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Medicinal Plant Use and Market Dynamics in Benghazi, Libya: A Quantitative Ethnobotanical and Economic Assessment

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استخدام النباتات الطبية وديناميكيات سوقها في بنغازي، ليبيا: تقييم إثنوبوتاني واقتصادي كمي

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Abstract:

Background and Aims: Medicinal and aromatic plants (MAPs) play a pivotal role in the primary healthcare and local economies of the Mediterranean region. Despite this significance, quantitative ethnobotanical and economic assessments of MAP markets in urban centers like Benghazi, Libya, remain scarce. This study presents a comprehensive quantitative ethnobotanical evaluation and economic analysis of the commercial MAP trade and consumption patterns in Benghazi. **Methods**: Ethnobotanical and market surveys were conducted across 39 herbal shops (attarat) distributed between East (53.8%) and West (46.2%) Benghazi, recording 2,650 commercial transactions. Additionally, clinical interviews were conducted with 70 patients across seven specialized healthcare centers, supplemented by semi-structured interviews with traditional healers. Data were analyzed non-parametrically using SPSS (v28), including Mann–Whitney U, Kruskal–Wallis, and Chi-square tests. **Results**: A total of 114 medicinal plant species belonging to 44 families were documented. The family Lamiaceae was the most prevalent and consumed (19.2%, 11 species), followed by Apiaceae (10.3%), Asteraceae (10.2%), and Zingiberaceae (7.4%). Annual monetary consumption was significantly higher in East Benghazi compared to West Benghazi ($p < 0.01$). Large bulk packaging (50–100 kg) dominated market inventory (49.7%), with 31.8% of commercial entries exceeding an annual value of 1,000 LYD. Demographically, females constituted 68.6% of patient consumers. While perceived therapeutic efficacy was independent of gender ($p = 0.54$), it was significantly associated with patient age ($p = 0.001$), plant part used ($p = 0.001$), and preparation method ($p = 0.001$). Seeds (31.4%) and leaves (22.9%) were the most utilized parts, with powdering (38.6%) and decoction (30.0%) being the primary preparation modes. Zingiber officinale (8.6%) and Cinnamomum verum (7.1%) emerged as the most frequently consumed species among patients. **Conclusion**: The findings highlight a strong cultural continuity in MAP utilization alongside a heavy reliance on imported commercial herbs. Implementing sustainable wild-harvesting regulations and promoting local cultivation of high-value medicinal species are strongly recommended to ensure ecological preservation and economic sustainability.

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Keywords: Ethnobotany, Medicinal Plants, Economic Valuation, Lamiaceae, Benghazi, Libya, Market Survey.

الملخص

الخلفية والأهداف: تؤدي النباتات الطبية والعطرية (MAPs) دوراً محورياً في الرعاية الصحية الأولية والاقتصادات المحلية لمنطقة البحر الأبيض المتوسط. وعلى الرغم من هذه الأهمية، فإن التقييمات الإثنوبوتانية والاقتصادية الكمية لأسواق النباتات الطبية والعطرية في المراكز الحضرية مثل بنغازي في ليبيا لا تزال شحيحة. تقدم هذه الدراسة تقييماً إثنوبوتانياً كمياً شاملاً وتحليلاً اقتصادياً لتجارة النباتات الطبية والعطرية التجارية وأنماط استهلاكها في مدينة بنغازي. **المنهجية:** أُجريت مسوحات إثنوبوتانية وسوقية عبر 39 متجراً للعطارة موزعة بين شرق بنغازي (53.8%) وغربها (46.2%)، حيث سُجلت 2,650 معاملة تجارية. بالإضافة إلى ذلك، أُجريت مقابلات سريرية مع 70 مريضاً في سبعة مراكز صحية تخصصية، مدعومة بمقابلات شبه منظمة مع المعالجين التقليديين. حُللت البيانات إحصائياً بالطرق غير المعلمية باستخدام برنامج الحزم الإحصائية للعلوم الاجتماعية (SPSS الإصدار 28)، متضمنة اختبارات مان-ويتني(Mann–Whitney U) ، وكراوسكال-واليس(Kruskal–Wallis) ، ومربع كاي-(Chi-square). **النتائج:** جرى توثيق ما مجموعه 114 نوعاً من النباتات الطبية تنتمي إلى 44 عائلة نباتية. وكانت عائلة الشفويات (Lamiaceae) الأكثر انتشاراً واستهلاكاً بنسبة (19.2%، 11 نوعاً)، تلتها العائلة الخيمية (Apiaceae) بنسبة (10.3%)، والنجمية (Asteraceae) بنسبة (10.2%)، والزنجبيلية (Zingiberaceae)بنسبة (7.4%). وبلغ الاستهلاك النقدي السنوي مستويات أعلى بصورة ملحوظة في شرق بنغازي مقارنة بغربها ($p < 0.01$). هيمنت عبوات التعبئة بالجملة الكبيرة (50–100 كجم) على مخزون السوق بنسبة (49.7%)، في حين تجاوزت 31.8% من المدخلات التجارية قيمة سنوية قدرها 1,000 دينار ليبي. وديموغرافياً، شكلت الإناث 68.6% من المرضى المستهلكين. وبينما كان الإدراك الفعّال العلاجي مستقلاً عن الجنس($p = 0.54$) ، إلا أنه ارتبط ارتباطاً معتبراً ومعنوياً بعمر المريض ($p = 0.001$)، والجزء المستخدم من النبات($p = 0.001$) ، وطريقة التحضير ($p = 0.001$). وكانت البذور (31.4%) والأوراق (22.9%) الأجزاء الأكثر استخداماً، بينما مثّل السحق والمسحوق (38.6%) والغلي (30.0%) طريقتي التحضير الأساسيتين. وبرز كل من الزنجبيل الطبي (Zingiber officinale) بنسبة (8.6%) والقرفة الحقيقية (Cinnamomum verum) بنسبة (7.1%) كأكثر الأنواع استهلاكاً بين المرضى. **الخاتمة:** تسلط النتائج الضوء على استمرارية ثقافية قوية في استخدام النباتات الطبية والعطرية إلى جانب الاعتماد الكثيف على الأعشاب التجارية المستوردة. ويوصى بشدة بتنفيذ لوائح تنظيمية مستدامة للحصاد البري وتعزيز الزراعة المحلية لأنواع النباتات الطبية عالية القيمة لضمان الحفاظ البيئي والاستدامة الاقتصادية.

الكلمات المفتاحية: علم النبات العرقي (الإثنوبوتاني)، النباتات الطبية، التقييم الاقتصادي، الشفويات، بنغازي، ليبيا، مسح السوق.

Introduction

Medicinal plants have been inextricably linked to human health and cultural development since antiquity. These natural resources are rich in bioactive compounds that serve as fundamental bases for drug discovery and development (Sofowora et al., 2013). They play a crucial role in sustaining human societies and their cultures worldwide, while simultaneously representing important nutritional sources with demonstrated therapeutic value (Sofowora et al., 2013). Medicinal plants can be defined as plants containing inherent active substances that, when used by humans or animals, exert specific physiological effects, whether in disease resistance, immunity enhancement, or disease treatment (Wilson, 2019). Aromatic plants, a subset of medicinal plants, contain volatile active compounds utilized in perfumery and cosmetics, with the important distinction that while nearly all aromatic plants possess medicinal properties, the reverse is not necessarily true (Wilson, 2019).

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Traditional medicine, particularly herbal medicine, represents the indigenous medical system employed for maintaining health, preventing physical and mental illnesses, and diagnosing and treating diseases through approaches distinct from conventional evidence-based medicine, drawing upon accumulated theories, beliefs, and experiential knowledge (Aslam and Ahmad, 2016). The boundary between food and medicine often blurs in traditional practices, as many plants serve dual purposes—consumed as food while simultaneously valued for their perceived therapeutic benefits, particularly among wild edible species (Aslam and Ahmad, 2016).

Globally, over one-tenth of plant species—exceeding 5,000 taxa—are utilized in pharmaceutical and health products (Rafieian-Kopaei, 2011). However, the distribution of medicinal plants is far from uniform across the globe. China and India harbor the largest numbers of medicinal plant species, with 11,146 and 7,500 species respectively, followed by Colombia, South Africa, the United States, and 16 other countries where medicinal plants constitute between 7% (Malaysia) and 44% (India) of their total flora (Srujana et al., 2012). Significantly, certain plant families not only contain greater numbers of medicinal species but also exhibit higher proportions of threatened taxa requiring conservation attention (Huang, 2011).

Medicinal plants have historically played a crucial role in traditional healthcare systems across Libya, serving as primary resources for therapeutic remedies. Investigating their chemical profiles is essential for understanding their underlying pharmacological properties; therefore, alongside assessing their biological potentials, phytochemical screening remains a vital tool for evaluating multi-target activities of local extracts (Alshawish et al., 2025).

The Arab-Islamic civilization made seminal contributions to pharmaceutical development. Arab physicians systematically documented their clinical experiences in compendia known as "Al-Mujarrabat" (tested remedies), from which effective and lesser-known therapeutics were extracted and disseminated (Mašić et al., 2017). They pioneered the use of simple (single-ingredient) remedies to determine precise therapeutic effects, while simultaneously developing complex compound formulations that played decisive roles in clinical practice (Mašić et al., 2017). Ibn Sina's (Avicenna) monumental work "The Canon of Medicine" served as Europe's principal medical textbook for centuries, describing over 1,000 medicinal drugs, while his "Kitab al-Shifa" (The Book of Healing) constituted a comprehensive scientific encyclopedia (Saad et al., 2006). Beyond therapeutic applications, Arab scholars meticulously documented plant toxicity, exemplified by Jabir ibn Hayyan's comprehensive treatise on various plant poisons and their antidotes, "Kitab al-Sumum wa Ina' al-Sumum" (The Book of Poisons and Antidotes) (Saad et al., 2006).

Arab practitioners were true pioneers in establishing fundamental pharmaceutical practices, including the creation of dedicated drug stores, the functional differentiation between physicians (responsible for disease diagnosis) and pharmacists (tasked with drug extraction and formulation), and the subsequent professional development within each domain (Naseri, 2004). This specialization catalyzed advancements in pharmaceutical sciences, with Jabir ibn Hayyan successfully extracting and isolating various chemical substances including alcohols, nitric acid, and sulfuric acid (Naseri, 2004).

Recognizing the enduring significance of traditional medicine, the World Health Organization (WHO) has recently promulgated a strategic plan for its development and promotion across four domains: (1) defining traditional medicine and formulating appropriate policies and plans; (2) advancing research and education, particularly at the university level; (3) establishing unity and collaboration between traditional and modern medicine practitioners; and (4) developing necessary herbal cultivation programs to prevent natural resource depletion (Naseri, 2004).

Libya's flora, particularly in the Cyrenaica region, exhibits remarkable botanical diversity owing to its strategic location on the southern Mediterranean coast and its varied topographic and climatic conditions. Previous ethnobotanical investigations in Libya have documented

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substantial traditional knowledge. Othman (2012) surveyed medicinal plants in the Western Mountain region, identifying 23 species from 15 families, with findings indicating higher consumption among women (compared to men) and adults over 35 years, with approximately 70% of plants used internally and over 60% sourced locally. El-Aeib et al. (2015) examined the unsustainable exploitation of medicinal and aromatic plants in the Green Mountain region, documenting 80 commonly used species, with 13 species harvested directly from natural vegetation generating annual sales of 1,090,000 Libyan dinars from 108 tons of dry plant material. Alzarbi et al. (2018) inventoried 111 medicinal and aromatic plant species in Wadi Al-Kouf, including nine endemic taxa. Subsequently, Alzarbi et al. (2020) identified 93 species traded in Al-Abyar market, with *Thymus capitatus*, *Rosmarinus officinalis*, and *Salvia fruticosa* representing the highest-selling species, yielding annual revenues of 2,220, 5,220, and 9,125 Libyan dinars respectively. Most recently, Al-Doukali et al. (2021) documented 18 medicinal and aromatic plant species in the Gheran Agricultural Park near Tripoli, with the Lamiaceae family predominating.

Beyond Libya, regional ethnobotanical studies have illuminated various aspects of medicinal plant knowledge and trade. Al-Turki et al. (2008) investigated medicinal and wild food plants in the Jordanian Badia, documenting their nutritional significance, particularly regarding vitamin and mineral content. In Iraqi Kurdistan, Boer et al. (2011) examined the Qaysari Market's medicinal plant trade, recording 82 species and noting that 64% were imported, commanding higher prices than native species. Govindasamy et al. (2011) analyzed Tunisia's aromatic and medicinal plant market, identifying constraints and opportunities for sector expansion. Alqethami et al. (2017) explored gendered medicinal plant knowledge among women in Mecca, documenting 110 species and noting younger women's increasing preference for biomedical resources. El-Shabasy (2016) surveyed Jizan Region's medicinal flora in Saudi Arabia, recording 141 species representing 46% of the kingdom's medicinal plants. Egyptian studies have examined the economic dimensions, with Mustafa (2018) analyzing chamomile and marjoram production economics, and Bassiouni et al. (2019) investigating coriander export competitiveness.

International market-oriented ethnobotanical studies provide valuable comparative frameworks. Martinez (1995) analyzed wild medicinal plant commercialization in Mexico, revealing that collectors received merely 6.17% of the final consumer price. Dold and Cocks (2002) documented South Africa's Eastern Cape medicinal plant trade, recording 166 species with an estimated annual value of 27 million Rand, while noting that 93% were harvested unsustainably. Botha et al. (2004) examined market profiles in South Africa's Lowveld, identifying 176 species and highlighting complex local variations in harvesting and marketing. Brandão et al. (2013) investigated temporal changes in Brazilian public markets, finding that only 50.2% of samples matched official pharmacopoeia species, indicating erosion of traditional knowledge. Sher et al. (2014) analyzed high-value medicinal plant economics in Pakistan, documenting collection patterns and supply chains. Randriamiharisoa et al. (2015) surveyed Antananarivo's markets in Madagascar, recording 89 commercial species with high seller profitability. Tinitana et al. (2016) examined southern Ecuador's traditional markets, documenting 160 species and calculating informant consensus factors. Petrakou et al. (2020) surveyed Peloponnisos's herbal markets in Greece, recording 103 taxa and documenting their therapeutic applications. Ferreira et al. (2021) conducted temporal assessments in northeastern Brazil, identifying 163 species and revealing regional variations in traded assemblages.

Despite this rich regional and international context, Benghazi—Libya's second-largest city with approximately 864,299 inhabitants (Libyan Center for Electoral Research and Studies, 2021)—lacks comprehensive documentation of its medicinal plant market. While previous Libyan studies have focused primarily on floristic inventories or exploitation patterns in specific regions, no study has systematically examined the quantitative consumption patterns,

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economic dimensions, and demographic correlates of medicinal plant use in an urban Libyan market. This gap is particularly significant given Benghazi's position as a major commercial hub and its diverse population, which may reflect broader trends in medicinal plant consumption within Libyan urban centers.

Therefore, this study aimed to: (1) inventory and document the medicinal plant species commercially traded in Benghazi's local markets; (2) quantify the annual consumption volumes and economic values of these plants; (3) document the traditional therapeutic applications of medicinal plants from the perspectives of traditional healers, herbalists, and patients; (4) analyze the relationships between patients' demographic characteristics (age, gender) and their perceived treatment effectiveness; and (5) identify the most commonly used plant parts and preparation methods. This comprehensive assessment will provide baseline data essential for conservation planning, sustainable resource management, and potential integration of traditional medicine into primary healthcare strategies in Libya.

Materials and Methods

3.1 Study Area

3.1.1 Geographic Location

This study was conducted in Benghazi, the second-largest city in Libya, situated within the "Benghazi Plain"—a low-lying area extending from Tocra in the east to Qaminis in the west and Soluq in the southwest. The plain is predominantly flat with minor topographical variations. The eastern sector of this plain comprises fertile soils suitable for agriculture, whereas the western sector consists of semi-sabkha (saline) terrain with limited agricultural potential. Benghazi serves as the convergence point between what is historically known as "White Cyrenaica" and "Red Cyrenaica" (Mersal, 2008).

Geographically, Benghazi is located in the northern and northwestern part of the African continent, occupying a central position along the southern Mediterranean coastline. Astronomically, the city is situated at longitude 20.06667°E and latitude 32.11667°N, with a total land area of approximately 43,535 km² (Mersal, 2008).

Figure 1: Study Area

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3.1.2 Demographic Characteristics

Cyrenaica (Barqah) region constitutes one of Libya's largest administrative divisions, containing over one-quarter of the nation's population, with Benghazi serving as its principal urban center and capital. The city's population density has increased substantially due to natural population growth and rural-to-urban migration, rising from 3.5 inhabitants/km² in 1973 to 10.9 inhabitants/km² in 2018 (Al-Khafifi et al., 2020). The Benghazi branch recorded the highest population density within the region, reaching 785.4 inhabitants/km² with a total population of 628,399 in 2018 (Al-Khafifi et al., 2020). This concentration reflects Benghazi's functional roles in education, industry, commerce, and administration, which have attracted approximately half of the region's population to the coastal plain, combined with its moderate climate and surrounding agricultural lands (Al-Khafifi et al., 2020).

According to the Libyan Center for Electoral Research and Studies (2021), Libya's total estimated population was 6,619,256, with Benghazi accounting for 864,299 inhabitants distributed between the eastern sector (626,225 inhabitants) and western sector (238,074 inhabitants). Table 3.1 presents the population distribution across Libyan municipalities, while Table 1 details the population of Benghazi's eastern and western sectors.

Table 1: Estimated population of Libyan municipalities, 2021

Municipality	**Estimated Population (2021)**
Tripoli	1,427,559
East Benghazi	626,225
West Benghazi	238,074
Al-Butnan	186,920
Western Region	207,305
Souf Al-Jeen	109,154
Al-Wahat	47,257
Al-Nuqazah	334,920
Jufra	61,327
Misrata	705,902
Zawiya	422,049
Jafara Plain	351,713
Al-Asab'ah	34,074
Kufra	50,971
Zuwara	37,158
Al-Marj	138,443
Central Region	165,646
Fezzan	341,319
Derna	136,372
Al-Jabal Al-Akhdar	238,028
Al-Qubbah	57,843
Southwestern Region	117,606
Ajdabiya	167,913
Western Mountain	415,477
Total	**6,619,256**

Source: Libyan Center for Electoral Research and Studies (2021)

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Table 2: Estimated population of Benghazi study area by sector, 2021

Sector	Estimated Population (2021)
East Benghazi	626,225
West Benghazi	238,074
Total	**864,299**

Source: Libyan Center for Electoral Research and Studies (2021)

For the purposes of this study, Benghazi was divided into two sectors—eastern and western—based on the administrative divisions established by the Social Security Fund, enabling comparative analysis of medicinal plant consumption patterns across different urban areas.

3.2.1 Field Surveys of Medicinal Plant Shops (Herbalist Shops)

3.2.1.1 Sampling Framework

Table 3: Inventory of medicinal plant shops surveyed in Benghazi with assigned codes

Shop Code	District/Sector
H01	East Benghazi
H02	East Benghazi
H03	East Benghazi
H04	West Benghazi
H05	East Benghazi
H06	West Benghazi
H07	East Benghazi
H08	West Benghazi
H09	East Benghazi
H10	West Benghazi
H11	East Benghazi
H12	West Benghazi
H13	East Benghazi
H14	West Benghazi
H15	East Benghazi
H16	West Benghazi
H17	East Benghazi
H18	West Benghazi
H19	East Benghazi
H20	West Benghazi
H21	East Benghazi
H22	West Benghazi
H23	East Benghazi
H24	West Benghazi
H25	East Benghazi
H26	West Benghazi
H27	East Benghazi
H28	West Benghazi
H29	East Benghazi
H30	West Benghazi
H31	East Benghazi

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H32	West Benghazi
H33	East Benghazi
H34	West Benghazi
H35	East Benghazi
H36	West Benghazi
H37	East Benghazi
H38	West Benghazi
H39	East Benghazi

The study was conducted throughout Benghazi city, where over sixty herbalist shops (specialized medicinal plant retailers) were initially identified across various urban districts. A total of 39 shops were purposively selected to ensure comprehensive geographic coverage of the city's eastern and western sectors, based on the administrative division of the Social Security Fund (East Benghazi and West Benghazi). To maintain confidentiality of participating commercial establishments, each shop was assigned a unique code (H01–H39) for data analysis and presentation.

3.2.1.2 Data Collection Instrument

A structured questionnaire was developed specifically for this study to collect comprehensive data from each surveyed herbalist shop. The questionnaire captured the following information:

- Local (vernacular) name of each plant
- Scientific name
- Plant family
- Package size (kg)
- Monthly consumption (kg)
- Most consumed plants
- Least consumed plants
- Highest-priced plants
- Lowest-priced plants

3.2.1.3 Survey Period and Frequency

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Field surveys were conducted over a twelve-month period from November 2021 to November 2022. Each shop was visited multiple times throughout the year to capture seasonal variations in consumption patterns, sales volumes, and package weights, thereby generating robust and representative data on medicinal plant utilization in the study area.

3.2.1.4 Compilation of Medicinal Plant Inventory

A comprehensive inventory of medicinal plants was developed progressively, beginning with shops exhibiting moderate to high marketing capacity. The inventory was completed through surveys of wholesale establishments in the central market, ultimately yielding a master list of 114 plant species, encompassing both locally sourced and imported taxa. These plants were commercially available in various forms, including:

- Powdered material
- Leaves
- Seeds
- Roots
- Inflorescences
- Oils
- Other preparations

Monthly consumption quantities were recorded for each plant species in every shop where the species was available, enabling calculation of annual consumption estimates.

صورة رقم (4.4) نبات الزعتر *Thymus capitatus*

3.2.1.5 Plant Identification and Authentication

Medicinal plants were identified and authenticated through multiple approaches: (1) consultation with traditional healers (practitioners of folk medicine), (2) interviews with experienced herbalists and shop owners, (3) reference to specialized literature on Libyan flora, and (4) verification using established taxonomic resources including the "Flora of Libya" (El-Gadi, 1988-1992) .

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Table 4: Districts surveyed in Benghazi during the study period

No.	District Name
1	Garyounis
2	Al-Fuwayhat
3	Al-Rahbah
4	Al-Hada'iq
5	Shabnah
6	Bu'atni
7	Al-Masakin
8	Al-Majouri
9	Sidi Yunus
10	Al-Baraka
11	Bu Hdaima
12	Al-Wuhayshi
13	Suria Street
14	Al-Laythi
15	Al-Sulmani Al-Sharqi
16	Al-Sabri
17	Al-Sulmani Al-Gharbi
18	Wust Al-Balad
19	Hay Al-Salam
20	Venice Street
21	Wahda Al-Arabiya Street

3.2.2 Clinical Component of the Study (Health Centers and Clinics)

To complement the market survey data and provide a comprehensive understanding of medicinal plant consumption patterns from a therapeutic perspective, a clinical component was incorporated. This component aimed to document:

- The specific diseases for which medicinal plants were employed
- The forms in which plants were administered
- Perceived therapeutic outcomes (relief, cure, or prevention)

3.2.2.1 Patient Survey Instrument

A structured questionnaire was developed to collect data from patients attending various health facilities. The questionnaire captured the following information:

- Plant species used
- Plant part utilized (roots, leaves, bark, seeds, whole plant, fruits, gums)
- Method of preparation and administration (decoction, infusion, direct consumption, powdered form, fumigation)
- Patient demographic characteristics:
  - Gender (male, female)
  - Age category (<20 years, 20-40 years, 40-60 years, >60 years)
- Disease category being treated:
  - Kidney dialysis
  - Diabetes
  - Hypertension
  - Therapeutic nutrition (weight loss, weight gain, weight maintenance)
  - Cancer
  - Women's health and obstetrics
  - Respiratory diseases

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- Allergies

3.2.2.2 Health Facilities Surveyed

A total of seven health facilities were included in the study, encompassing specialized centers, general clinics, and private practices. To maintain confidentiality, each facility was assigned a unique code (C01–C07) for data analysis and presentation, as detailed in Table 5.

Table 5: Health facilities surveyed in this study with assigned codes

Facility Code	Facility Type
C01	Oncology Center
C02	General Health Center
C03	Diabetes Center
C04	Private Clinic
C05	Medical Center (Oncology)
C06	Private Clinic
C07	Kidney Diseases Center

3.2.2.3 Patient Interviews

Seventy patients were interviewed across the surveyed health facilities. To maintain patient confidentiality, each participant was assigned a unique identifier (P01–P70). Interviews explored:

- The perceived effectiveness of medicinal plants in their treatment
- Whether traditional medicine played a primary role in their recovery
- The timing of herbal medicine consumption relative to conventional pharmaceuticals (simultaneously, before, or after)
- Their overall assessment of the therapeutic efficacy of medicinal plants

Most patients demonstrated cooperation and provided valuable insights regarding medicinal plant effectiveness. Healthcare professionals exhibited exceptional collaboration and occasionally contributed corrections to certain medical information concerning plant toxicity and efficacy, thereby enhancing the accuracy of documented data.

3.2.3 Field Visits to Traditional Medicine Centers (Herbal Medicine Clinics)

Additional field visits were conducted to specialized traditional medicine centers and practitioners throughout Benghazi. These visits targeted facilities where patients receive treatment primarily through herbal medicine, enabling documentation of therapeutic applications and perceived efficacy of the plants inventoried in this study. To maintain confidentiality, each traditional medicine practitioner was assigned a unique code (T01–T04). Practitioners exhibited varying levels of expertise and educational backgrounds; some possessed no formal training in botany or pharmaceutical sciences, while others had medical backgrounds complemented by specialized training in herbal medicine.

Table 6: Traditional medicine practitioners surveyed with assigned codes

Practitioner Code	Expertise/Background
T01	Herbal Medicine Center Practitioner
T02	Herbal Medicine Center Practitioner
T03	Independent Herbal Expert
T04	Pharmacy-based Herbal Specialist

3.2.4 Data Compilation and Processing

All collected data were entered into a structured database using Microsoft Excel. Data cleaning and verification procedures were implemented to ensure accuracy and consistency prior to statistical analysis.

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3.2.5 Statistical Analysis

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) version 28 . The following statistical procedures were employed:

3.2.5.1 Descriptive Statistics

Frequencies, percentages, means, and standard deviations were calculated to characterize the sample demographics, plant consumption patterns, and distribution of variables across study categories.

3.2.5.2 Normality Testing

The Kolmogorov-Smirnov test was applied to assess the normality of data distribution for continuous variables, particularly annual consumption in Libyan dinars. This test informed the selection of appropriate parametric or non-parametric tests for subsequent analyses.

3.2.5.3 Comparative Analyses

Mann-Whitney U Test: This non-parametric alternative to the independent samples t-test was employed to compare annual medicinal plant consumption (in Libyan dinars) between the two independent geographic sectors (East Benghazi and West Benghazi). The test was selected due to the non-normal distribution of consumption data.

Kruskal-Wallis Test: This non-parametric alternative to one-way ANOVA was utilized to examine differences in annual consumption across multiple independent groups, specifically:

- Differences in consumption according to plant family
- Differences in consumption according to package weight categories

Where significant differences were detected by the Kruskal-Wallis test, post-hoc pairwise comparisons were conducted to identify which specific groups differed significantly.

3.2.5.4 Association Analyses

Chi-Square Test (χ^2): This test was employed to examine associations between categorical variables, specifically:

- Association between perceived treatment effectiveness and patient age
- Association between perceived treatment effectiveness and patient gender
- Association between perceived treatment effectiveness and plant part used
- Association between perceived treatment effectiveness and method of preparation/administration

For all statistical tests, significance was set at $\alpha = 0.05$, with p-values < 0.05 considered statistically significant. Results were reported with corresponding test statistics, degrees of freedom, and exact p-values where appropriate.

3.2.6 Ethical Considerations

All participants (herbalists, patients, and traditional medicine practitioners) were informed about the study objectives prior to data collection. Verbal informed consent was obtained from each participant. Participants were assured of the confidentiality of their responses and their right to withdraw from the study at any point without consequence.

Results

4.1 Overview

This chapter presents the findings of the study, which aimed to evaluate the annual consumption patterns of medicinal plants in the local market of Benghazi city. Following data collection through structured questionnaires and interviews, statistical analyses were performed to characterize consumption patterns and test the study hypotheses. The results are presented in two main sections: (1) descriptive statistics characterizing the sample and consumption patterns, and (2) inferential statistics testing the research hypotheses.

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Table .7: Medicinal plant species recorded in Benghazi markets with their scientific names, families, and local names

Scientific Name	Family	Local Name
PTERIDOPHYTA		
Adiantum capillus-veneris L.	ADIANTACEAE	Kuzberat al-bi'r
GYMNOSPERMS		
Ephedra alata Decne.	EPHEDRACEAE	Al-'alanda
Ginkgo biloba L.	GINKGOACEAE	Al-jinko
Juniperus phoenicea L.	CUPRESSACEAE	Al-'ar'ar - Al-sha'rah
ANGIOSPERMS – MONOCOTYLEDONS		
Allium sativum L.	ALLIACEAE	Al-thum
Cocos nucifera L.	ARECACEAE	Jawz al-hind
Cyperus rotundus L.	CYPERACEAE	'Ushbat al-sa'd - Habb al-'aziz
Crocus sativus L.	IRIDACEAE	Al-za'faran
Aloe vera L.	LILIACEAE	Al-sabbar
Urginea maritima (L.) Baker	LILIACEAE	Basal fir'awn
Avena sativa L.	POACEAE	Al-shufan
Cymbopogon schoenanthus (L.) Spreng.	POACEAE	Al-dhikhr
Hordeum vulgare L.	POACEAE	Al-sha'ir
Triticum aestivum L.	POACEAE	Al-qamh
Zea mays L.	POACEAE	Shush al-dhura
ANGIOSPERMS – DICOTYLEDONS		
Deverra tortuosa (Desf.) DC. (Syn. *Pituranthos tortuosus* (Desf.) Benth.)	APIACEAE	Al-qazzah
Ferula assa-foetida L.	APIACEAE	Al-hiltit
Carum carvi L.	APIACEAE	Karawya
Coriandrum sativum L.	APIACEAE	Kusbar habb
Foeniculum vulgare Mill.	APIACEAE	Kamun 'arid (shamar)
Petroselinum crispum (Mill.) Hill	APIACEAE	Ma'danus
Pimpinella anisum L.	APIACEAE	Kamun hilu - Yansun
Pistacia lentiscus L.	ANACARDIACEAE	Al-mastaka
Achillea millefolium L.	ASTERACEAE	Ikhiliya - Umm alf warqah
Artemisia herba-alba Asso (Syn. *Seriphidium herba-album* (Asso) Sojak)	ASTERACEAE	Al-shih
Carthamus tinctorius L.	ASTERACEAE	'Usfur
Chamomilla aurea (Loefl.) Gay	ASTERACEAE	Al-qumaylah
Cichorium intybus L.	ASTERACEAE	Al-shikuriya - Hindiba'
Echinops sp.	ASTERACEAE	Qa'mul al-jamal - Shuk al-ibil
Helichrysum stoechas (L.) Moench	ASTERACEAE	'Ushbat al-arnab
Phagnalon rupestre (L.) DC.	ASTERACEAE	'Ushbat al-arnab
Rhaponticum acaule (L.) DC.	ASTERACEAE	Tafighah
Saussurea costus (Falc.) Lipschitz	ASTERACEAE	Qust hindi

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Tussilago farfara L.	ASTERACEAE	Hashishat al-ri'ah - Al-su'al
Betula nana L.	BETULACEAE	Bitula
Lithospermum officinale L.	BORAGINACEAE	Hashishat al-qalb - Habbat al-qalb
Anastatica hierochuntica L.	BRASSICACEAE	Kaf maryam
Brassica juncea (L.) Czern.	BRASSICACEAE	Khardal
Lepidium sativum L.	BRASSICACEAE	Habb al-rashad
Commiphora myrrha (Nees) Engl.	BURSERACEAE	Murrah
Boswellia serrata Roxb. ex Colebr.	BURSERACEAE	Luban murr
Boswellia sacra Flueck.	BURSERACEAE	Luban
Ceratonia siliqua L.	CAESALPINIACEAE	Kharrub
Capparis spinosa L. subsp. *orientalis* (Duhamel) Jafri	CAPPARACEAE	Al-kabbar
Valeriana officinalis L.	CAPRIFOLIACEAE	Sunbul hindi
Atriplex halimus L.	CHENOPODIACEAE	Qataf
Chenopodium quinoa Willd.	CHENOPODIACEAE	Kinwah
Citrullus colocynthis (L.) Schrad.	CUCURBITACEAE	Hanzal
Cuscuta epithymum (L.) L.	CUSCUTACEAE	Harirat al-za'tar
Jatropha curcas L.	EUPHORBIACEAE	Habbat al-muluk
Ricinus communis L.	EUPHORBIACEAE	Al-khirwa'
Cassia angustifolia Vahl	FABACEAE	Al-sanamaki
Glycyrrhiza glabra L.	FABACEAE	'Irq al-sus
Glycine max (L.) Merr.	FABACEAE	Al-soya
Trigonella foenum-graecum L.	FABACEAE	Al-hulbah
Quercus coccifera L.	FAGACEAE	Al-ballut
Globularia alypum L.	GLOBULARIACEAE	Al-zariqah
Globularia arabica Jaub. & Spach	GLOBULARIACEAE	Al-zariqah
Hypericum perforatum L.	HYPERICACEAE	'Ushbat al-khal'ah
Ajuga iva (L.) Schreb.	LAMIACEAE	Al-shunduqurah
Ballota saxatilis Sieber ex C.Presl	LAMIACEAE	Samwah
Lavandula multifida L.	LAMIACEAE	Al-khuzamah
Mentha spp.	LAMIACEAE	Al-na'na'
Marrubium vulgare L.	LAMIACEAE	Al-rubiya
Melissa officinalis L.	LAMIACEAE	Al-mulayzah
Ocimum basilicum L.	LAMIACEAE	Al-habaq
Origanum majorana L.	LAMIACEAE	Bardaqush
Rosmarinus officinalis L.	LAMIACEAE	Ikhlil
Salvia fruticosa Mill.	LAMIACEAE	Tuffah al-shahi - Al-miramiyyah
Thymus capitatus (L.) Hoffmanns. & Link	LAMIACEAE	Al-za'tar
Cinnamomum verum J.Presl	LAURACEAE	Qirfah
Laurus nobilis L.	LAURACEAE	Waraq al-ghar
Lawsonia inermis L.	LYTHRACEAE	Hinnah
Hibiscus sabdariffa L.	MALVACEAE	Karkadeh
Grewia tenax (Forssk.) Fiori	MALVACEAE	Qudaym
Azadirachta indica A.Juss.	MELIACEAE	Waraq al-neem

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Eucalyptus spp.	MYRTACEAE	Al-kafur
Myrtus communis L.	MYRTACEAE	Ās barri
Psidium guajava L.	MYRTACEAE	Waraq al-jawafah
Syzygium aromaticum (L.) Merr. & L.M.Perry	MYRTACEAE	Qurunful
Myristica fragrans Houtt.	MYRISTICACEAE	Jawzat al-tib
Portulaca oleracea L.	PORTULACACEAE	Rijl al-asad - Al-bilibshah
Punica granatum L.	PUNICACEAE	Budrat al-rumman
Tilia platyphyllos Scop.	TILIACEAE	Tilyu
Moringa oleifera Lam.	MORINGACEAE	Al-muringa
Linum usitatissimum L.	LINACEAE	Al-kittan
Rheum palmatum L.	POLYGONACEAE	Rawand
Citrus limon (L.) Osbeck	RUTACEAE	Laymun mujaffaf
Haplophyllum tuberculatum (Forssk.) A.Juss.	RUTACEAE	Shajarat al-rayh
Ruta graveolens L.	RUTACEAE	Al-fijal
Nigella sativa L.	RANUNCULACEAE	Habbet al-barakah
Ziziphus lotus (L.) Lam.	RHAMNACEAE	Al-sidr
Crataegus spp.	ROSACEAE	Zu'rur
Rosa damascena Mill.	ROSACEAE	Ward
Illicium verum Hook.f.	SCHISANDRACEAE	Buthur al-najm al-ahmar
Atropa belladonna L.	SOLANACEAE	Sitt al-hasan - Belladonna
Hyoscyamus muticus L.	SOLANACEAE	Sukran
Capsicum annuum L.	SOLANACEAE	Filfil ahmar
Thymelaea hirsuta (L.) Endl.	THYMELAEACEAE	Muthnan
Urtica pilulifera L.	URTICACEAE	Qurrays
Verbena officinalis L.	VERBENACEAE	Rijl al-hamamah - Hashishat al-awja'
Viola spp.	VIOLACEAE	Zahrat al-banafsaj
Curcuma longa L.	ZINGIBERACEAE	Kurkum
Zingiber officinale Roscoe	ZINGIBERACEAE	Zanjabil
Alpinia officinarum Hance	ZINGIBERACEAE	Khawlanjan
Elettaria cardamomum (L.) Maton	ZINGIBERACEAE	Habbahan
Peganum harmala L.	ZYGOPHYLLACEAE	Harmal
Phyllanthus emblica L.	PHYLLANTHACEAE	Amlaj

Source: Compiled by the author based on field surveys

4.2 Descriptive Analysis

4.2.1 Expert Interviews: Traditional Medicine Practitioners and Herbalists

Semi-structured interviews were conducted with five traditional medicine practitioners and herbalists who possessed both academic qualifications and extensive practical experience in folk medicine. To maintain confidentiality, each practitioner was assigned a unique code (T01–T05). When asked about the primary therapeutic applications of medicinal plants, the informants provided comprehensive responses that were categorized into major therapeutic areas:

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Respiratory ailments: Several plants were identified for treating colds, coughs, and respiratory conditions, including *Thymus capitatus* (za'tar), *Psidium guajava* leaves (waraq al-jawafah), *Tussilago farfara* (hashishat al-ri'ah), *Glycyrrhiza glabra* ('irq al-sus), *Linum usitatissimum* (al-kittan), *Illicium verum* (buthur al-najm al-ahmar), *Carum carvi* (karawya), and dried *Citrus limon* (laymun mujaffaf).
Nervous system disorders: Plants with sedative and calming properties included *Mentha* spp. (al-na'na'), *Rosmarinus officinalis* (ikhlil), *Melissa officinalis* (al-mulayzah), *Atriplex halimus* (qataf), *Illicium verum*, and *Saussurea costus* (qust hindi).
Hormonal and reproductive health: Plants used for hormonal regulation, polycystic ovary syndrome, and fertility included *Anastatica hierochuntica* (kaf maryam), *Origanum majorana* (bardaqush), *Echinops* sp. (shuk al-ibil), *Achillea millefolium* (ikhiliya), and *Ajuga iva* (al-shunduqurah).
Cardiovascular conditions: Plants employed for blood pressure management included *Origanum majorana*, *Glycyrrhiza glabra*, *Elettaria cardamomum* (habbahan), *Moringa oleifera* (al-muringa), *Hibiscus sabdariffa* (karkadeh), and *Cymbopogon schoenanthus* (al-dhikhr).
Urinary tract and renal disorders: Plants used for urinary tract infections, kidney stones, and genitourinary conditions included *Helichrysum stoechas* ('ushbat al-arnab), *Carum carvi*, *Chamomilla aurea* (al-qumaylah), *Hordeum vulgare* (al-sha'ir), *Coriandrum sativum* (kusbar habb), *Quercus coccifera* bark (laha' al-ballut), and *Echinops* sp.
Antioxidant applications: Plants recognized for their antioxidant properties included *Crocus sativus* (al-za'faran), *Curcuma longa* (kurkum), and *Ephedra alata* (al-'alanda).
Additionally, informants reported cosmetic applications for several medicinal plants:
Hair care: *Phyllanthus emblica* (amlaj), *Ziziphus lotus* (al-sidr), *Ricinus communis* (al-khirwa'), *Ruta graveolens* (al-fijal), *Laurus nobilis* (waraq al-ghar), and *Rosmarinus officinalis*.
Skin care: *Chamomilla aurea*, *Ricinus communis*, *Laurus nobilis*, and *Rosmarinus officinalis.
Several key observations emerged from the expert interviews:
1. **Multi-functional therapeutic applications:** Many plants exhibited multiple medicinal uses, indicating that their bioactive compounds affect diverse physiological systems and disease conditions.
2. **Dual therapeutic-cosmetic applications:** A subset of medicinal plants possessed both therapeutic and cosmetic applications, reflecting their versatile phytochemical profiles.
3. **Diverse preparation methods and plant parts:** Plants were utilized through various preparation methods (decoction, powder, infusion) and employed different plant parts (leaves, flowers, roots, seeds), demonstrating the depth of traditional knowledge regarding optimal extraction and administration of bioactive compounds.

4.2.2 Descriptive Statistics: Herbal Shop Sample

4.2.2.1 Sample Distribution by Geographic Sector

A total of 2,650 data points were collected from the 39 surveyed herbal shops. Table 8 presents the distribution of the sample according to geographic sector (East Benghazi and West Benghazi).

Table 8: Distribution of the study sample from herbal shops by geographic sector

Variable	Category	Frequency	Percentage
Sector	East Benghazi	1,426	53.8%
	West Benghazi	1,224	46.2%
	Total	**2,650**	**100.0%**

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The results indicate that 53.8% of the sample originated from East Benghazi, while 46.2% originated from West Benghazi. The relatively balanced distribution confirms that the sample adequately represents both sectors of the city. Figure 2 provides a graphical representation of the sectoral distribution.

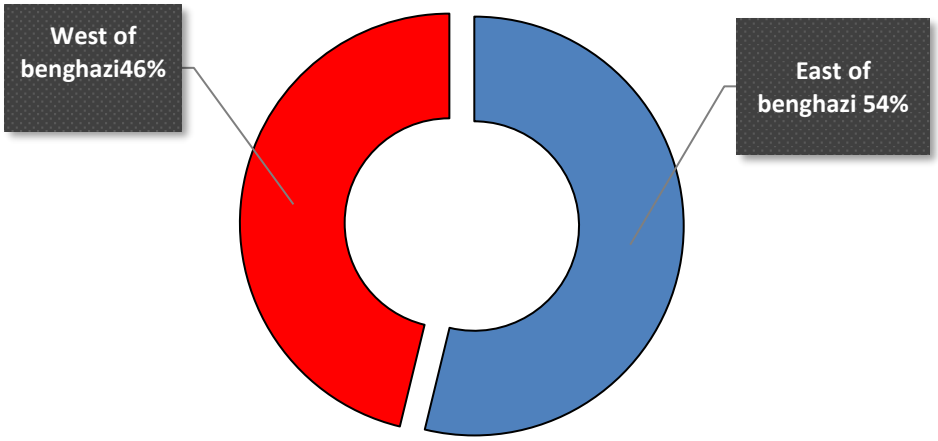

Figure 2: Distribution of the study sample by geographic sector.

4.2.2.2 Distribution by Package Weight

Table 9 presents the distribution of medicinal plant samples according to package weight categories.

Table 9: Distribution of medicinal plant samples by package weight (kg)

Variable	Weight Category (kg)	Frequency	Percentage
Package Weight (kg)	0–24 kg	619	23.4%
	25–49 kg	164	6.2%
	50–100 kg	1,318	49.7%
	>100 kg	549	20.7%
	Total	**2,650**	**100.0%**

The results reveal that the highest proportion of samples (49.7%) fell within the 50–100 kg package weight category, followed by the 0–24 kg category (23.4%), the >100 kg category (20.7%), and finally the 25–49 kg category (6.2%). Notably, approximately 70% of all samples had package weights exceeding 50 kg, indicating a predominance of bulk purchasing and wholesale transactions in the Benghazi medicinal plant market.

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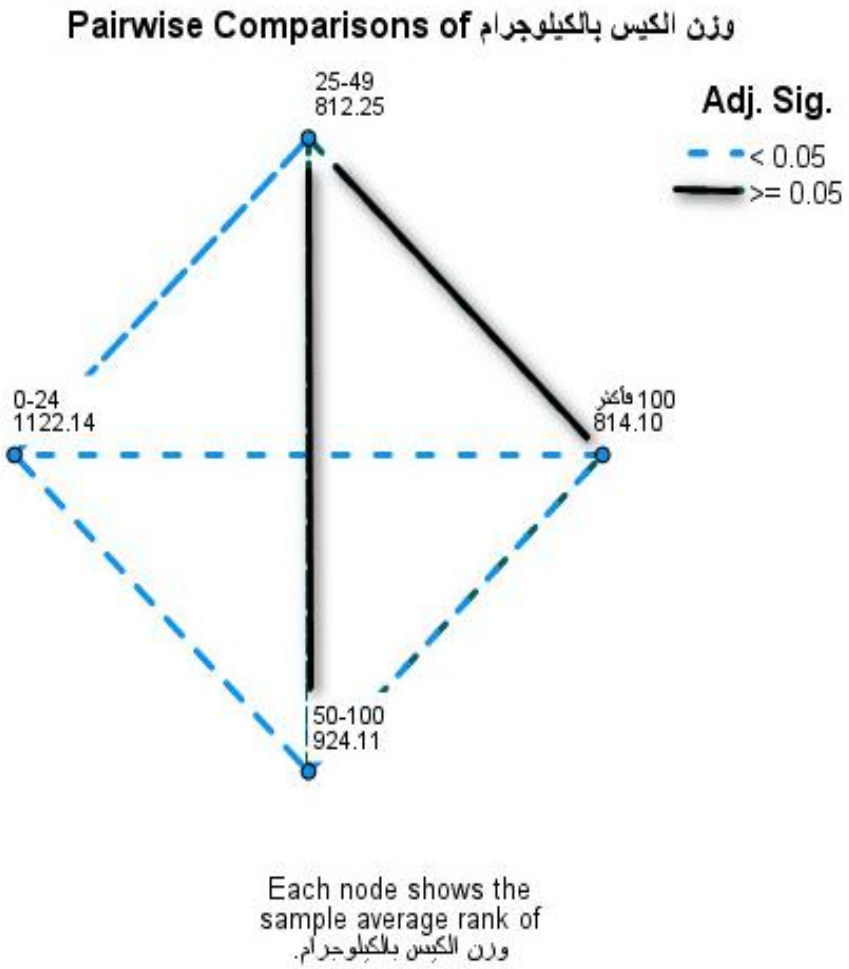

4.2.2.3 Distribution by Annual Consumption Value

Table 10 presents the distribution of medicinal plant samples according to annual consumption value in Libyan Dinars (LYD).

Table 10: Distribution of medicinal plant samples by annual consumption value (LYD)

Variable	Consumption Category (LYD)	Frequency	Percentage
Annual Consumption (LYD)	<250	755	28.5%
	250–749	719	27.1%
	750–999	332	12.5%
	≥1000	844	31.8%
	Total	**2,650**	**100.0%**

The highest proportion of samples (31.8%) fell within the highest consumption category (≥1000 LYD annually), followed by the <250 LYD category (28.5%), the 250–749 LYD category (27.1%), and finally the 750–999 LYD category (12.5%). These findings demonstrate substantial economic activity in the medicinal plant market, with nearly one-third of samples representing annual consumption values exceeding 1000 LYD. Figure 3 provides a graphical representation of consumption value distribution.

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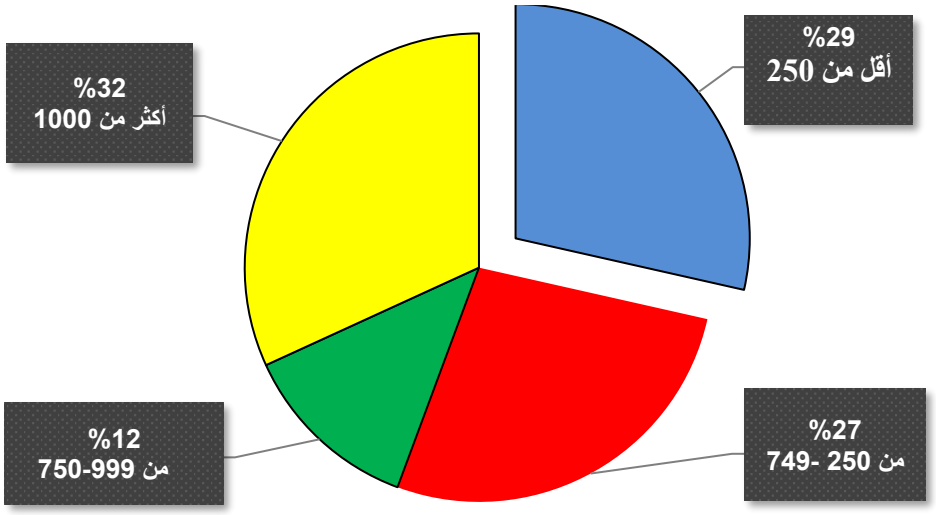

Figure 3: Distribution of medicinal plant samples by annual consumption value (LYD)

4.2.2.4 Distribution by Plant Family

Table 11 presents the distribution of medicinal plant samples according to plant family, based on the taxonomic classification of the 114 recorded species.

Table 11: Distribution of medicinal plant samples by plant family

Family	Frequency	Percentage	Rank
LAMIACEAE	510	19.2%	1
APIACEAE	273	10.3%	2
ASTERACEAE	271	10.2%	3
ZINGIBERACEAE	195	7.4%	4
POACEAE	195	7.4%	4
MYRTACEAE	195	7.4%	4
SOLANACEAE	194	7.3%	5
FABACEAE	156	5.9%	6
BURSERACEAE	117	4.4%	7
SCHISANDRACEAE	78	2.9%	8
CHENOPODIACEAE	78	2.9%	8
EUPHORBIACEAE	78	2.9%	8
LAURACEAE	78	2.9%	8
MALVACEAE	78	2.9%	8
RUTACEAE	78	2.9%	8
ROSACEAE	76	2.9%	8
Total	**2,650**	**100.0%**	

The Lamiaceae family exhibited the highest representation, comprising 19.2% of all samples, followed by Apiaceae (10.3%) and Asteraceae (10.2%). Zingiberaceae, Poaceae, and Myrtaceae each accounted for 7.4% of samples, while Solanaceae represented 7.3%. The remaining families each contributed less than 6% of the total sample. This predominance of Lamiaceae, Apiaceae, and Asteraceae reflects the widespread availability and consumption of species from these families in Libyan traditional medicine and household use. Figure 4 provides a graphical representation of family distribution.

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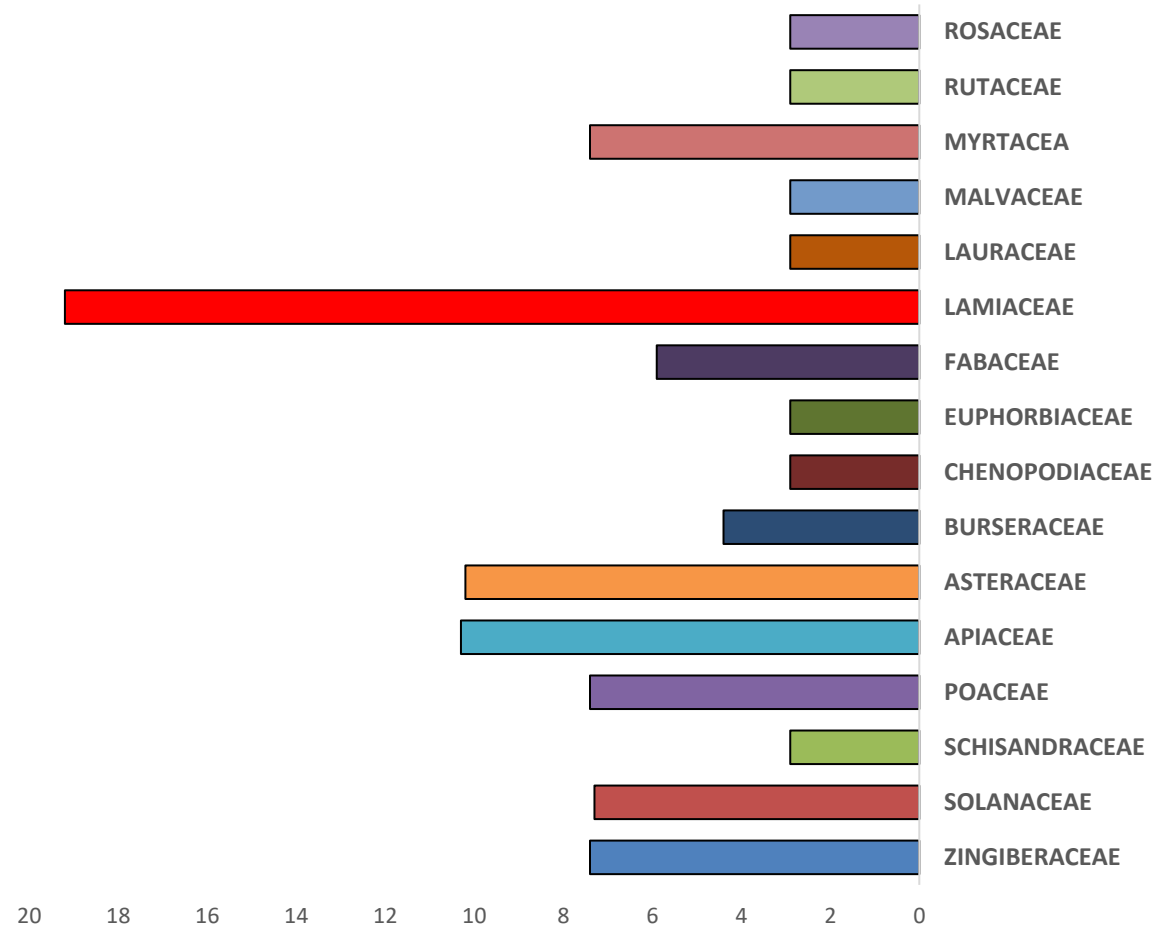

Figure 4: Distribution of medicinal plant samples by plant family

4.2.3 Normality Testing

Prior to selecting appropriate inferential statistical tests, the normality of data distribution for the continuous variable (annual consumption in LYD) was assessed using the Kolmogorov-Smirnov test. The null hypothesis (H_0) stated that the sample data were drawn from a normally distributed population, while the alternative hypothesis (H_1) stated that the data were not normally distributed.

Table 12: Normality test results for the study sample

	Kolmogorov-Smirnova		
	Statistic	**df**	**p-value**
Total	0.220	1808	0.000

The Kolmogorov-Smirnov test revealed a statistically significant result ($p < 0.001$), indicating that the annual consumption data significantly deviated from a normal distribution. Consequently, non-parametric statistical tests were employed for all subsequent inferential analyses.

4.3 Inferential Statistics: Herbal Shop Sample

4.3.1 Hypothesis 1: Sectoral Differences in Annual Consumption

The first hypothesis stated: "There are significant differences in the annual consumption value (LYD) of medicinal plants between East Benghazi and West Benghazi."

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The Mann-Whitney U test, a non-parametric alternative to the independent samples t-test, was employed to compare annual consumption values between the two geographic sectors. Table 13 presents the results of this analysis.

Table 13: Mann-Whitney U test results for annual consumption (LYD) by geographic sector

Sector	N	Sum of Ranks	Mean Rank	Mann-Whitney U	p-value	Decision
East Benghazi	982	951,061	968.49	342,724	0.001	Significant
West Benghazi	826	684,275	828.42			

The mean rank for East Benghazi (968.49) was substantially higher than that for West Benghazi (828.42). The Mann-Whitney U test yielded a statistically significant result ($U = 342{,}724$, $p < 0.01$), leading to rejection of the null hypothesis. This finding confirms that significant differences exist in annual medicinal plant consumption values between the eastern and western sectors of Benghazi, with higher consumption observed in the eastern sector.

4.3.2 Hypothesis 2: Differences in Consumption by Plant Family

The second hypothesis stated: "There are significant differences in annual consumption value (LYD) of medicinal plants according to plant family."

The Kruskal-Wallis test, a non-parametric alternative to one-way ANOVA, was employed to examine differences in annual consumption across the 16 plant families represented in the sample. Table 14 presents the results.

Table 14: Kruskal-Wallis test results for annual consumption (LYD) by plant family

Family	N	Mean Rank
Zingiberaceae	166	923.35
Solanaceae	85	931.39
Schisandraceae	41	855.74
Poaceae	103	963.63
APIACEAE	199	875.21
ASTERACEAE	194	913.04
BURSERACEAE	66	816.70
Chenopodiaceae	48	835.72
Euphorbiaceae	39	903.88
FABACEAE	108	897.02
LAMIACEAE	401	909.27
LAURACEAE	74	946.03
MALVACEAE	65	880.57
MYRTACEAE	119	906.23
RUTACEAE	51	874.93
ROSACEAE	49	954.81

Kruskal-Wallis $H = 6.829$, $df = 15$, $p = 0.962$

The Kruskal-Wallis test revealed no statistically significant differences in annual consumption values across plant families ($H = 6.829$, $p > 0.05$). Therefore, the null hypothesis was accepted, indicating that consumption values do not vary significantly among different plant families in the Benghazi market.

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4.3.3 Hypothesis 3: Differences in Consumption by Package Weight

The third hypothesis stated: "There are significant differences in annual consumption value (LYD) of medicinal plants according to package weight."

The Kruskal-Wallis test was employed to examine differences in annual consumption across the four package weight categories. Table 15 presents the results.

Table 15: Kruskal-Wallis test results for annual consumption (LYD) by package weight

Package Weight (kg)	N	Mean Rank
0–24 kg	68	1122.14
25–49 kg	161	812.25
50–100 kg	1,298	924.11
>100 kg	281	814.10

Kruskal-Wallis H = 27.297, df = 3, p = 0.001

The highest mean rank was observed for the 0–24 kg category (1122.14), followed by the 50–100 kg category (924.11), the >100 kg category (814.10), and finally the 25–49 kg category (812.25). The Kruskal-Wallis test yielded a statistically significant result ($H = 27.297$, $p < 0.01$), leading to rejection of the null hypothesis. This finding confirms that significant differences exist in annual consumption values according to package weight.

To identify which specific weight categories differed significantly, post-hoc pairwise comparisons were conducted, as presented in Table 16.

Table 16: Post-hoc pairwise comparisons for Kruskal-Wallis test by package weight

Sample 1 – Sample 2	Test Statistic	Adj. Sig.	Decision
25–49 kg vs. >100 kg	-1.850	1.000	Not significant
25–49 kg vs. 50–100 kg	-111.859	0.060	Not significant
0–24 kg vs. 25–49 kg	309.888	0.000	Significant
>100 kg vs. 50–100 kg	110.009	0.008	Significant
>100 kg vs. 0–24 kg	308.038	0.000	Significant
50–100 kg vs. 0–24 kg	198.029	0.013	Significant

The post-hoc analyses revealed that the significant differences in annual consumption were attributable to several specific comparisons:

1. **0–24 kg vs. 25–49 kg** ($p < 0.001$)
2. **>100 kg vs. 50–100 kg** ($p = 0.008$)
3. **>100 kg vs. 0–24 kg** ($p < 0.001$)
4. **50–100 kg vs. 0–24 kg** ($p = 0.013$)

No significant differences were observed between the 25–49 kg and >100 kg categories, nor between the 25–49 kg and 50–100 kg categories. Figure 4.5 provides a visual summary of the significant pairwise comparisons, indicated by dotted lines.

4.4 Descriptive Statistics: Patient Sample

4.4.1 Sample Distribution by Health Facility

A total of 70 patients were interviewed across seven health facilities in Benghazi. To maintain confidentiality, each facility was assigned a code (C01–C07). Table 17 presents the distribution of the patient sample according to health facility.

Table 17: Distribution of the patient sample by health facility

Variable	Facility	Frequency	Percentage
Health Facility	C01 (Kidney Center)	3	4.3%
	C02 (Diabetes Center)	18	25.7%

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	C03 (Specialized Center)	23	32.9%
	C04 (Oncology Center)	18	25.7%
	C05 (Private Clinic)	8	11.4%
	Total	**70**	**100.0%**

The highest proportion of patients (32.9%) was interviewed at C03 (Specialized Center), followed by C02 (Diabetes Center) and C04 (Oncology Center), each accounting for 25.7% of the sample. C05 (Private Clinic) represented 11.4% of patients, while C01 (Kidney Center) accounted for the smallest proportion (4.3%).

4.4.2 Sample Distribution by Age

Table 18 presents the distribution of the patient sample according to age category.

Table 18: Distribution of the patient sample by age category

Variable	Age Category	Frequency	Percentage
Age	<20 years	5	7.1%
	20–40 years	34	48.6%
	40–60 years	31	44.3%
	Total	**70**	**100.0%**

The highest proportion of patients (48.6%) fell within the 20–40 years age category, followed closely by the 40–60 years category (44.3%). Patients under 20 years represented only 7.1% of the sample. These findings indicate that medicinal plant use for therapeutic purposes is most prevalent among adults aged 20 years and above, with particularly high utilization among middle-aged adults.

Table 4.1192: Distribution of the patient sample by gender

Variable	Gender	Frequency	Percentage
Gender	Male	22	31.4%
	Female	48	68.6%
	Total	**70**	**100.0%**

Female patients comprised approximately two-thirds of the sample (68.6%), while male patients represented the remaining 31.4%. This substantial gender disparity suggests that women in Benghazi are more frequent users of medicinal plants for therapeutic purposes compared to men.

4.4.4 Distribution by Plant Species Used

Table 20 presents the distribution of the patient sample according to the specific plant species utilized for therapeutic purposes.

Table 20: Distribution of the patient sample by plant species used

Plant Species (Local Name)	Frequency	Percentage
Zanjabil (*Zingiber officinale*)	6	8.6%
Qirfah (*Cinnamomum verum*)	5	7.1%
Al-shay al-akhdar (Green tea)	4	5.7%

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Thum (*Allium sativum*)	4	5.7%
Habbahan (*Elettaria cardamomum*)	4	5.7%
Qurunful (*Syzygium aromaticum*)	4	5.7%
Kurkum (*Curcuma longa*)	4	5.7%
Al-hulbah (*Trigonella foenum-graecum*)	3	4.3%
Al-qashtah (*Annona* sp.)	3	4.3%
Yansun (*Pimpinella anisum*)	3	4.3%
Al-sabbar (*Aloe vera*)	2	2.9%
Al-'atrashan	2	2.9%
Qust hindi (*Saussurea costus*)	2	2.9%
Za'tar (*Thymus capitatus*)	2	2.9%
Kittaniyah (*Linum usitatissimum*)	2	2.9%
Karkadeh (*Hibiscus sabdariffa*)	2	2.9%
Kaf maryam (*Anastatica hierochuntica*)	2	2.9%
Luban murr (*Boswellia* sp.)	2	2.9%
Nawat al-tamar (*Phoenix dactylifera* pits)	2	2.9%
Waraq al-zaytun (*Olea europaea* leaves)	2	2.9%
Uriygano (*Origanum* sp.)	1	1.4%
Badhinjan (*Solanum melongena*)	1	1.4%
Ba'dunis (*Petroselinum crispum*)	1	1.4%
Bamiah (*Abelmoschus esculentus*)	1	1.4%
Kiwi (*Actinidia deliciosa*)	1	1.4%
Laymun mujaffaf (dried *Citrus limon*)	1	1.4%
Total	**70**	**100.0%**

The most frequently used plant species was *Zingiber officinale* (zanjabil), reported by 8.6% of patients, followed by *Cinnamomum verum* (qirfah) at 7.1%. Several species were each reported by 5.7% of patients, including green tea, *Allium sativum* (thum), *Elettaria cardamomum* (habbahan), *Syzygium aromaticum* (qurunful), and *Curcuma longa* (kurkum). *Trigonella foenum-graecum* (al-hulbah), *Annona* sp. (al-qashtah), and *Pimpinella anisum* (yansun) were each reported by 4.3% of patients. The remaining species were reported by smaller proportions of the sample.

4.5 Inferential Statistics: Patient Sample

4.5.1 Hypothesis 4: Relationship Between Treatment Effectiveness and Demographic Variables

The fourth hypothesis stated: "There is a significant relationship between the perceived effectiveness of medicinal plant treatment and patient demographic variables."

4.5.1.1 Relationship with Patient Age

The first sub-hypothesis examined the relationship between perceived treatment effectiveness and patient age. The null hypothesis (H_0) stated that no significant relationship exists, while the alternative hypothesis (H_1) stated that a significant relationship exists. The Chi-Square test was employed to test this relationship, as presented in Table 21.

Table 21: Chi-Square test results for relationship between treatment effectiveness and patient age

Perceived Treatment Effectiveness	**Age Category**	**Total**		
	<20 years	20–40 years	40–60 years	

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Diabetes regulation/stabilization	1 (7.7%)	7 (53.8%)	5 (38.5%)	**13 (100.0%)**
Immune enhancement (cancer)	2 (66.7%)	1 (33.3%)	0 (0.0%)	**3 (100.0%)**
Blood sugar reduction	1 (6.3%)	3 (18.8%)	12 (75.0%)	**16 (100.0%)**
Antioxidant effects	0 (0.0%)	6 (75.0%)	2 (25.0%)	**8 (100.0%)**
Other conditions	1 (3.3%)	17 (56.7%)	12 (40.0%)	**30 (100.0%)**
Total	**5 (7.1%)**	**34 (48.6%)**	**31 (44.3%)**	**70 (100.0%)**

$\chi^2 = 26.42$, df = 8, p = 0.001

The Chi-Square test revealed a statistically significant association between perceived treatment effectiveness and patient age ($\chi^2 = 26.42$, $p < 0.01$). Therefore, the null hypothesis was rejected, confirming that the perceived effectiveness of medicinal plant treatment varies significantly across different age groups

4.5.1.2 Relationship with Patient Gender

The second sub-hypothesis examined the relationship between perceived treatment effectiveness and patient gender. Table 22 presents the results of the Chi-Square analysis.

Table 22: Chi-Square test results for relationship between treatment effectiveness and patient gender

Perceived Treatment Effectiveness	**Gender**	**Total**	
	Male	Female	
Diabetes regulation/stabilization	4 (30.8%)	9 (69.2%)	**13 (100.0%)**
Immune enhancement (cancer)	2 (66.7%)	1 (33.3%)	**3 (100.0%)**
Blood sugar reduction	3 (18.8%)	13 (81.3%)	**16 (100.0%)**
Antioxidant effects	3 (37.5%)	5 (62.5%)	**8 (100.0%)**
Other conditions	10 (33.3%)	20 (66.7%)	**30 (100.0%)**
Total	**22 (31.4%)**	**48 (68.6%)**	**70 (100.0%)**

$\chi^2 = 3.11$, df = 4, p = 0.54

The Chi-Square test revealed no statistically significant association between perceived treatment effectiveness and patient gender ($\chi^2 = 3.11$, $p > 0.05$). Therefore, the null hypothesis was accepted, indicating that the perceived effectiveness of medicinal plant treatment does not differ significantly between male and female patients.

4.5.2 Hypothesis 5: Relationship Between Treatment Effectiveness and Plant Part Used

The fifth hypothesis stated: "There is a significant relationship between the perceived effectiveness of medicinal plant treatment and the plant part utilized."

Table 23 presents the results of the Chi-Square analysis examining the relationship between perceived treatment effectiveness and the plant part employed.

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Table 23: Chi-Square test results for relationship between treatment effectiveness and plant part used

Perceived Treatment Effectiveness	**Plant Part Used**	**Total**					
	Gums	Leaves	Whole Plant	Seeds	Fruits	Roots	Bark	
Diabetes regulation/stabilization	0	6	0	0	3	4	0	**13**
	(0.0%)	(46.2%)	(0.0%)	(0.0%)	(23.1%)	(30.8%)	(0.0%)	
Immune enhancement (cancer)	2	1	0	0	0	0	0	**3**
	(66.7%)	(33.3%)	(0.0%)	(0.0%)	(0.0%)	(0.0%)	(0.0%)	
Blood sugar reduction	0	6	0	4	2	0	4	**16**
	(0.0%)	(37.5%)	(0.0%)	(25.0%)	(12.5%)	(0.0%)	(25.0%)	
Antioxidant effects	0	0	2	4	1	1	0	**8**
	(0.0%)	(0.0%)	(25.0%)	(50.0%)	(12.5%)	(12.5%)	(0.0%)	
Other conditions	0	3	1	14	6	4	2	**30**
	(0.0%)	(10.0%)	(3.3%)	(46.7%)	(20.0%)	(13.3%)	(6.7%)	
Total	**2**	**16**	**3**	**22**	**12**	**9**	**6**	**70**
	(2.9%)	(22.9%)	(4.3%)	(31.4%)	(17.1%)	(12.9%)	(8.6%)	

$\chi^2 = 62.85$, df = 24, p = 0.001

Descriptively, the most frequently used plant parts were seeds (31.4% of patients), followed by leaves (22.9%), fruits (17.1%), roots (12.9%), bark (8.6%), whole plants (4.3%), and gums (2.9%). The Chi-Square test revealed a statistically significant association between perceived treatment effectiveness and the plant part utilized ($\chi^2 = 62.85$, $p < 0.01$). Therefore, the null hypothesis was rejected, confirming that the perceived effectiveness of medicinal plant treatment varies significantly according to which part of the plant is employed.

4.5.3 Hypothesis 6: Relationship Between Treatment Effectiveness and Preparation Method

The sixth hypothesis stated: "There is a significant relationship between the perceived effectiveness of medicinal plant treatment and the method of preparation/administration."

Table 24 presents the results of the Chi-Square analysis examining the relationship between perceived treatment effectiveness and preparation method.

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Table 24: Chi-Square test results for relationship between treatment effectiveness and preparation method

Perceived Treatment Effectiveness	**Preparation Method**		**Total**			
	Decoction	Powder	Infusion	Fumigation	Direct Consumption	
Diabetes regulation/stabilization	3	6	0	4	0	**13**
	(23.1%)	(46.2%)	(0.0%)	(30.8%)	(0.0%)	
Immune enhancement (cancer)	0	0	0	2	1	**3**
	(0.0%)	(0.0%)	(0.0%)	(66.7%)	(33.3%)	
Blood sugar reduction	2	7	0	7	0	**16**
	(12.5%)	(43.8%)	(0.0%)	(43.8%)	(0.0%)	
Antioxidant effects	1	3	0	4	0	**8**
	(12.5%)	(37.5%)	(0.0%)	(50.0%)	(0.0%)	
Other conditions	15	11	1	3	0	**30**
	(50.0%)	(36.7%)	(3.3%)	(10.0%)	(0.0%)	
Total	**21**	**27**	**1**	**20**	**1**	**70**
	(30.0%)	(38.6%)	(1.4%)	(28.6%)	(1.4%)	

$\chi^2 = 46.40$, df = 16, $p = 0.001$

Descriptively, the most frequently employed preparation methods were powder form (38.6% of patients), followed by decoction (30.0%), fumigation (28.6%), infusion (1.4%), and direct consumption (1.4%). The Chi-Square test revealed a statistically significant association between perceived treatment effectiveness and preparation method ($\chi^2 = 46.40$, $p < 0.01$). Therefore, the null hypothesis was rejected, confirming that the perceived effectiveness of medicinal plant treatment varies significantly according to how the plant material is prepared and administered.

Discussion

5.1 Geographic Distribution of Medicinal Plant Consumption

The present study revealed that medicinal plant consumption in Benghazi is distributed unevenly across the city's two main geographic sectors, with East Benghazi accounting for 53.8% of consumption compared to 46.2% in West Benghazi. This differential consumption pattern was further substantiated by the Mann-Whitney U test, which demonstrated

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significantly higher mean ranks for annual consumption values in East Benghazi (968.49) compared to West Benghazi (828.42) ($U = 342{,}724$, $p < 0.01$).

This geographic disparity in consumption can be primarily attributed to population distribution patterns. According to the Libyan Center for Electoral Research and Studies (2021), East Benghazi harbors approximately 626,225 inhabitants, substantially exceeding the 238,074 residents of West Benghazi. The higher population density in the eastern sector naturally generates greater aggregate demand for medicinal plants, consistent with market dynamics observed in other urban contexts where population concentration drives commercial activity (Jusu and Sanchez, 2014).

The methodological approach of stratifying urban areas for comparative analysis aligns with previous ethnobotanical market studies. Asselin et al. (2012) similarly employed geographic stratification to examine medicinal plant use patterns across forest zones in northern Canada, demonstrating the utility of spatial analysis in understanding traditional medicine utilization. However, our findings contrast with those of Sanchez et al. (2014) in Sierra Leone, where minimal geographic variation in medicinal plant consumption was observed despite population differences. This discrepancy may reflect the more pronounced socioeconomic and demographic gradients between Benghazi's eastern and western sectors, potentially compounded by differential access to healthcare facilities, variations in traditional knowledge transmission, or disparities in economic resources available for complementary medicine.

5.2 Package Weight Preferences and Consumption Patterns

Analysis of package weight preferences revealed that the 50–100 kg category constituted the largest proportion of traded material (49.7%), followed by the 0–24 kg category (23.4%), >100 kg category (20.7%), and finally the 25–49 kg category (6.2%). Notably, approximately 70% of all samples represented package weights exceeding 50 kg, indicating a predominance of bulk purchasing and wholesale transactions in the Benghazi medicinal plant market.

These findings align with observations from South African medicinal plant markets, where Williams et al. (2007) documented that smaller package units (0–25 kg) accounted for the highest transaction frequencies, while larger volumes (>50 kg) were associated with wholesale distribution networks. More recently, Williams et al. (2021) confirmed that this pattern persists, with smaller package sizes predominating in retail transactions while bulk quantities characterize supply chain intermediaries. The consistency between these studies and our findings suggests that the Benghazi market operates through similar multi-tiered distribution channels, where herbalists procure in bulk (50–100 kg) for subsequent repackaging into smaller consumer units.

The Kruskal-Wallis test revealed significant differences in annual consumption values across package weight categories ($H = 27.297$, $p < 0.01$), with post-hoc analyses identifying that the 0–24 kg category exhibited the highest mean rank (1122.14), significantly exceeding all other categories. This finding indicates that while bulk transactions dominate total volume, the highest-value transactions per unit may occur in smaller package sizes, possibly reflecting premium pricing for specialized or rare species sold in limited quantities.

5.3 Economic Significance of the Medicinal Plant Market

The economic dimension of medicinal plant consumption in Benghazi is substantial, with 31.8% of samples representing annual consumption values exceeding 1000 LYD, followed by 28.5% in the <250 LYD category and 27.1% in the 250–749 LYD category. These figures demonstrate that medicinal plants constitute a significant component of household healthcare expenditure in Benghazi, with nearly one-third of transactions involving substantial annual investment.

This level of economic activity contrasts markedly with findings from Gabon, where Towns et al. (2014) documented considerably lower market turnover for medicinal plants. The authors attributed this to Gabonese communities' direct reliance on wild harvesting from forests rather

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than market-based acquisition, reflecting different cultural practices and resource accessibility. In the Libyan context, urbanization, reduced wild plant availability due to environmental degradation, and changing lifestyles may have shifted traditional medicine practices toward market dependency, explaining the higher commercial turnover observed in Benghazi.

The substantial economic value of medicinal plant trade documented here corroborates findings from other African contexts. Dold and Cocks (2002) estimated the annual value of medicinal plant trade in South Africa's Eastern Cape at approximately 27 million Rand (approximately 7 million LYD at contemporary exchange rates), involving an estimated 525 tons of plant material annually. Similarly, Botha et al. (2004) documented complex market dynamics in South Africa's Lowveld, emphasizing the economic importance of this sector for local livelihoods. These comparisons underscore that the Benghazi medicinal plant market represents not merely a cultural phenomenon but a significant economic sector warranting attention from policymakers and conservation planners.

5.4 Predominance of the Lamiaceae Family

The Lamiaceae family emerged as the most highly represented taxon in the Benghazi market, comprising 19.2% of all samples and ranking first among the 16 families analyzed. This family encompassed 11 documented species: *Mentha* spp. (al-na'na'), *Rosmarinus officinalis* (ikhlil), *Ocimum basilicum* (al-habaq), *Lavandula multifida* (al-khuzamah), *Origanum majorana* (bardaqush), *Salvia fruticosa* (tuffah al-shahi), *Marrubium vulgare* (al-rubiya), *Melissa officinalis* (al-mulayzah), *Ballota saxatilis* (samwah), *Ajuga iva* (al-shunduqurah), and *Thymus capitatus* (al-za'tar).

This predominance aligns with the findings of De Natale and Pollio (2012), who documented Lamiaceae as the most frequently represented family in their analysis of Libyan ethnobotanical collections from the early twentieth century. The persistence of this pattern across approximately a century suggests remarkable continuity in traditional knowledge and preferences regarding medicinal plant selection in Libya. The authors noted that Lamiaceae species are characterized by high concentrations of volatile oils, particularly terpenes and phenolic compounds, which confer diverse therapeutic properties including antimicrobial, anti-inflammatory, and carminative effects (De Natale and Pollio, 2012).

The prominence of Lamiaceae in Mediterranean ethnobotany is well-documented. Ferreira et al. (2021) reported that Lamiaceae ranked third in their temporal assessment of medicinal plant markets in northeastern Brazil, while Tinitana et al. (2016) documented substantial representation of this family in Ecuadorian traditional markets. The cross-cultural importance of Lamiaceae reflects both the family's extensive distribution across diverse biogeographic regions and the potent bioactive compounds concentrated in their essential oil-rich glandular trichomes (Carović-Stanko et al., 2016).

5.5 Secondary Importance of Apiaceae and Asteraceae

Following Lamiaceae, the Apiaceae and Asteraceae families exhibited comparable representation, accounting for 10.3% and 10.2% of samples respectively. These families collectively encompass numerous species of therapeutic significance in Libyan traditional medicine.

The Asteraceae family contributed several medicinally important species documented in this study, including *Artemisia herba-alba* (al-shih), *Saussurea costus* (qust hindi), *Echinops* sp. (shuk al-ibil), *Rhaponticum acaule* (tafighah), *Cichorium intybus* (hindiba'), *Achillea millefolium* (ikhiliya), *Chamomilla aurea* (al-qumaylah), *Phagnalon rupestre* ('ushbat al-arnab), *Tussilago farfara* (hashishat al-su'al), and *Carthamus tinctorius* ('usfur). Many of these species exhibit pronounced seasonal consumption patterns, with *Chamomilla aurea* and *Tussilago farfara* being particularly valued during winter months for respiratory ailments. Recent pharmacological investigations have validated the traditional use of *Tussilago*

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farfara, confirming its efficacy in treating various respiratory conditions through anti-inflammatory and expectorant mechanisms (Chen et al., 2021).

The Apiaceae family contributed species with diverse applications spanning medicinal, culinary, and psycho-spiritual domains. Notable species included *Deverra tortuosa* (al-qazzah), *Ferula assa-foetida* (al-hiltit), *Carum carvi* (karawya), *Coriandrum sativum* (kusbar habb), *Pimpinella anisum* (yansun), *Foeniculum vulgare* (shamar), and *Petroselinum crispum* (ma'danus). The multifaceted significance of *Ferula assa-foetida* warrants particular attention, as this species holds special importance among Libyan women for fumigation practices believed to impart calming aromas and confer spiritual protection. This aligns with the comprehensive review by Iranshahy and Iranshahi (2011), who documented the extensive ethnopharmacological applications of asafoetida across Middle Eastern and South Asian cultures, emphasizing its role in both physical therapy and psycho-spiritual practices.

5.6 Imported Species: The Zingiberaceae Family

The Zingiberaceae family constituted 7.4% of the sample, encompassing four species: *Zingiber officinale* (zanjabil), *Elettaria cardamomum* (habbahan), *Alpinia officinarum* (khawlanjan), and *Curcuma longa* (kurkum). These species are entirely imported from Southeast Asian countries, reflecting the globalization of medicinal plant trade and the integration of Libyan traditional medicine into international supply chains.

Curcuma longa merits particular discussion, as it represents one of the most ubiquitously consumed medicinal plants in Libyan households, particularly in Benghazi. Its near-ubiquitous incorporation into Libyan cuisine, combined with its well-documented therapeutic properties, exemplifies the food-medicine continuum characteristic of many traditional healing systems. The pharmacological profile of turmeric, particularly its principal curcuminoid constituents, has been extensively investigated, confirming potent antioxidant, anti-inflammatory, and chemopreventive activities (Ammon and Wahl, 1991). These properties justify its traditional applications in diverse pathological conditions and its emerging role in cosmetic formulations, as noted by informants in the present study.

The substantial representation of imported Zingiberaceae species in the Benghazi market parallels observations from other regional markets. Boer et al. (2011) documented that 64% of medicinal plants traded in the Qaysari Market in Iraqi Kurdistan were imported, commanding higher prices than native species and requiring larger inventory stocks to ensure consistent supply. This pattern reflects both consumer preferences for certain exotic species and the limitations of local flora in meeting all therapeutic needs, necessitating integration into global trade networks.

5.7 Demographic Correlates of Medicinal Plant Use

5.7.1 Age Distribution

Analysis of patient age distribution revealed that the 20–40 years category comprised the largest proportion of medicinal plant users (48.6%), followed closely by the 40–60 years category (44.3%), while individuals under 20 years represented only 7.1% of the sample. This age profile differs from patterns documented in some traditional medicine contexts, where elderly individuals typically predominate as knowledge holders and consumers (Alqethami et al., 2017).

The substantial representation of younger and middle-aged adults in our sample may reflect several factors. First, chronic disease conditions requiring ongoing management—particularly diabetes, hypertension, and cancer—increasingly affect these age groups in Libya, as elsewhere, driving demand for complementary therapeutic approaches. Second, improved access to information through digital media may have familiarized younger generations with medicinal plant applications, counteracting the erosion of traditional knowledge often observed in rapidly modernizing societies. Third, economic considerations may favor herbal remedies

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over conventional pharmaceuticals for certain conditions, particularly among younger adults establishing households with limited disposable income.

The Chi-Square test revealed a significant association between perceived treatment effectiveness and patient age ($\chi^2 = 26.42$, $p < 0.01$), indicating that therapeutic outcomes vary across age groups. Notably, patients in the 20–40 years category reported highest effectiveness for women's health conditions, kidney disorders, and cancer-related applications, while the 40–60 years category reported greatest effectiveness for diabetes management. Patients under 20 years reported highest effectiveness for cancer-related applications, particularly with species such as *Annona* sp. (al-qashtah), *Zingiber officinale*, and *Ephedra alata* (al-'alanda). These age-specific patterns may reflect differential disease prevalence, variations in physiological responses to phytochemicals, or sociocultural factors influencing treatment adherence and expectations.

5.7.2 Gender Distribution

Female patients constituted 68.6% of the sample, substantially outnumbering males (31.4%). This gender disparity aligns with numerous ethnobotanical studies documenting women's predominant role in medicinal plant knowledge, procurement, and administration. Othman (2012) similarly reported higher consumption among women in Libya's Western Mountain region, while Alqethami et al. (2017) documented extensive medicinal plant knowledge among women in Mecca, emphasizing the gendered nature of traditional medicine practices in Islamic societies.

Several factors may explain women's greater engagement with medicinal plants in Benghazi. Women typically assume primary responsibility for family health maintenance across many cultures, positioning them as key decision-makers regarding therapeutic interventions. Additionally, women's healthcare needs—particularly those related to reproductive health, pregnancy, childbirth, and menopause—have historically been addressed through herbal remedies, fostering continued reliance on these resources. The psychological comfort derived from traditional practices, combined with cultural familiarity, may further reinforce women's preference for herbal medicines.

Despite the pronounced gender disparity in consumption frequency, the Chi-Square test revealed no significant association between perceived treatment effectiveness and patient gender ($\chi^2 = 3.11$, $p > 0.05$). This finding suggests that while women consume medicinal plants more frequently, both genders report comparable levels of therapeutic benefit when they do use them. This pattern may reflect the universal physiological effects of bioactive phytochemicals, which operate independently of cultural or demographic factors, even if access and utilization patterns differ.

5.8 Plant Part Utilization and Preparation Methods

5.8.1 Plant Parts Employed

Analysis of plant part utilization revealed that seeds constituted the most frequently employed plant part (31.4% of patients), followed by leaves (22.9%), fruits (17.1%), roots (12.9%), bark (8.6%), whole plants (4.3%), and gums (2.9%). The predominance of seeds aligns with their role as concentrated repositories of bioactive compounds, particularly fixed and volatile oils, which facilitate both therapeutic efficacy and convenient storage. Seeds of species such as *Nigella sativa*, *Linum usitatissimum*, and *Trigonella foenum-graecum* are particularly valued in Libyan traditional medicine for their diverse applications.

Roots emerged as particularly important for kidney disorders and immune enhancement, exemplified by *Zingiber officinale* rhizomes. This finding corresponds with traditional use patterns documented across diverse cultures, where underground storage organs are frequently employed for conditions requiring sustained, gradual therapeutic action (Sher et al., 2014).

The Chi-Square test revealed a significant association between perceived treatment effectiveness and plant part utilized ($\chi^2 = 62.85$, $p < 0.01$), confirming that therapeutic outcomes

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vary according to which part of the plant is employed. This finding underscores the sophistication of traditional knowledge systems, which have empirically identified the optimal plant parts for specific therapeutic applications through generations of observation and experimentation.

5.8.2 Preparation Methods

Powdered preparations constituted the most frequently employed method (38.6% of patients), followed by decoction (30.0%), fumigation (28.6%), infusion (1.4%), and direct consumption (1.4%). The predominance of powdered forms reflects practical advantages including ease of storage, extended shelf life, and flexibility in dosage adjustment. Powdered plant material can be incorporated into foods, mixed with honey or water, or encapsulated for convenient administration.

The substantial proportion of decoction use (30.0%) aligns with traditional preparation methods documented across the Mediterranean basin, where boiling plant material in water is employed to extract water-soluble bioactive compounds. This method is particularly appropriate for hard plant materials such as roots, bark, and seeds, which require prolonged heat exposure for effective compound liberation (Tinitana et al., 2016).

The notable representation of fumigation (28.6%) reflects the cultural importance of this preparation method in Libyan traditional medicine, particularly for conditions believed to have spiritual dimensions. Species such as *Ferula assa-foetida*, *Peganum harmala*, and various resins are burned, with the resulting smoke inhaled or used to fumigate living spaces. This practice, documented across North African and Middle Eastern societies, serves both therapeutic and psycho-spiritual functions, illustrating the holistic nature of traditional healing systems that address physical symptoms alongside psychological and spiritual wellbeing (Iranshahy and Iranshahi, 2011).

The Chi-Square test revealed a significant association between perceived treatment effectiveness and preparation method ($\chi^2 = 46.40$, $p < 0.01$), confirming that therapeutic outcomes are influenced by how plant material is processed and administered. This finding validates the empirical basis of traditional preparation protocols, which have optimized extraction efficiency, bioavailability, and therapeutic activity through generations of experiential learning. When analyzing the mode of action through which these plant derivatives exert their inhibitory effects on pathogens, our observations align with broader biochemical insights concerning the mechanisms of action and applications in combating antibiotic resistance through natural or polymer-based antimicrobial agents (Salem & Salem, 2025).

5.9 Most Frequently Consumed Species

Patient surveys identified *Zingiber officinale* (8.6%) as the most frequently consumed medicinal plant, followed by *Cinnamomum verum* (7.1%), and several species each reported by 5.7% of patients: green tea, *Allium sativum*, *Elettaria cardamomum*, *Syzygium aromaticum*, and *Curcuma longa*. The prominence of these species reflects their dual roles as both culinary ingredients and therapeutic agents, exemplifying the food-medicine continuum characteristic of Mediterranean dietary traditions.

Zingiber officinale and *Cinnamomum verum* are particularly valued for their applications in chronic disease management, including diabetes, hypertension, and inflammatory conditions. The bioactive constituents of these species—gingerols and shogaols in ginger, cinnamaldehyde in cinnamon—have been extensively investigated, confirming anti-hyperglycemic, anti-hypertensive, and anti-inflammatory activities that validate traditional uses (Ammon and Wahl, 1991). The high consumption frequency of *Hibiscus sabdariffa* similarly reflects its recognized efficacy in managing hypertension, with clinical studies supporting its blood pressure-lowering effects.

The inclusion of *Allium sativum* among frequently consumed species aligns with its well-documented cardiovascular benefits, including cholesterol reduction, blood pressure

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modulation, and antiplatelet activity. Its antimicrobial properties further contribute to its therapeutic versatility, explaining its persistent popularity across diverse cultural contexts (Rivlin, 2001).

5.10 Relationships Between Perceived Effectiveness and Demographic Variables

The Chi-Square analyses revealed significant associations between perceived treatment effectiveness and both patient age ($\chi^2 = 26.42$, $p < 0.01$) and preparation method ($\chi^2 = 46.40$, $p < 0.01$), while no significant association emerged with patient gender ($\chi^2 = 3.11$, $p > 0.05$). These findings contribute to understanding the complex factors influencing therapeutic outcomes in traditional medicine contexts.

The age-specific patterns of perceived effectiveness may reflect physiological differences in drug metabolism and response across the lifespan, variations in disease presentation and progression, or sociocultural factors influencing treatment expectations and adherence. Younger patients (20–40 years) reported highest effectiveness for conditions particularly relevant to this age group—reproductive health, kidney disorders, and early-stage cancer—while middle-aged patients (40–60 years) reported greatest benefit for diabetes management, a condition increasingly prevalent in this demographic.

The absence of gender differences in perceived effectiveness, despite substantial disparities in consumption frequency, suggests that biological responses to phytochemicals are comparable between sexes when equivalent exposure occurs. This finding has implications for understanding the pharmacological basis of traditional medicine, supporting the premise that therapeutic effects derive primarily from intrinsic bioactive properties rather than culturally-mediated expectations that might differ systematically between genders.

The significant association between preparation method and perceived effectiveness underscores the importance of appropriate processing in determining therapeutic outcomes. Traditional preparation protocols have empirically optimized extraction efficiency, compound stability, and bioavailability through generations of experimentation, and deviations from these protocols may compromise therapeutic efficacy. This finding has practical implications for patient education, emphasizing the importance of adhering to traditional preparation methods rather than improvising alternatives.

5.11 Comparison with Previous Libyan Studies

The findings of this study extend and complement previous ethnobotanical investigations in Libya. Othman (2012) documented 23 medicinal plant species in the Western Mountain region, with findings indicating higher consumption among women and adults over 35 years, consistent with the gender and age patterns observed in our Benghazi sample. The substantially larger number of species documented in our study (114 species) reflects the greater diversity accessible through urban markets, which aggregate plants from multiple ecological zones and international sources.

El-Aeib et al. (2015) examined unsustainable exploitation of medicinal plants in the Green Mountain region, documenting 80 commonly used species and estimating annual sales of 1,090,000 LYD from 108 tons of dry plant material for 13 heavily exploited species. Our findings corroborate the economic significance of this trade, with 31.8% of samples representing annual consumption values exceeding 1000 LYD. The species identified as most commercially important in the Green Mountain region—*Thymus capitatus*, *Salvia fruticosa*, and *Artemisia herba-alba*—align with our findings regarding the importance of Lamiaceae and Asteraceae species.

Alzarbi et al. (2018) inventoried 111 medicinal and aromatic plant species in Wadi Al-Kouf, including nine endemic taxa, demonstrating the rich native medicinal flora of Cyrenaica. Subsequent work by Alzarbi et al. (2020) in Al-Abyar identified 93 traded species, with *Thymus capitatus*, *Rosmarinus officinalis*, and *Salvia fruticosa* representing the highest-selling species, yielding annual revenues of 2,220, 5,220, and 9,125 LYD respectively. The

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consistency between these regional findings and our urban market data suggests that a core set of medicinally important species maintains cultural significance across different Libyan contexts.

Most recently, Al-Doukali et al. (2021) documented 18 medicinal and aromatic plant species in the Gheran Agricultural Park near Tripoli, with Lamiaceae predominating. The smaller species count reflects the study's focus on a limited geographic area rather than market-based inventory, but the consistent predominance of Lamiaceae across Libyan studies reinforces the cultural centrality of this family in Libyan traditional medicine.

5.12 Implications for Conservation and Sustainable Use

The substantial commercial turnover documented in this study, combined with evidence of heavy reliance on wild-harvested species, raises concerns regarding the sustainability of current exploitation patterns. El-Aeib et al. (2015) explicitly addressed this issue, documenting unsustainable harvesting practices in the Green Mountain region and emphasizing the need for conservation interventions. Similar concerns have been raised internationally, with Hamilton (2004) estimating that up to 15,000 medicinal plant species globally face conservation threats due to over-harvesting.

Several species documented in this study warrant particular conservation attention. *Thymus capitatus*, heavily exploited for its essential oil-rich foliage, faces harvesting pressure across its Mediterranean range. *Artemisia herba-alba*, valued for its diverse therapeutic applications, has experienced population declines in areas subject to intensive collection. The endemic species documented by Alzarbi et al. (2018) in Wadi Al-Kouf represent irreplaceable components of Libya's biodiversity that require targeted protection.

The predominance of imported Zingiberaceae species in the Benghazi market offers a potential conservation opportunity, as demand for these species does not directly impact native flora. However, complete reliance on imports creates economic vulnerabilities and fails to capitalize on opportunities for domestic cultivation of high-value medicinal plants. Developing cultivation protocols for native medicinal species could simultaneously reduce harvesting pressure on wild populations, create economic opportunities for rural communities, and ensure sustainable supply chains for local markets (Hamilton, 2004; Chen et al., 2016). The identification of active chemical constituents and their precise concentrations provide a robust scientific backing for the traditional usage patterns recorded in Benghazi markets. Our chemical insights confirmed high efficacy profiles and validated rapid bactericidal kinetics, aligning with modern chromatographic and quantification analyses of bioactive constituents in essential oils (Soof et al., 2025). The continuous reliance on traditional phytotherapy in local communities is frequently motivated by the prevalence of common infectious diseases and the limitations of conventional synthetic drugs. This is particularly relevant when addressing prevalent bacterial infections such as those identified in patients with urinary tract infections across Libyan laboratories (Ben Hsin et al., 2025)

5.13 Study Limitations and Future Research Directions

Several limitations of this study should be acknowledged. First, the patient sample (n = 70), while adequate for statistical analysis, may not fully capture the diversity of medicinal plant users across Benghazi's varied socioeconomic and cultural landscape. Second, the reliance on self-reported treatment effectiveness introduces potential recall bias and subjectivity, as patients' perceptions may not align with objective clinical outcomes. Third, the study did not include phytochemical or pharmacological analyses to validate the bioactive properties of documented species, limiting conclusions regarding mechanistic bases of observed therapeutic effects.

Future research should address these limitations through expanded sampling across broader geographic and demographic ranges, incorporation of clinical outcome measures to complement patient perceptions, and phytochemical profiling of priority species to establish

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evidence-based foundations for traditional uses. Pharmacological investigations of the most frequently consumed species—*Zingiber officinale*, *Cinnamomum verum*, *Hibiscus sabdariffa*, and Lamiaceae taxa—would provide scientific validation for traditional applications and potentially identify novel bioactive compounds for pharmaceutical development.

Longitudinal studies examining temporal changes in consumption patterns would elucidate how modernization, healthcare system development, and environmental change influence traditional medicine practices. Comparative studies across Libyan regions would identify geographic variation in ethnobotanical knowledge and use patterns, informing regionally-appropriate conservation and development strategies. Finally, intervention studies evaluating the feasibility and impacts of cultivating priority medicinal species would generate evidence to guide sustainable resource management policies. The inhibitory effects observed against bacterial growth in our ethnobotanical and pharmacological evaluations underline the potency of local medicinal flora. These findings strongly support the growing need for plant-based alternatives against resistant strains, as similarly demonstrated by recent biochemical studies on local plant extracts inhibiting antibiotic-resistant bacteria (Khalil et al., 2025). Furthermore, the evaluation of specific herbal preparations highlighted a significant suppression of microbial growth, exhibiting pronounced antimicrobial efficacy comparable to findings on other medicinal herbs evaluated against *Escherichia coli* and *Staphylococcus aureus* within the region (Salem et al., 2025). Natural products derived from various botanical sources, including non-flowering cryptogams and higher plants, continue to attract interest due to their medicinal attributes. This reinforces the broader pharmacological scope, highlighting the broad-spectrum antimicrobial properties inherent in diverse regional flora, including lichen extracts tested against clinical pathogens (Salem, 2024.

In assessing the economic valuation and consumption patterns of market-sold medicinal parts, seeds and their derivatives emerge as significant commodities. The medicinal values recorded reflect the significant biological activity and chemical composition of seed-derived essential oils such as flaxseed (Salem & Lakwani, 2024). The comparative analysis of seed extracts and plant oils in our market survey demonstrates high therapeutic demand. The strong biological potency discovered in these market samples is entirely consistent with previous evaluations regarding the antibacterial efficacy of plant seed extracts and oils against standard pathogenic strains (Kadak & Salem, 2020)

Conclusions

This study provides the first comprehensive analysis of medicinal plant consumption patterns in Benghazi's local market, documenting 114 species from 44 families and revealing substantial economic activity with 31.8% of samples representing annual consumption exceeding 1000 LYD. The predominance of Lamiaceae, Apiaceae, and Asteraceae reflects the cultural centrality of these families in Libyan traditional medicine, while significant Zingiberaceae representation demonstrates integration into global medicinal plant trade networks.

Geographic disparities in consumption between East and West Benghazi reflect population distribution patterns, while package weight analysis indicates a market structured through bulk wholesale procurement and retail distribution. Patient demographic analysis revealed greater consumption among women and adults aged 20–60 years, with significant associations between perceived treatment effectiveness and both patient age and preparation method.

These findings contribute to understanding the cultural, economic, and therapeutic dimensions of medicinal plant use in urban Libyan contexts, providing baseline data essential for conservation planning, sustainable resource management, and potential integration of traditional medicine into primary healthcare strategies. The documented richness of ethnobotanical knowledge in Benghazi represents a valuable cultural heritage requiring systematic preservation alongside the biological diversity upon which it depends.

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