol. 112, pp. 313–319, 2018.
- [71] P. Matusinsky, M. Zouhar, R. Pavela, and P. Novy, “Anti-fungal effect of five essential oils against important pathogenic fungi of cereals,” *Industrial Crops and Products*, vol. 67, pp. 208–215, 2015.
- [72] M. N. Qureshi, S. Numonov, A. Abudurexiti, and H. A. Aisa, “Phytochemical investigations and evaluation of antidiabetic potential of *Prunus dulcis* nuts,” *LWT-Food Science and Technology*, vol. 66, pp. 311–317, 2016.
- [73] N. Dhingra, A. Kar, R. Sharma, and S. Bhasin, “In-vitro antioxidative potential of different fractions from *Prunus dulcis* seeds: vis a vis antiproliferative and antibacterial activities of active compounds,” *South African Journal of Botany*, vol. 108, pp. 184–192, 2017.
- [74] J. Kocot, M. Kielczykowska, D. Luchowska-Kocot, J. Kurzepa, and I. Musik, “Antioxidant potential of propolis, bee pollen, and royal jelly: possible medical application,” *Oxidative Medicine and Cellular Longevity*, vol. 2018, pp. 1–29, 2018.