Ethnobotanical knowledge and traditional uses of propolis among the Algerian population: a comparative and multivariate analysis

Hibat-allah Brahimi, Hakima Oulebsir-Mohandkaci, Noui Hendel, Madani Sarri

Correspondence

Hibat-allah Brahimi[1,*], Hakima Oulebsir-Mohandkaci[1], Noui Hendel[2], Madani Sarri[3]

[1]Valorization and Conservation of Biological Resources Laboratory, Faculty of Sciences, M'hamed Bougara University, Boumerdes, Algeria
[2]Department of Microbiology and Biochemistry, Faculty of Sciences, Mohamed Boudiaf University, M'sila, Algeria
[3]Department of Nature and Life Sciences, Faculty of Sciences, Mohamed Boudiaf University, M'sila, Algeria

*Corresponding Author: ha.brahimi@univ-boumerdes.dz

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Research

Abstract

Background: Propolis is a natural resinous substance collected by honeybees from tree buds and plant exudates and is recognized for its beneficial biological properties. This study aims to provide a comparative overview of the various therapeutic, agri-food applications of propolis in Algeria, as well as the different forms and combinations with other natural products.

Methods: This ethnobotanical study collected information on propolis use from 111 participants via semi-structured interviews. The data were analysed by calculating various parameters, including usage value and the relative frequency of citations. We used Multiple Component Analysis (MCA) and Principal Component Analysis (PCA) to determine all propolis properties. Cronbach's alpha analysis was used to assess the homogeneity of our survey. We used Pearson's test ($\alpha = 0.05$) to test the relationship between propolis production parameters.

Results: The ethnobotanical survey revealed that (73%) of participants possessed detailed knowledge of propolis' properties. The reported therapeutic benefits included support for the digestive system (40.5%), immune system (72%), along with wound treatment (66.7%). The study also found that, in Algeria, propolis is combined with other natural products (55.9%), to increase its effectiveness. With data reliability and homogeneity, analysis is shown to be stable and consistent across all questionnaire criteria. In addition, the Pearson test determined a correlation between the color of propolis in Algeria and the type of the plants.

Conclusions: This study expands our understanding of propolis and its various uses, emphasizing its potential for development into pharmaceutical, dermatological and agricultural products.

Keywords: Propolis, survey, Algeria, traditional uses, galenic forms, therapeutic properties, correlation analysis

Background

The word propolis derives from Greek, where 'pro' means 'protection' and 'polis' means 'the city', referring to the protection of the city (the hive). Propolis has been extensively used in traditional medicine since ancient times and has more recently become a well-known ingredient of many foods and cosmetics worldwide (Falcão *et al.* 2013, Zulhendri *et al.* 2021). Honeybees utilize propolis to seal off holes in the hive, smooth the inner walls, and keep intruders away from the entrance. It also serves as a critical biochemical defense against pathogenic microorganisms (Athikomkulchai *et al.* 2013). A great deal of research in recent years has focused on the chemical composition and biological effects of this substance (Chi *et al.* 2020, Dutra *et al.* 2023, Widelski *et al.* 2023). Its composition varies according to its botanical origin, the species of bee, and the harvesting period (Otmane *et al.* 2020a). It usually consists of resin and balsams (50-70%), essential oils, aromatic oils and wax (30-50%), pollen (5-10%), and other bioactive compounds such as amino acids, minerals, vitamins, phenolic compounds, and flavonoids (Nur *et al.* 2017, Rivera-Yañez *et al.* 2021). These compounds give this beehive product antiseptic, anti-inflammatory, antibacterial, antioxidant, anticancer, antiviral, antifungal, anti-ulcer, local anesthetic, antitumor, and immunostimulating properties (Simone-Finstrom & Spivak, 2010, Abbas *et al.* 2020, Qiao *et al.* 2023).

As a consequence, propolis has long been used for various applications due its numerous health benefits, and its properties are now well recognized. Today, research worldwide continues to confirm these benefits. This was demonstrated by Tzani *et al.* (2022) in their study of cosmetic product formulations in Greece. Polish researchers Ożarowski & Karpiński (2023) studied the effect of propolis on viral respiratory diseases. Similarly, Italian researchers Magnavacca *et al.* (2022) investigated its effects on pandemic respiratory infections. In an agricultural application study, Duarte *et al.* (2013) suggested that Brazilian propolis could be as a feed supplement for along with raw propolis.

Other research conducted in Saudi Arabia by Alghutaimel *et al.* (2024) analyzed the use of propolis in dentistry. As demonstrated in the study by Alanazi *et al.* (2021), propolis exhibits promising properties for treating parasites and cancers. Similarly, Brazilian researchers investigated propolis as a natural food additive to improve production efficiency (Da silva *et al.* 2013, Santos *et al.* 2023). Silveira *et al.* 2023 studied additional Brazilian propolis varieties, revealing anti-COVID-19 properties in certain types. In another study, Lopes-Rocha *et al.* (2012) performed a comprehensive analysis of topical Brazilian propolis effects on oral surgical wound healing. In Egypt, Elkhateeb *et al.* (2022) conducted an extensive study on propolis extracts, identifying both antibacterial and skin-regenerative properties. In addition, they highlighted flavonoid content as a critical factor enhancing the extracts' antioxidant effects. Balderas-Cordero *et al.* (2023) examined Mexican propolis applied topically to cutaneous inflammatory processes and wound healing, confirming its anti-inflammatory and therapeutic potential for skin disorders. Balderas-Cordero *et al.* (2023) examined Mexican propolis applied topically to cutaneous inflammatory processes and wound healing, confirming its anti-inflammatory and therapeutic potential for skin disorders. Furthermore, a diverse range of commercial propolis-based products is now available, including sprays, dyes, gels, toothpastes, and dermatological creams (Barros *et al.* 2019).

Despite the globally extensive research on propolis, Algeria lacks studies in quantifying traditional uses by ethnobotanical indices (RFC/UV), and ecological correlations (PCA, MCA and Pearson correlation). Our study adds data, by investigating the propolis traditional uses and its application in different fields among the Algerian population, through multivariate analysis of 111 responses. As an ethnopharmacological survey, it aims to document and analyze the diverse applications of propolis within Algeria.

Materials and Methods

Description of the ethnopharmacological survey

This study covered 28 provinces (Wilayas), mainly distributed across northern and eastern Algeria, namely: Bejaïa, Bouira, Boumerdes, Jijel, Batna, Tlemcen, Skikda, Oum El Bouaghi, Biskra, Tizi Ouzou, Algiers, Constantine, Mila, Setif, Tipaza, Oran, Ain Defla, Tebessa, Annaba, Medea, Mascara, M'sila, El taref, Tiaret, and Blida. The only chosen representative regions of the Sahara were Timimoune, Adrar, and Tamanrasset as propolis production remains limited in desert areas due to unfavorable pedoclimatic conditions. The selection criteria prioritized regions with established beekeeping traditions in Algeria (figure 1).

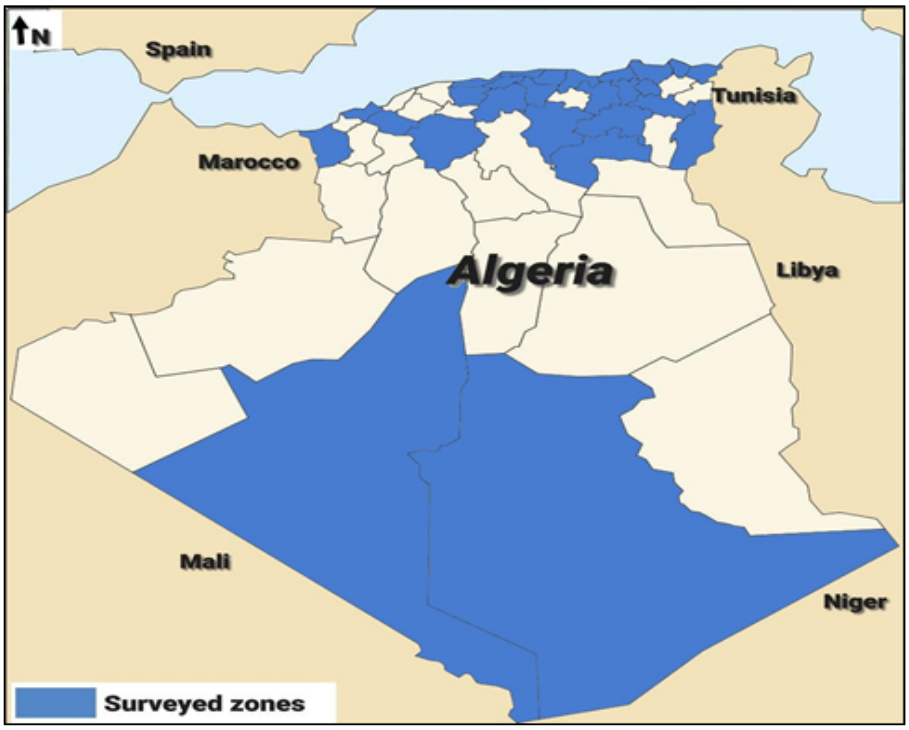

Figure 1. Study area with surveyed localities

Data collection

The survey gathered comprehensive information about propolis usage in Algeria from local populations. Conducted over a one-year period (July 2020 to July 2021), it engaged respondents across diverse age groups and educational backgrounds, including herbalists and beekeepers. Interviews were conducted in Arabic, English, and French. Additionally, the study incorporated supplementary data from provincial Agricultural Services Directorates (DSA) and Agricultural Chambers (figure 2).

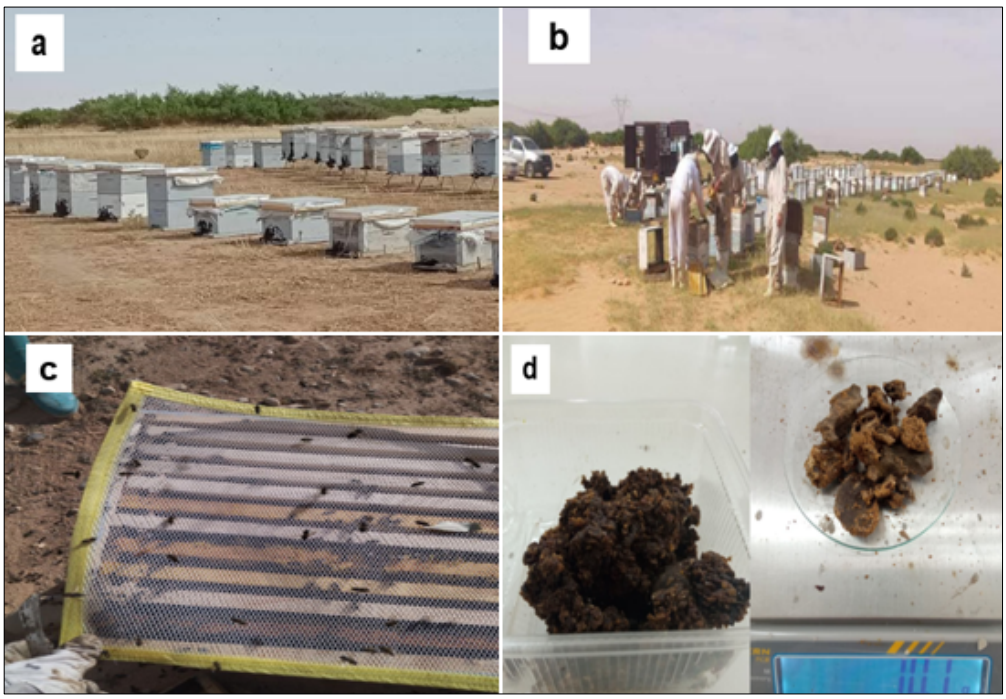

Figure 2. Field investigation with respondents and propolis collection; (**a**) apiary , (**b**) propolis harvest, (**c**) propolis harvesting grid, (**d**) harvested propolis

Data Analysis

The following ethnobotanical indices were calculated for statistical data analysis. For these calculations, we applied the formulas described by Ahmad *et al.* (2014), Hedidi *et al.* (2024) and Belhacini *et al.* (2024).

Relative citation frequency (RFC)

This index reflects propolis' significance as a nationally recognized medicinal product. The following formula was applied for its calculation,

$$RFC=FC/N \quad (0 < RFC < 1)$$

Where: FC is the frequency with which the informants mention the use of propolis and N is the total number of participants in the survey.

FC: Frequency of propolis use citations among informants.

N: Total number of participants in the survey.

Usage value (UV)

This index is used everywhere and would be a good way to see how important a vegetarian is to people in a community.

$$UV=Ui/N$$

Where: Ui is the total number of citations. These citations concern different uses of Algerian propolis. N the number of informants.

Data reliability and homogeneity

Cronbach's alpha method

To assess the internal consistency of our survey, we used the Cronbach's alpha coefficient method (1951). Piette. (2016) and Adeniran. (2025) describe this as follows: It's a statistical index used to evaluate the internal consistency or homogeneity of an evaluation instrument comprising a set of items that contribute to measuring the same dimension. This index reflects the degree of homogeneity. It provides a direct reading of a questionnaire's internal consistency, a number between (0 to 1). In addition, internal consistency is a well-known concept. It refers to how test components are linked to each other.

Kaiser–Meyer–Olkin (KMO) and Bartlett's Test

There are two statistical tests available for assessing data factorization: the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. Shrestha. (2021) defines the Kaiser–Meyer–Olkin (KMO) test as a method of assessing the suitability of data for factor analysis. In other words, it determines whether the sample size is appropriate. The KMO test measures the adequacy of the sample for each variable in the model, as well as for the model as a whole. On the other hand, Panda. (2021) notes that Bartlett's sphericity test is a statistical test used to assess the suitability of data and measure the interdependence of variables.

In the context of our study, we have proposed two specific hypotheses. The first study focuses on the origin of propolis in Algeria and is based on several variables, such as colour, biome and the type of plants present in apiaries (trees, other types of plants). The second hypothesis focuses on propolis production criteria in Algeria, taking into account variables such as the harvesting season, quantity, and type of hive. To analyze the results and study the relationship between all variables we performed a multiple correspondence analysis (MCA). This enabled us to provide an accurate assessment.

Statistical analysis

Initially, the questionnaire data were processed using Microsoft Excel. Subsequently, they were analyzed with SPSS software (version 28), employing Principal Component Analysis (PCA), Multiple Correspondence Analysis (MCA), and Pearson's and Spearman's Rho tests were used to evaluate the correlation coefficients and determine their significance with a probability threshold of 5%. These methods revealed underlying structures, groupings, and relationships within the dataset that might not be apparent in the raw data.

Results

Sociodemographic characteristics and topography of the regions

The socio-demographic data of respondents are presented in Table 1. Gender distribution reveals a male predominance (79.30%) compared to females (20.7%). Interviews indicated that (96.5%) of the respondents were aged 20-60 years. The

analysis shows that beekeeper/arborist and academics constituted half of the sample (55.8%), followed by other professions (44.2%). Regarding education, most participants have completed higher education (57.78%), followed by secondary education (25.2%), with a smaller proportion having only primary education (3.6%).

Table 1. Socio-demographic characteristics of the surveyed area

Criteria	Categories	Number	Percentage (%)
Gender	Female	23	20,7
	Male	88	79,3
Age	20-40	58	52,3
	41-60	48	43,2
	> 60	5	4,5
Education level	Primary	4	3,6
	Secondary	28	25,2
	University	79	71,2
Profession	Beekeeper/Arborist	38	34,2
	Academic work	24	21,6
	Engineer/agronomist	7	6,3
	Medical professions/Physiotherapists	7	6,3
	Trader	11	9,9
	Student	3	2,7
	Doctoral student	4	3,6
	Employee/manager	11	9,9
	Retired	4	3,6
	Unemployed	2	1,8

Furthermore, results (Figure 3), show that our survey covered 28 Algerian provinces, distributed across central, eastern, and western regions. Southern provinces represented only 6% of responses.

Many interviewees in desert provinces (Adrar, Timimoun, and Tamanrasset) reported unfamiliarity with propolis, as beekeeping is uncommon in the Sahara due to soil and climatic constraints.

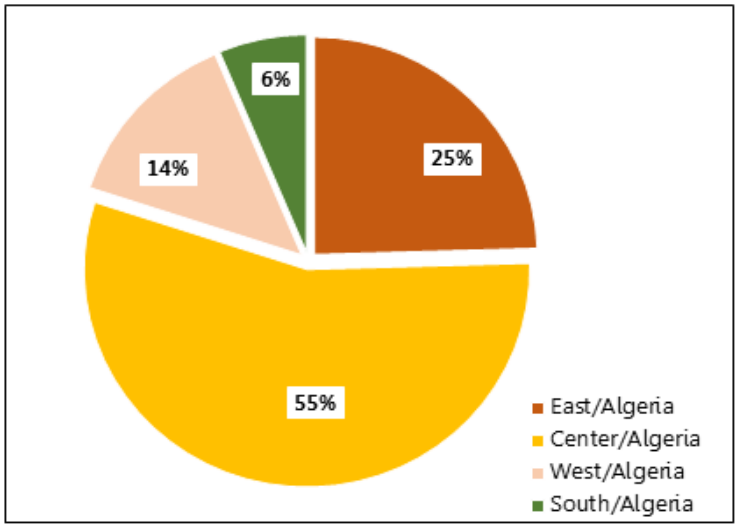

Figure 3. Distribution of study regions

Analysis of surveyed regions by biome revealed variation in hive placement across ecological zones (Figure 4). Mountainous regions were most prominent among the six biomes, with 33.3% (n=40) of beekeepers locating hives in these areas. Some beekeepers reported relocating hives to different biomes seeking better floral resources and climates, which facilitates increased honey production (Table 2).

Table 2. Analysis of the distribution of the surveyed beekeepers according to the biome and relief

Biome	Number	Percentage (%)
Mountainous	40	33.3%
Desertic	6	6.3%
Steppic	8	10.8%
Plateau	7	6.3%
Coastal	16	14.4%
Other/transhumance	34	28.8%

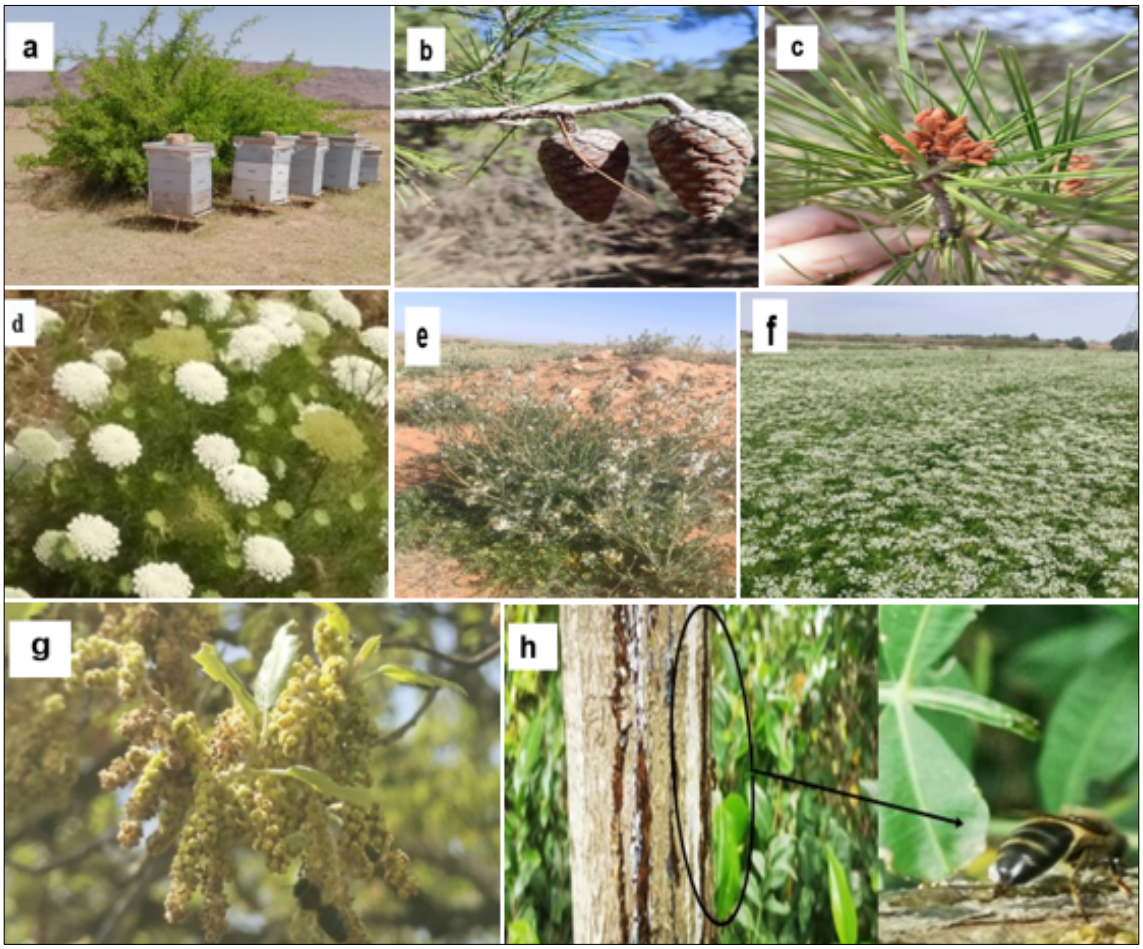

Figure 4. Some plants around visited apiaries. (**a**) *Ziziphus* sp.; (**b**) *Pinus halepensis* (female cone); (**c**) *Pinus halepensis* (male cone); (**d**) *Daucus* sp ; (**e**) *Eruca sativa*; (**f**) *Pimpinella anisum*; (**g**) *Quercus* sp.; (**h**) *Cupressus* sp.

Regional names and colors of Algerian propolis

Our ethnopharmacological survey revealed that while "propolis" is the primary term used across Algerian regions, ten additional local names were documented: العكبر (Akbar), البروبوليس (propolis), الشمع (Alchamaa), الستفور (Satfour), علك النحل (Alk Elnahl), صمغ النحل (Samgh Elnahl), الشهدة (Elchahda), القير (Elkir), قطمير (Katmir), and الزفتر (Elzaftar). These names, whether scientific or vernacular, reflect Algeria's linguistic diversity (Table 3). In addition, the survey results indicate that most Algerian propolis is brown (46.8%, n = 52), while 39.6% (n = 44) of respondents described it as having 'other' color variations.

Table 3. Frequency analysis of general characteristics of propolis in Algeria

		Number	Percentage (%)
Do you know anything about propolis?	Yes	105	94,6
	No	6	5,4
Principal name in Algeria	Propolis	42	37,8
	Akber	48	43,2
	Alchamaa **الشمع**/ Samgh **صمغ النحل**	8	7,2
	Other names : (Satfour **الستفور**), (Alk Elnahl	13	11,7

	(علك النحل Elchahda) (الشهدة ,Elkir) (القير (katmir قطمير), (Elzaftar الزفتر)		
Colors	Brown	52	46,8
	Yellow	6	5,4
	Dark brown (black)	4	3,6
	Green	3	2,7
	Red	2	1,8
	Other	44	39,6

The varied uses of propolis

Therapeutic, dermatological and cosmetic uses

This study analyzes propolis use in general therapeutics among the Algerian population. Figure 5 summarizes its diverse applications in therapeutic, dermatological, and cosmetic fields. Among primary therapeutic uses, propolis was most frequently employed for; immune system reinforcement (72%, n=80); respiratory and digestive system infections (47.7%, n=53 and 40.5%, n=45 respectively); oral/dental ailments (46%, n=52), and ENT (ear, nose, throat) conditions (36%, n=40). One of the first therapeutic and pharmaceutical uses of propolis was as a treatment for the reinforcing of the immune system (72%, n=80) and treating respiratory and digestive system infections (47.7%, n=53), and (40.5%, n= 45) systems, as well as oral and dental ailments (46%, n=52) and ENT (ear, nose, and throat) (36%, n=40). Our findings demonstrate significant interest in propolis for dermatological applications: wound/sore treatment (66.7%, n=74) showed highest prevalence; eczema and burn management (63.1%, n=70); cleansing effects (55%, n=61); healing balm stimulation (39.6%, n=44), and antifungal applications (37.8%, n=42). Propolis's recognized antibiotic activity confirms its importance in local therapy. Cosmetic uses included: moisturizing creams (50.5%, n=56); toothpaste manufacturing (reported by 33.3% of respondents), and hair care products (limited shampoos incorporation at 21.6%).

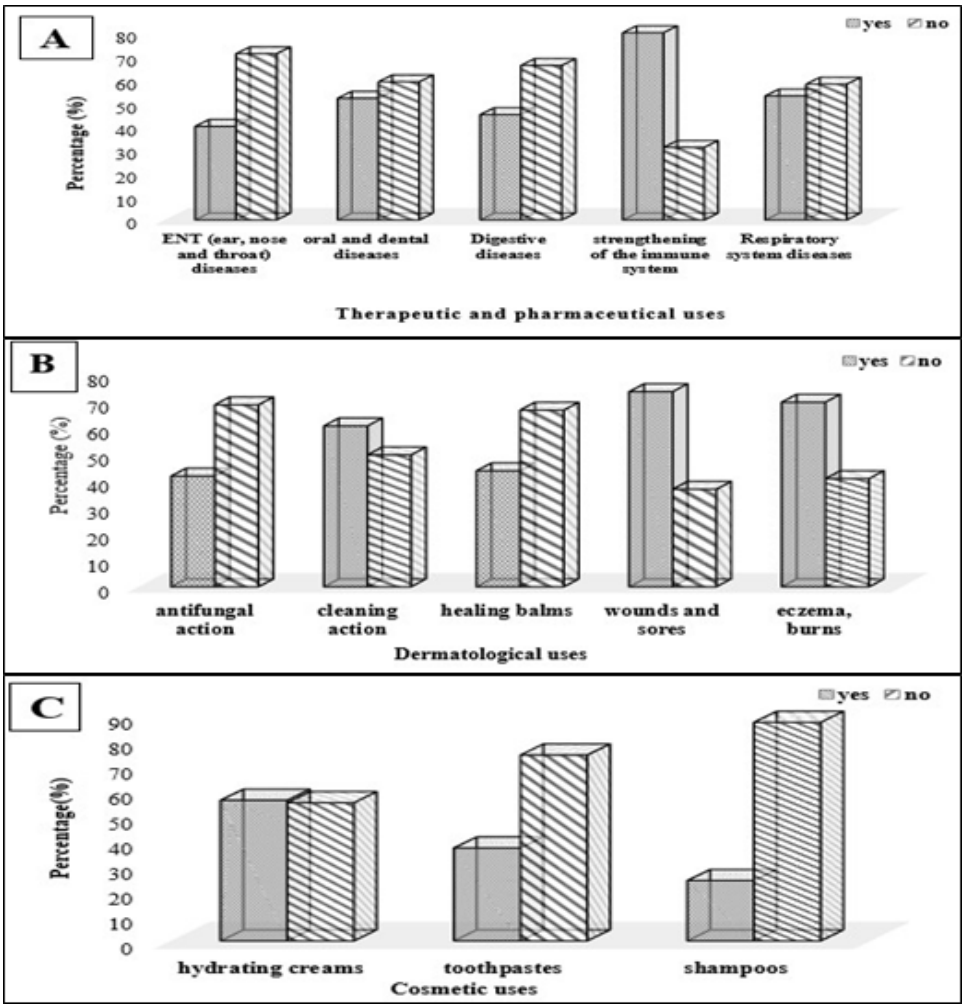

Figure 5. Distribution of the frequency of therapeutic (**A**), dermatological (**B**), and cosmetic (**C**) uses of propolis in Algeria

Alimentary, artisanal and agricultural uses

In the food sector, propolis plays a significant role. This study demonstrates its use as both a food additive (57.7%, n=64) and antioxidant (59.5%). However, its application in food packaging or as a preservative, particularly for fish, remains uncommon. These findings confirm that hive products like propolis have applications extending beyond therapeutic and cosmetic uses into food technology. Regarding agricultural applications, propolis is primarily used for: seed and tuber preservation/storage (48.6%) and poultry feed supplementation (42.3%). Previous studies have confirmed that propolis enhances productive performance in chickens when added to their diet. Figure 6 shows that (27%) of the artisans use propolis as a varnish. There were reports (73%) that other respondents had another use of artisanal for propolis. Figure 6 illustrates artisanal uses: (27%) of artisans employ propolis as varnish and (73%) of respondents reported other artisanal applications.

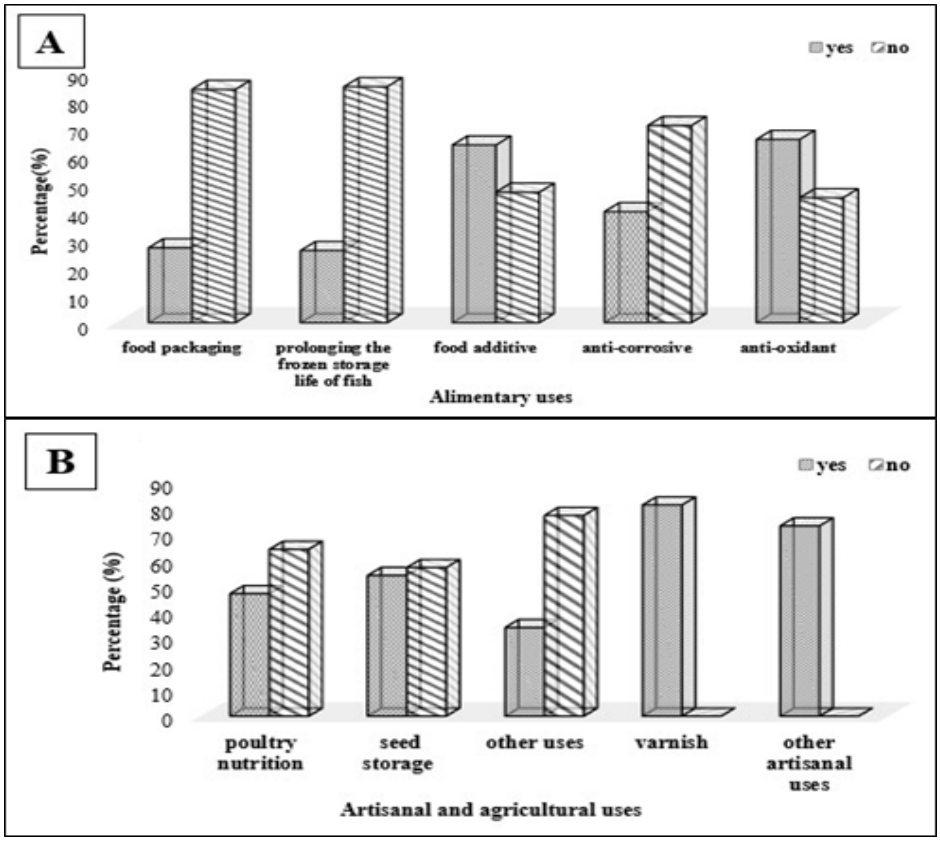

Figure 6. Distribution of the frequency of alimentary (**A**), agricultural, and artisanal (**B**) uses in Algeria

Galenic forms and methods of preparation

The study results of Algerian propolis galenic forms are presented in the table below. These findings contribute to better understanding traditional uses in the study area, including preparation methods, combinations with other products, and administration modes. In Algeria, knowledge and experience regarding propolis use and its properties vary regionally (Table 4).

Table 4. Frequency of the galenic forms and administration modes of propolis in Algeria

Propolis forms and administration modes			Percentage (%)
Form of use	Powder	Yes	66,7
		No	33,3
	Solution	Yes	38,7
		No	61,3
Preparation	Maceration	Yes	17,1
		No	82,9
	Infusion	Yes	15,3
		No	84,7
	Decoction	Yes	9
		No	91
Association with other products	Alone		23,4
	Mixed (beeswax, honey, pollen and royal jelly,		55,9

	carob, olive oil)	
	Both cases	20,7
Administration modes	Topical	18,9
	Buccal	14,4
	Both cases	51,4
	Other modes of administration	15,3

Methods of conservation and storage duration

Propolis storage duration and preservation methods are crucial factors for maintaining standardized product quality suitable for market requirements. Our survey results (table 5) indicate that: most respondents store propolis in dark places (57.5%); the majority use glass bottles for storage (81.1%), some utilize plastic or paper bags. A clear correlation exists between storage methods and duration: 53.2% store propolis indefinitely; (17%) keep it for less than one year; (10.8%) maintain it for 1-3 years, and (18.9%) preserve it for more than 3 years.

Table 5. Frequency of storage duration and conservation methods

Conservation conditions			**Percentage (%)**
Conservation methods	Protected from exposure to light	Yes	57,7
		No	42,3
	Exposure to light	Yes	32,4
		No	67,6
Preservative nature	Glass bottles	Yes	81,1
		No	18,9
	Plastic bags	Yes	43,2
		No	56,8
	Paper bags	Yes	36,9
		No	63,1
	Others	Yes	18
		No	82
Storage duration	Limitless		53,2
	Less than 1 year		17,1
	Between 1 and 3 years		10,8
	More than 3 years		18,9

Propolis production and marketing in Algeria

Our results indicate that only a small proportion of Algerians purchase propolis (29.7%, n=33), primarily due to its high price according to 62.2% (n=69) of respondents. The analysis of collected data (figure 7) reveals that consumers predominantly use locally produced propolis (84.7%) rather than imported varieties (5.4%). This preference for local propolis stems from several factors: the significantly higher cost of imported products, and the established trust in local producers who typically reside near consumers.

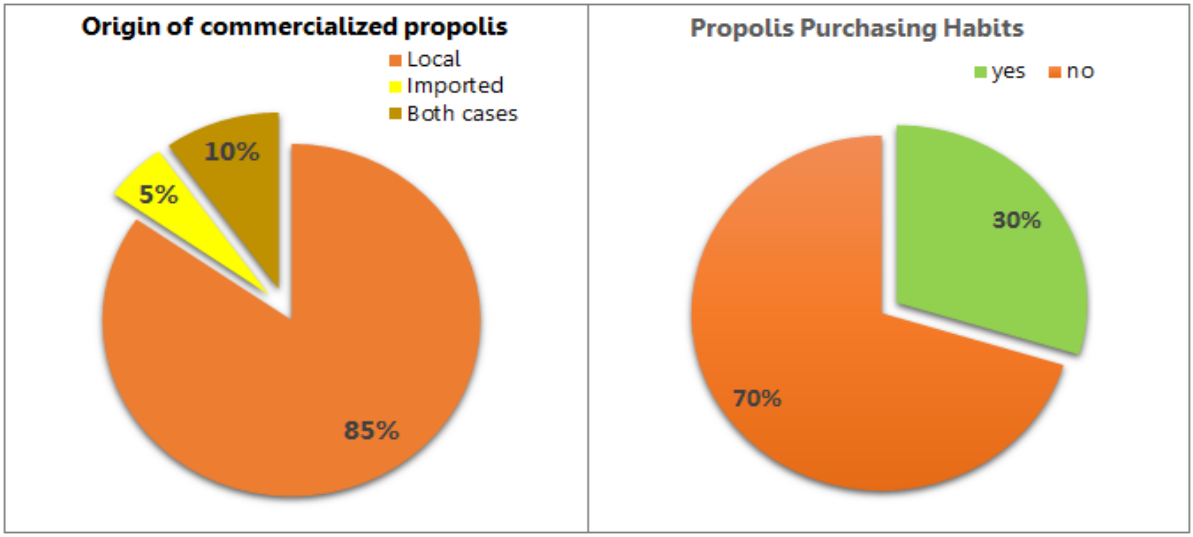

Figure 7. Distribution of propolis marketing frequency in Algeria

In addition, the Figure 8 represents some products made from propolis that are marketed in Algeria, including therapeutic, cosmetic products, and nutritional supplements.

Figure 8. Some commercialized propolis products in Algeria

Quantitative analysis of ethnobotanical data

Relative frequency of citation (RFC) and (UV)

As part of our evaluation, we identified Relative Citation Frequency (RFC) and Use Value (UV) as key indicators for assessing propolis knowledge and use. These metrics provide valuable insights for biological and chemical studies while documenting community knowledge about this natural product. Results are presented in tables 6 and 7. The RFC for propolis ranged from 0.009 to 0.135 among participants. The highest values occurred in central Algeria, particularly in Algiers (0.135), M'sila (0.081), and Boumerdes (0.054), with other provinces showing average RFC values between (0.018 and 0.027).

Table 6. Relative citation frequency (RFC) values for propolis in Algeria

	Region of Algeria (provinces)	RFC of propolis
North	Tipaza	0.018
	Alger	0.135
	Boumerdes	0.054
	Bejaïa	0.036
	Tizi Ouzou	0.027
Center	M’sila	0.081
	Biskra	0.009
	Bouira	0.054
	Medea	0.018
	Ain Defla	0.018
	Blida	0.018
	Oum Bouaghi	0.009
West	Tiaret	0.027
	Tlemcen	0.054
	Oran	0.009
	Mascara	0.009

East	Skikda	0.036
	Tebessa	0.018
	Jijel	0.018
	Mila	0.009
	Eltaref	0.009
	Constantine	0.027
	Batna	0.036
	Annaba	0.009
	Setif	0.027
South	Timimoune	0.018
	Tamanrasset	0
	Adrar	0.009

Our quantitative analysis scientifically evaluated the Algerian population's propolis knowledge. This approach revealed diverse applications, categorized into five disease groups based on consumption patterns (table 7). Notable use values included: immune system reinforcement (0.720); eczema and burn treatment (0.630); food additive applications (0.576), and seed and tuber preservation (0.486).

Table 7. Usage values (UV) of propolis for the different categories

Categories		**Algerian Propolis UV**
Therapeutic and pharmaceutical uses	ENT (ear, nose and throat) diseases	0.360
	oral and dental diseases	0.468
	Digestive diseases	0.405
	Strengthening the immune system	0.720
	Respiratory system diseases	0.477
Cosmetic uses	shampoos	0.216
	Hydrating creams	0.504
	toothpastes	0.333
Dermatological Uses	antifungal action	0.378
	cleaning action	0.549
	Healing balms	0.396
	Wounds and sores	0.666
	Eczema and burns	0.630
Alimentary uses	Food packaging	0.243
	prolonging the frozen storage life of fish	0.234
	Food additive	0.576
	Anticorrosive	0.360
	Antioxidant	0.594
Agricultural uses	poultry nutrition	0.423
	seed and tuber preservation and storage	0.486
Artisanal uses	Varnish	0.270

Multiple correspondence analysis (MCA) and principal component analysis (PCA)

Multiple Correspondence Analysis (MCA) showed significant correlations between propolis' botanical characteristics and its properties. This analysis provided a global graphical representation to visualize relationships among variables. The MCA serves as a crucial tool for evaluating correlations between variables and principal axes, distinguishing four variable groups based on their correlation strength with the first two axes. Figures 9 and 10 present selected variables: Figure 9 with three variables (color, biome [mountain, steppe and plateau], and plant type [trees, other plants]), and figure 10 with four variables (seasons, propolis quantity and hive type) showing their inter-correlations. Multiple correspondence analysis (MCA) clearly shows the use of langstroth-type hives by the Algerian population. Propolis is mainly harvested in autumn. In various regions of Algeria, the quantity of propolis collected from the hive can differ, ranging from 100 to 300 grams or exceeding 300 grams. In addition, as shown in table 5 above, the majority of respondents (53%) claim that propolis can be stored indefinitely.

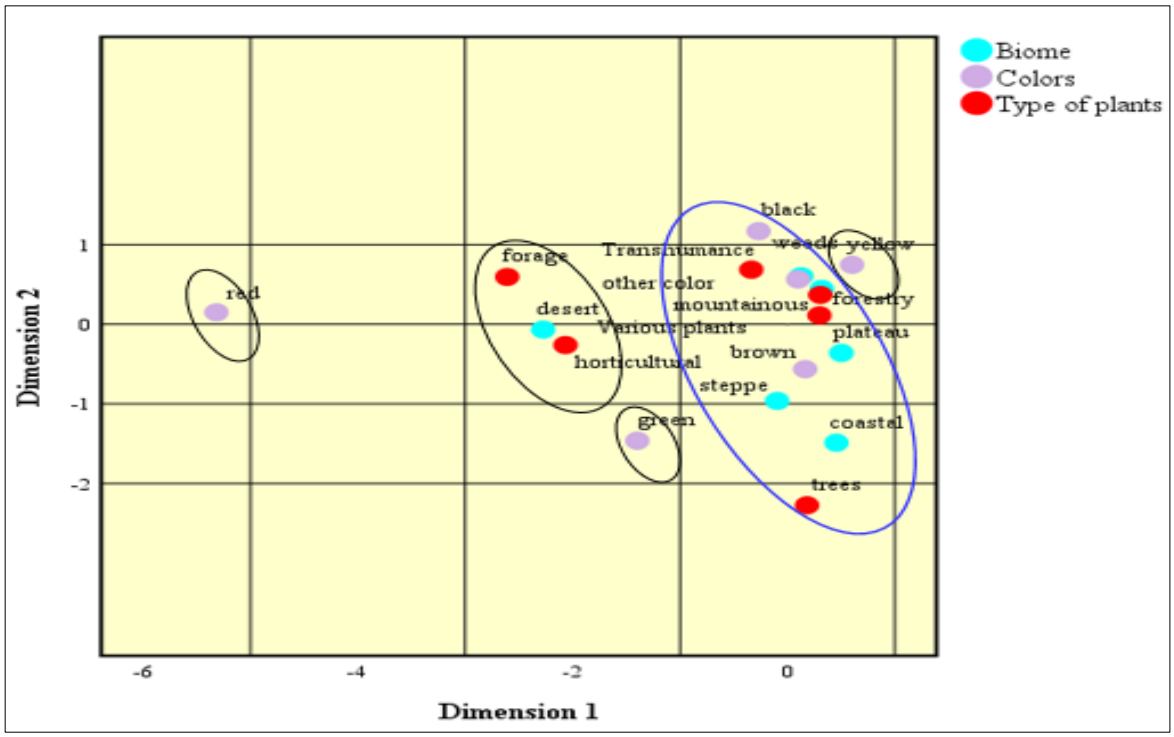

Figure 9. Multiple Correspondence Analysis (MCA) of the origin of propolis in Algeria

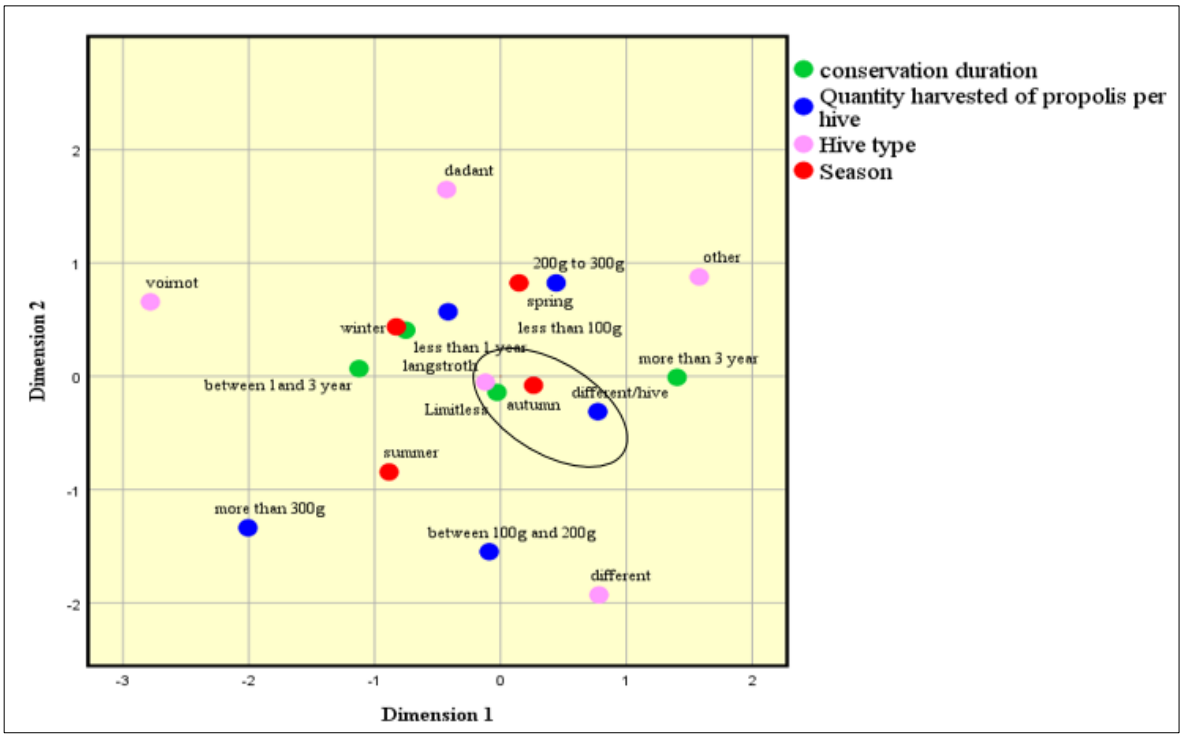

Figure 10. Multiple Correspondence Analysis (MCA) of the propolis production parameters in Algeria

Cronbach's alpha analysis

As shown in Table 8, Cronbach's analysis indicates that the data have been divided into two axes and that Cronbach's alpha values are high such as the origin of propolis (0.651), these values are considered satisfactory given that the study results were applied to different survey parameters. This suggests that the study is stable and consistent across all parameters of our questionnaire.

Table 8. Cronbach's alpha analysis

The origin of propolis in Algeria				
Dimension	**cronbach's alpha**	**Variance represented**		
		Total (Own value)	**Inertia**	**% of variance**
1	0,685	1,840	0,613	61,322
2	0,615	1,695	0,565	56,506
Total		3,535	1,178	
Mean	0,651[a]	1,767	0,589	58,914
The propolis production parameters in Algeria				
Dimension	**cronbach's alpha**	**Variance represented**		
		Total (Own value)	**Inertia**	**% of variance**
1	0,500	1,599	0,400	39,979
2	0,444	1,499	0,375	37,486
Total		3,099	0,775	
Mean	0,473[a]	1,549	0,387	38,732
[a]. Cronbach's alpha is based on the mean eigenvalue.				

On the other hand, as indicated in the aforementioned report, figure 11 shows a correlation between the pharmacological properties of propolis in three axes. It was found that maceration is the most widely used form of propolis preparation. This use is generally in the form of a powder or solution combined with other products. Propolis is therefore a product with great potential for use in the therapeutic and pharmaceutical treatment of ENT diseases. Propolis is a natural product with multiple health benefits. In addition, Algerians use it not only as a food additive, but also for oral and dental care, to boost the immune system and treat digestive ailments. It is also effective against dermatological conditions such as eczema and sores.

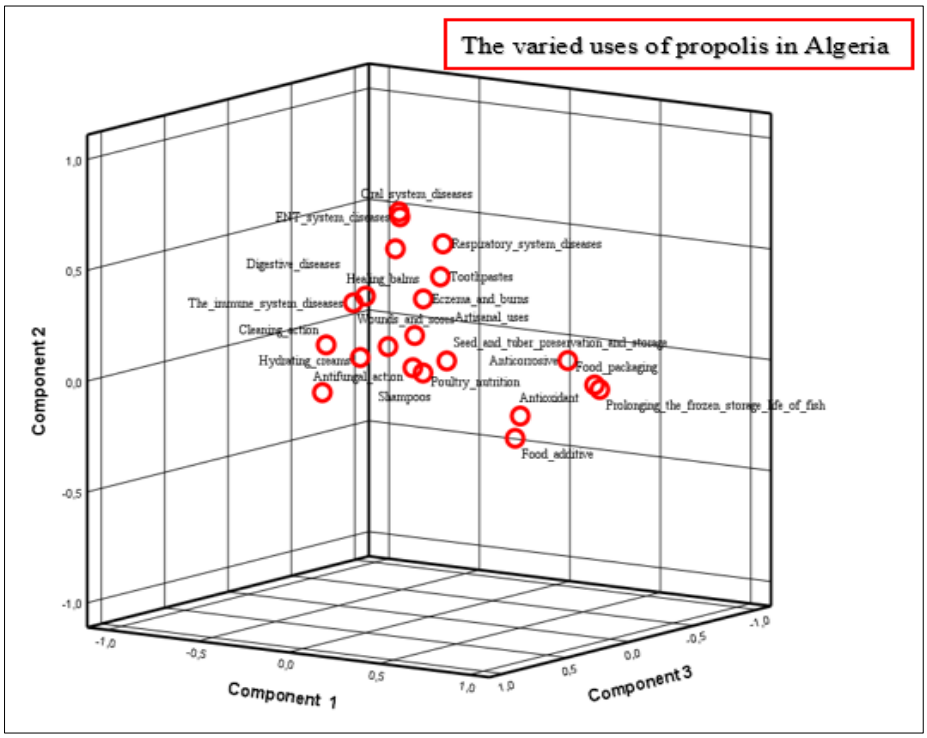

Figure 11. Principal component analysis (PCA) for different uses of propolis in Algeria

Kaiser–Meyer–Olkin (KMO) and Bartlett's Test

An evaluation of the twenty uses of propolis in Algeria was conducted. To achieve this objective, we implemented the Kaiser-Meyer-Olkin (KMO) analysis method and the Bartlett sphericity test, and the results of the KMO and Bartlett tests are presented in table 9. The calculation of the KMO index gave a value of 0.654, the Bartlett test had a highly significant value: Chi2 = 888.635; $p < 0.000$. As previously indicated, this validates the alignment of the data with principal component analysis (PCA). This dataset is therefore suitable for factor analysis.

Table 9. KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0,655
Bartlett's Test of Sphericity	Chi^2	925,770
	df.	210
	Significance	0,000

Pearson Correlation Analysis

Pearson correlation analysis (table 10) provided relevant information about the relationship between botanical and geographical characteristics. Additionally, a correlation was identified between the colour of propolis in Algeria and the characteristics of the plants, including their type (0.293**). The colour of propolis is directly linked to the plant source from which honeybees collect the resinous materials they use to produce it. Moreover, because propolis is made from resinous materials collected by honeybees from plant buds and tree bark, which explains the variety of colours seen. Also, there is correlation between propolis harvesting technique and the quantity produced (0.262**), it has therefore been concluded that the efficiency of the propolis harvesting techniques employed in Algeria, such as the use of propolis screens or scraping hive frames, inevitably impacts the quantity and quality of the propolis extracted. It therefore follows that the most appropriate techniques will guarantee the greatest possible extraction of the resinous substance, but inappropriate techniques may result in some of it being lost or a less pure product being obtained.

Table 10. Pearson correlation analysis between production parameters, botanical and geographical of propolis

Correlation						
		Biome	**Type of plants**	**Colors**	**Propolis harvesting technique**	**Quantity harvested of propolis per hive**
Biome	Pearson correlation	1	0,024	0,057	0,114	0,129
	Spearman's R	1,000	0,065	0,068	0,137	0,169
Type of plants	Pearson correlation	0,024	1	**0,293****	0,148	**0,188***
	Spearman's Rho	0,065	1,000	*0,287***	0,153	0,177
Colors	Pearson correlation	0,057	**0,293****	1	**0,295****	**0,262****
	Spearman's R	0,068	*0,287***	1,000	*0,310***	*0,235**
Propolis harvesting technique	Pearson correlation	0,114	0,148	**0,295****	1	**0,195***
	Spearman's R	0,137	0,153	*0,310***	1,000	0,165
Quantity harvested of propolis per hive	Pearson correlation	0,129	0,188*	**0,262****	**0,195***	1
	Spearman's R	0,169	0,177	*0,235**	0,165	1,000

**The correlation is significant at the 0.05 level (two-tailed).*

***The correlation is significant at the 0.01 level (two-tailed).*

Discussion

The present study provides a comprehensive inventory of propolis applications in Algeria. Previous research on Algerian propolis has primarily focused on its antibacterial (Otmane *et al.* 2020b, Debab *et al.* 2022), antifungal (Aşan *et al.* 2022, Ouahab *et al.* 2023), and antioxidant (Soltani *et al.* 2020) properties. Our findings reveal that propolis usage frequency among Algerians correlates strongly with respondent demographics. Our survey participants were predominantly young adults (20-40 years), contrary to Bentabet *et al*.'s (2022) findings in western Algeria (Aïn Témouchent), where youth demonstrated limited knowledge of dermatological treatments. In Turkey, according to Günbatan *et al.* (2015), 63% of respondents were over 50 years old. Moreover, (79.3%) of the respondents to our survey were men, and 20.7% were women, showing a male predominance. Our sample showed significant gender disparity, with 79.3% male and 20.7% female participants, aligning with Azonbakin *et al*.'s (2021) findings on male-dominated plant knowledge in Benin.

Numerous studies have documented propolis's diverse biological properties. Our survey results confirm its widespread therapeutic and pharmaceutical use in Algerian society, primarily for immune system enhancement and respiratory ailment treatment. Furthermore, Saeed *et al.* (2017) findings corroborated our study, demonstrating propolis's efficacy against various dermatological conditions including vesiculitis, eczema, and pruritus. Analysis of cosmetic applications revealed prevalent use of propolis in moisturizing creams. Regarding alimentary uses, although relatively uncommon in Algeria, propolis serves occasionally as both a food additive and antioxidant. Alolofi *et al.* (2019) reported enhancement of milk production by supplementing cattle feed with Indian propolis (collected in Bulandshahr district). Similarly, Abdel-Rahman & Mosaad. (2013) observed reduced stress behaviors; improved growth performance; and enhanced immune response following incorporating propolis as a natural feed additive for ducks.

Analysis of propolis' botanical origin is essential for identifying key indicators including regional characteristics and local flora. Survey results demonstrate that mountainous areas show the highest prevalence of propolis production. These findings align with Ibishi *et al.* (2023), who reported that mountainous regions are characterized by particularly rich flora, which contributes to the distinctive composition of propolis collected in these environments. The plant resins used as raw materials for propolis production represent a crucial element in this analysis (Bobis, 2022).

Propolis shows considerable color variation. Dezmirean *et al.* (2020) demonstrated that poplar-derived propolis ranges from orange-yellow to reddish-brown, often with dark brown hues. Our multifactorial analysis revealed the predominant use of modern hive systems in Algeria; Langstroth and Dadant hives, representing the most common modern hive types worldwide (Erat & Menemen, 2019). Our findings align with Valencia *et al.* (2012), who observed that bee resin collection peaks between summer and autumn, coinciding with reduced honey production. The seasonal peak in propolis collection (late summer to early autumn) appears driven primarily by forager behavior patterns rather than climatic factors or winter hive preparation. Nevertheless, propolis exhibits multiple variations attributable to various factors. These include geographical location, vegetation type, botanical origin, climatic variations (including heat waves and prolonged drought periods), and weather conditions. As demonstrated by Do Nascimento *et al.* (2019), other factors must be considered, including but not limited to bee type and queen genetics, hive management and harvest timing.

The quality of propolis varies considerably depending on the type of plant from which the honeybees collect the resin, and the method of harvesting and production. We can say that the type of plant is the factor because the chemical composition and therapeutic properties of propolis depend on the types of trees, buds and plants from which bees collect it. This affects its colour, odor and effectiveness. Additionally, the methods used to collect material from the hives can influence its nature.

The therapeutic use of propolis is the result of a long experience that has been accumulated and passed down from one generation to another. These results are in line with those obtained by Belhacini *et al.* (2024) in Algeria. The latter evaluated an ethnobotanical study of the plant using quantitative indices, such as RFC and UV. The UV and RFC results are comparable. They are comparable to those previously reported by Belmouhoub *et al.* (2024). They are also comparable to those reported by Merouane *et al.* (2022), Boutabia *et al.* (2020).

This study provides a comprehensive analysis of propolis utilization in Algeria, offering valuable information on population demographics, harvesting methods, and the Primary forms and uses of this natural resource. The results of the study reveal several key principles and relationships that could guide future strategies to increase propolis productivity in the country.

Conclusion

The diversity of practices in each region of Algeria is reflected in the numerous therapeutic uses of propolis in Algerian society. This has been demonstrated through quantitative ethnobotanical analysis (RFC = 0.009–0.135; UV up to 0.720). People use propolis in many ways: as an immune treatment (72% of respondents), a wound healing treatment (66.7%), a respiratory treatment (47.7%), and a digestive treatment (40.5%). This comprehensive study, based on people's responses and statistical analysis, proved that propolis is used as a food additive (57.7%) and antioxidant (59.5%) in several other areas, including agriculture (poultry nutrition). Furthermore, correlations and statistical analyses have revealed that the productivity of the propolis is closely linked to a number of factors. These include the types of plants adjacent to the apiaries and the harvesting techniques used. Future studies should focus on the factors that affect the quality and productivity of propolis.

Further research is essential to deepen our understanding of propolis-related practices and traditional knowledge in Algeria. We strongly advocate for the utilization of diverse ethnobotanical indicators. Which are crucial for systematically

documenting and interpreting these practices. Additionally, future investigations should focus on the melissopalynological analysis of Algerian propolis, a study that would represent a significant milestone in the advancement of apicultural science and contribute valuable insights to the field.

Declarations

Ethics approval and consent to participate: All respondents gave their consent before the start of the botanical study
Consent for publication: Not applicable
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Author contributions: H.A.B. collected the data, analyzed, and wrote the text, conceptualization, investigation, methodology. In addition, drafted the final manuscript. H.O.M. participated in the validation, helped with discussions, and wrote the final version of the text. N.H. and M.S. participated in the data curation, formal analysis and writing review and validation. All authors reviewed and approved the final version of the manuscript.

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Literature cited

Abbas AO, Alaqil AA, El-Beltagi HS, Abd El-Atty HK, Kamel NN. 2020. Modulating Laying Hens Productivity and Immune Performance in Response to Oxidative Stress Induced by *E. coli* Challenge Using Dietary Propolis Supplementation. Antioxidants 9: 893. doi: 10.3390/antiox9090893.

Abdel-Rahman MA, Mosaad GM. 2013. Effect of Propolis as Additive on Some Behavioural Patterns, Performance and Blood Parameters in Muscovy Broiler Ducks. Journal of Advanced Veterinary Research 3:64-68.

Adeniran AO. 2025. Understanding Cronbach's Alpha in Social and Management Studies. Current Science Research Bulletin (02):11-16. https://csrbjournal.org/index.php/csrb.

Ahmad M, Sultana S, Fazl-i-Hadi S, Ben Hadda T, Rashid S, Zafar M, Khan MA, Khan MP Z, Yaseen G. 2014. An Ethnobotanical study of Medicinal Plants in high mountainous region of Chail valley (District Swat- Pakistan). Journal of Ethnobiology and Ethnomedicine 10(1): 36. doi: 10.1186/1746-4269-10-36.

Alanazi S, Alenzi N, Alenazi F, Tabassum H, Watson D. 2021. Chemical characterization of Saudi propolis and its antiparasitic and anticancer properties. Scientific Reports 11(1): 5390. doi: 10.1038/s41598-021-84717-5.

Alghutaimel H, Matoug-Elwerfelli M, Alhaji M, Albawardi F, Nagendrababu V, Dummer P. MH. 2024. Propolis Use in Dentistry: A Narrative Review of Its Preventive and Therapeutic Applications. International Dental Journal 74(3): 365-386. doi: 10.1016/j.identj.2024.01.018.

Alolofi A, Pandey R, Shah R. 2019. Impact of Propolis on Milk Yield, Composition and Somatic Cell Count of Cow Breeds at Dairy Farm of Banaras Hindu University, Varanasi, India. International Journal of Agriculture Environment and Biotechnology (12)2: 175-179. doi: 10.30954/0974-1712.06.2019.14.

Aşan Özüsağlam M, Tacer S, Boulechfar S, Zellagui A. 2022. An Investigation of the Bactericidal and Fungicidal Effects of Algerian Propolis Extracts and Essential Oils. Cumhuriyet Science Journal 43(1): 14-19. doi: 10.17776/csj.936040.

Athikomkulchai S, Awale S, Ruangrungsi N, Ruchirawat S, Kadota S. 2013. Chemical constituents of Thai propolis. Fitoterapia 88: 96-100. doi: 10.1016/j.fitote.2013.04.008.

Azonbakin S, Dangbemey P, Osseni R, Yaude SA, Kora F, Adovoekpe D, Djego F, Laleye A, Awede B. 2021. Enquête ethnobotanique sur les plantes utilisées dans le traitement de l'infertilité masculine au Benin. International Journal of Biological and Chemical Sciences 15(4): 1667-1677. doi: 10.4314/ijbcs.v15i4.28.

Balderas-Cordero D, Canales-Alvarez O, Sánchez-Sánchez R, Cabrera-Wrooman A, Canales-Martinez MM, Rodriguez-Monroy MA. 2023. Anti-Inflammatory and Histological Analysis of Skin Wound. International Journal of Molecular Sciences 24(11831): 2-19. doi: 10.3390/ijms241411831.

Barros KBNT, Neto EMR, Fonteles MMDF. 2019. Propolis and its Cosmetic Applications: A Technological Prospection. Journal of Young Pharmacists 11(4): 350-352. doi: 10.5530/jyp.2019.11.72.

Belhacini F, Anteur D, Rahim Z. 2024. Ethnobotanical study of the therapeutic plants of the Beni Haoua region in the wilaya of Chlef (Algeria). Ethnobotany Research and Applications (29). doi: 10.32859/era.29.49.1-15.

Belmouhoub M, Aberkane B, Tacherfiout M, Boukhalfa F, Khodja YK, Bachir-bey M. 2024. Ethnobotanical survey of medicinal plants used by people cured of SARS-CoV-2 in the center of Algeria. Ethnobotany Research and Applications 28:42. http://dx.doi.org/10.32859/era.28.42.1-26.

Bentabet N, Rajaa R, Sakina N. 2022. Enquête ethnobotanique et inventaire des plantes médicinales utilisées dans le traitement des maladies dermatologiques dans la ville d'Ain Temouchent. Journal of Applied Biosciences 170: 17704-17719. doi: 10.35759/JABs.170.4.

Bobiş O. 2022. Plants: Sources of Diversity in Propolis Properties. Plants 11(17): 2298. doi: 10.3390/plants11172298.

Boutabia L, Telailia S, Menaa M. 2020. Traditional therapeutic uses of *Marrubium vulgare* L. By local populations in the Haddada region (Souk Ahras, Algeria). Ethnobotany Research & Applications 19:44.

Chi Y, Luo L, Cui M, Hao Y, Liu T, Huang X, Guo X. 2020. Chemical Composition and Antioxidant Activity of Essential Oil of Chinese Propolis. Chemistry & Biodiversity 17(1): e1900489. doi: 10.1002/cbdv.201900489.

Da silva FC, Da Fonseca CR, De Alencar SM, Thomazini M, Balieiro JCDC, Pittia P, Favaro-Trindade CS. 2013. Assessment of production efficiency, physicochemical properties and storage stability of spray-dried propolis, a natural food additive, using gum Arabic and OSA starch-based carrier systems. Food and Bioproducts Processing 91(1): 28-36. doi: 10.1016/j.fbp.2012.08.006.

Debab M, Toumi-Benali F. 2022. Activités antimicrobienne et anthelminthique de la propolis de l'Ouest algérien. Phytothérapie, 20(45): 224-229. doi: 10.3166/phyto-2021-0288.

Dezmirean DS, Paşca C, Moise AR, Bobiş O. 2020. Plant Sources Responsible for the Chemical Composition and Main Bioactive Properties of Poplar-Type Propolis. Plants, 10(1): 22. doi: 10.3390/plants10010022.

Do Nascimento TG, Dos Santos Arruda RE, Da Cruz Almeida ET, Dos Santos Oliveira JM, Basílio-Júnior ID, Celerino De Moraes Porto IC, Rodrigues Sabino A, Tonholo J, Gray A, Ebel, RE, Clements C, Zhang T, Watson DG. 2019. Comprehensive multivariate correlations between climatic effect, metabolite-profile, antioxidant capacity and antibacterial activity of Brazilian red propolis metabolites during seasonal study. Scientific Reports 9(1): 18293. doi: 10.1038/s41598-019-54591-3.

Duarte CRA, Eyng C, Murakami AE, Santos TC. 2013. Intestinal morphology and activity of digestive enzymes in broilers fed crude propolis. Canadian Journal of Animal Science 94(1): 105-114. doi: 10.4141/cjas2013-059.

Dutra RP, De Sousa MM, Mignoni MSPM, De Oliveira KGM, Pereira EB, Figueredo AS, Da Costa AAC, Dias TG, Vasconcelos CC, Silva LA, Reis AS, Lopes AJO. 2023. Brazilian Amazon Red Propolis : Leishmanicidal Activity and Chemical Composition of a New Variety of Red Propolis. Metabolites 13(9): 1027. doi: 10.3390/metabo13091027.

Elkhateeb OM, Badawy MEI, Noreldin AE, Abou-Ahmed HM, El-Kammar MH, Elkhenany HA. 2022. Comparative evaluation of propolis nanostructured lipid carriers and its crude extract for antioxidants, antimicrobial activity, and skin regeneration potential. BMC Complementary Medicine and Therapies 22(1): 256. doi: 10.1186/s12906-022-03737-4.

Erat S, Menemen Y. 2019. Comparison of Plastic and Wooden Langstroth Hives in Terms of Some Traits. International Journal of Veterinary and Animal Research. 2651-3609 2(2): 37-45.

Falcão SI, Vale N, Gomes P, Domingues MRM, Freire C, Cardoso SM, Vilas-Boas M. 2013. Phenolic Profiling of Portuguese Propolis by LC-MS Spectrometry: Uncommon Propolis Rich in Flavonoid Glycosides. Phytochemical Analysis 24(4): 309-318. doi: 10.1002/pca.2412.

Günbatan T, Gürbüz İ, Gençler Özkan AM. 2016. The current status of ethno-pharmaco-botanical knowledge in Çamlıdere (Ankara, Turkey). Turkish Journal of Botany 40: 241-249. doi: 10.3906/bot-1501-37.

Hedidi D, Zemmar N, Belabass M, Hamdani FZ, Belhacini F, Abaidia, S. 2024. Valorization of local ethnobotanical knowledge in Ouled Ben Abdelkader region, Northwest of Algeria. Ethnobotany Research and Applications (28). doi: 10.32859/era.28.18.1-20.

Ibishi B, Kolovski V, Xhezairi B, Karapetkovska V. 2023. Study on methods for extracting propolis collected in Mountain apiaries. Professional paper (638):135. 497.7.

Lopes-Rocha MSC, Miranda JL, Lima NL, Ferreira FO, Santos AS, Marinho SA, Verli FD. 2012. Effect of topical propolis and dexamethasone on the healing of oral surgical wounds. Wound Healing Southern Africa 5(1): 25-30.

Magnavacca A, Sangiovanni E, Racagni G, Dell'Agli M. 2022. The antiviral and immunomodulatory activities of propolis : An update and future perspectives for respiratory diseases. Medicinal Research Reviews 42(2): 897-945. doi: 10.1002/med.21866.

Merouane A, Fellag S, Touaibia M, Beldi A. 2022. Ethnobotanical survey of medicinal plants consumed during holy month of Ramadan in the Chlef region, Algeria. Ethnobotany Research andApplications 23:29.

Nur FM, Nugroho RA, Fachmy S. 2017. Effects of propolis (*Trigona* sp.) extract supplementation on the growth and blood profile of Pangasius djambal. 020024. doi: 10.1063/1.4975962.

Otmane B, Mohamed H, Liliane B, Brahim A. 2020. Etude comparée des propriétés anti oxydante et anti microbienne de la propolis de quelques régions d'Algérie. Algerian Annals of Agronomy – ex. Annales de l'Institut National Agronomique El-Harrach (32) :1 & 2.

Ouahab A, Grara N, Menaiaia K, Khaldi K, Bensouici C. 2023. Phytochemical Analysis, Antioxidant, and Acetylcholinesterase Inhibitory Activity of Propolis from Northeastern Algeria. Phytothérapie 21(23): 119-129. doi: 10.3166/phyto-2022-0359.

Ożarowski M, Karpiński TM. 2023. The Effects of Propolis on Viral Respiratory Diseases. Molecules 28(1): 359. doi: 10.3390/molecules28010359.

Panda DP, Mishra S, Behera DB. 2021. Developing a Research Methodology with the Application of Explorative Factor Analysis and Regression. Journal of Business and Management (IOSR-JBM) (23):23-35. doi: 10.9790/487X-2304022335.

Piette P. 2016. Métrologie appliquée à la kinésithérapie : mesures, tests et bilans, concepts fondamentaux. EMC - Kinésithérapie-Médecine physique-Réadaptation (16) : 1-15. doi: 10.1016/s1283-0887(16)73672-3.

Qiao J, Wang Y, Zhang Y, Kong L, Zhang H. 2023. Botanical Origins and Antioxidant Activities of Two Types of Flavonoid-Rich Poplar-Type Propolis. Foods 12(12): 2304. doi: 10.3390/foods12122304.

Rivera-Yañez N, Rivera-Yañez CR, Pozo-Molina G, Méndez-Catalá CF, Reyes-Reali J, Mendoza-Ramos MI, Méndez-Cruz AR, Nieto-Yañez O. 2021. Effects of Propolis on Infectious Diseases of Medical Relevance. Biology 10(5): 428. doi: 10.3390/biology10050428.

Saeed M, Arain MA, Kamboh AA, Memon SA, Umar M, Rashid M, Babazadeh D, Abd El-Hack ME, Alagawany M. 2017. Raw Propolis as a Promising Feed Additive in Poultry Nutrition: Trends and Advances. Journal of Animal Health and Production, 5: 4. doi: 10.17582/journal.jahp/2017/5.4.132.142.

Santos EL, Barbosa JM, Porto-Neto FF, Ludke JV, Silva TJ, Lima MR, Soares EC, Ludke, M. CMM. 2023. Propolis extract as a feed additive of the Nile tilapia juveniles. Arquivo Brasileiro de Medicina Veterinária Zootecnia, 75(4): 744-752. doi: 10.1590/1678-4162-12806.

Shrestha N. 2021. Factor Analysis as a Tool for Survey Analysis. American Journal of Applied Mathematics and Statistics 9(1): 4-11. doi: 10.12691/ajams-9-1-2.

Silveira DMA, Menezes MDA, Souza SP, Galvão EBDS, Berretta AA, Caldas J1, Teixeira M B, Dantas Gomes MM, Damiani LP, Bahiense BA, Cabral JB, De Oliveira CWLM1, Mascarenhas TR, Pinheiro PCG, Alves MS, Vieira de Melo RM, Leite FM, Nonaka CKV, de Freitas Souza BS, Baptista NU, Teles F, da Guarda SF, Almeida Mendes AV, Rogério da HB. 2023. Standardized Brazilian green propolis extract (EPP-AF®) in COVID-19 outcomes: a randomized double-blind placebo-controlled trial. Scientific Reports 13: 18405. doi: 10.1038/s41598-023-43764-w.

Simone-Finstrom, M, Spivak M. 2010. Propolis and bee health: The natural history and significance of resin use by honeybees. Apidologie, 41(3): 295- 311. doi: 10.1051/apido/2010016.

Soltani EK, Mokhnache K, Charef N. 2020. Polyphenol Contents and Antioxidant Activity of Ethanolic and Aqueous Algerian Propolis Extracts (Region of Serdj el Ghoul). Journal of Drug Delivery and Therapeutics 10(1): 1-4. doi: 10.22270/jddt.v10i1.3797.

Tzani A, Pitterou I, Divani F, Tsiaka T, Sotiroudis G, Zoumpoulakis P, Detsi A. 2022. Green Extraction of Greek Propolis Using Natural Deep Eutectic Solvents (NADES) and Incorporation of the NADES-Extracts in Cosmetic Formulation. Sustainable Chemistry 4(1): 8-25. doi: 10.3390/suschem4010002.

Valencia D, Alday E, Robles-Zepeda R, Garibay-EscobarA, Galvez-Ruiz JC, Salas-Reyes M, Jiménez-Estrada M, Velazquez-Contreras E, Hernandez J, Velazquez C. 2012. Seasonal effect on chemical composition and biological activities of Sonoran propolis. Food Chemistry 131(2): 645-651. doi: 10.1016/j.foodchem.2011.08.086.

Widelski J, Okińczyc P, Suśniak K, Malm A, Paluch E, Sakipov A, Zhumashova, G, Ibadullayeva G, Sakipova Z, Korona-Glowniak I. 2023. Phytochemical Profile and Antimicrobial Potential of Propolis Samples from Kazakhstan. Molecules 28(7): 2984. doi: 10.3390/molecules28072984.

Zulhendri F, Felitti R, Fearnley J, Ravalia M. 2021. The use of propolis in dentistry, oral health, and medicine: A review. Journal of Oral Biosciences 63(1): 23-34. doi: 10.1016/j.job.2021.01.001.