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phytochemical study and biological evaluation of green mint

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Dedication

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Introduction

Medical and aromatic plants have been used by man in traditional medicine to treat certain diseases since ancient times. Because of their compounds, they contain a variety of secondary metabolites with therapeutic potential. However, in recent years, these plants have undergone significant development and are now used in the food, cosmetic, and pharmaceutical industries.

Algeria is one of the richest countries of the Mediterranean basin in phylogenetic resources of aromatic and medicinal interest, given the diversity of its bioclimatic stages. There are more than 300 species of therapeutic or aromatic use among the 3,150 among the 3,150 plant species that our country has. Most of the studies that were interested in the study of medicinal and aromatic plants in Algeria paid great attention to the academic aspect only, and did not highlight the importance of these plants in the revival of the economy as a renewable wealth. Algeria is considered as one of the most important importers of Egyptian medicinal and aromatic plants in spite of its capacity to plant these plants and to realize their export.

This is what prompted us in the course of our research to contribute to the integration of plant wealth and to study a plant that belongs to the Lamiaceae family of the mint species represented by spearmint "*Mentha spicata (L)"*, which is considered among the plants known and used a lot in Algeria for its therapeutic properties.

To find out how effective the green mint plant is, this is through previous studies that show various secondary metabolic compounds as well as the biological effectiveness of mints. One of the objectives of this study is to establish a feasibility study for the spearmint essential oil cultivation and extraction project. In order to answer these questions, the axes of our study were divided as follows:

- The first chapter: we discussed a theoretical study on medical and aromatic plants and their economic importance.
- Chapter two: theoretical reminders,
- Chapter three: feasibility study for the green mint extraction and cultivation project.

01 Overview of medicinal and aromatic plants

I) General about medicinal and aromatic plants

Recently, medicinal and aromatic plants have been widely used, but there has been considerable confusion among them. Many consumers think that medicinal plants are the same aromatic plants, due to the lack of specific definitions of the concepts of aromatic plants and medicinal plants and their extracts. It appears difficult to define their sector or to establish a comprehensive list of the products concerned.

I.1 Medicinal plants

In accordance with the definition of the French Pharmacopoeia (11th edition in force): **"Medicinal plants are vegetable-based medicines within the meaning of the European Pharmacopoeia, at least some of which have medicinal properties. These medicinal plants may also be used for food, condiments or hygienic purposes."**

A medicinal plant, unlike a «classic» plant, therefore possesses active principles responsible for a therapeutic action, but also undesirable effects called toxicity, as well as chemical drugs [2].

I.2 The aromatic plants

Aromatic plants are plants that contain enough aromatic molecules in one or more producing organs: leaves, flowers, stems, fruits, barks, roots, etc... **[7]**. An aromatic plant can also be defined as a plant that contains aromatic compounds in one or more of its organs or in its transformations, either in its own free form or in other forms that are hydrolyzed into essential oils **[9]**.

I.3 The difference between medicinal plants and aromatic plants

There are no division limits that can be used to differentiate between medicinal and aromatic plants. Some aromatic oils have medicinal uses such as cinnamon. Some plants classified as aromatic plants contain medical chemicals as well as aromatic oils. Therefore, a plant may be included in the list of medicinal plants by its use in traditional medicine or if some of its compounds in the separate form have no therapeutic effect. However, they can be used as raw materials in the preparation of medicines **[9]**.

I.4 Origin of medicinal and aromatic plants

They have two origins at the same time. The first are "wild" or "gathering" plants, and the second are cultivated plants **[3]**:

- Spontaneous plants: The spontaneous plants are difficult to cultivate and account for 60 to 70% of all drugs; however, the medicinal value of these plants varies depending on their origin, location, and growing conditions **[5]**.

- Cultivated plants: provide a sufficient amount of raw material that is homogeneous in both appearance and chemical composition. It can be increased or decreased depending on the medical needs. Naturally, cultivation must take place in the best possible conditions, taking into account, among other things, chemical races **[5]**.

I.5 Cultivation of medicinal and aromatic plants

Aromatic and medicinal plants have been cultivated in several Swiss regions since the early 1980s (Poschiavo, Valais, Vallée de Joux, Jura, Pre-Alps). These plants, along with small fruits, are classified as special crops.

These crops are grown in two major production areas. The first includes the Bagnes and Entremont valleys, while the second includes the right bank of the Rhone valley's hillside. These two zones are very different, both in terms of climate and topography, as well as modes of production. Plants that have been cultivated can be divided into two categories. Some are indigenous, but have been domesticated and selected. The others are also from the Mediterranean region and have been chosen.

The plants are commonly referred to as "aromatic and medicinal." These two adjectives do not always refer to two different types of plants. Many are used in both culinary and medicinal applications. Some, on the other hand, fall into only one of the two categories. This distinction is unimportant in this work.

The cultivation of medicinal plants is primarily for commercial purposes. She is not interested in assisting with the auto-supply of the farmer's household. According to the authors who have written on the subject, the traditional Swiss farming society practiced self-sufficiency agriculture in communities where money did not have the importance that it does today. With today's medicinal plant cultivation, we're a long way from that mythical past.

I.6 The stages and rules of medicinal plant collection

The active compounds in medicinal plants are unevenly distributed and concentrated in specific organs like fruits and leaves. As a result, one of the most important steps in production is the collection of plants, whether planted or wild. The collection method differs from plant to plant depending on the part to be harvested.

- **Roots and rhizomes:** The collection process occurs during the rest period of plant growth, which is in the autumn or spring season before plant growth begins. Perennials are removed in the second or third year, while annual plants are removed in the autumn of the first year. With ordinary water, the roots and rhizomes are

washed and free of soil and sand. Only the roots that have emerged in the spring are peeled. Autumn roots are high in active substances **[9]**.

- **Bark:** It is collected in the spring, when the plant produces juice as a result of its growth activity. The collection takes place after a period of humidity to help separate the bark from the wood **[9]**.
- **Stems and leaves of herbs:** Because of the increased photosynthetic activity in the spring, the leaves are rich in active chemicals before the formation of flowers, making this phase suitable for collecting. In the afternoon, the leaves are piled where the active chemicals have risen while preventing their collection and are humid since this accelerates the rot process **[9]**.
- **Flowers:** Because the collecting season for flowers is so limited, it requires accuracy and care in selecting the correct moment to collect them. The flowers usually collect before or at the beginning of the blooming like chamomile and jasmine, and there are flowers that collect their floral buds before opening them like clove because they are rich in active principles when they bloom, they lose part of them or lose them completely. Depending on the substances to be gathered, it may be best to collect them in the middle of the day when they are open and dry, and sometimes they are selected in the morning after drying the dewdrops to avoid losing their active contents due to heat. Flowers are sensitive to washing in hot water and should also avoid storing them in plastic bags **[9].**
- **Fruits:** If the fruits are fleshy, they are picked when they reach maturity or shortly before, whereas dry fruits are harvested when they reach maturity and begin to yellow. We wound the fruits when they are immature to extract the lactic compounds **[9]**.
- **Seeds:** After maturity, the harvesting process begins. Some seeds found in the fleshy fruits must be removed through fermentation **[9]**.

I.7 Drying and conservation of medicinal and aromatic plants

a) Drying of medicinal and aromatic plants

Some medical plants are utilized fresh to manufacture active chemicals, such as flowers, but the majority of these plants are dried under strict circumstances to retain their useful ingredients. The goal of drying is to:

- Protect the plant from roting by inhibiting the activity of bacteria
- Inhibit chemical reactions

- Suspension of enzymatic activity
- Facilitate the grinding process Facilitate storage

Medicinal plants are dried at temperatures between (40 - 60 °) C. The aromatic plants were collected in the morning and dried at a temperature not exceeding 50 ° C. Leaving the plant to dry in a normal environment can activate the enzymes present in the cell juices, resulting in the degradation of active substances. Medicinal plants are dried in ovens passing through a hot air stream at temperatures no higher than 65 ° c until they are dry, and then the dry plants are stored in conditions free of humidity, light, and high heat **[9]**.

Drying Techniques

- Natural drying: This approach is used to dry aromatic plants by exposing them to sunshine or putting them in the shade in the presence of wind **[9]**.
- Industrial drying: it uses industrial ovens of various sizes, temperatures, and heat quality to which the plant is exposed **[9]**.
- Lyophilization: This process exposes the plant to high temperatures after it has been rapidly frozen because the ice does not melt. This procedure can only be used in an airless atmosphere **[9]**.

b) Conservation of medicinal plants

Because this stage is critical for preserving the quality of the plant material, the storage facilities must be **[9]**:

- Non-flammable.
- It should be cool, screened, and properly ventilated.
- Stores are not prone to rodent and rat attacks.

I.8 Aromatic and therapeutic plant applications

For a long time, plants were only used in the form of herbal teas or powders. Many are now available in capsule form, but medicinal plants can be used in a variety of ways. Whatever their presentation, they are enjoying a revival of interest, which has been largely sparked and sustained by advertising as well as numerous popularization efforts. Plants are increasingly being used in mixing. Good office practices have been implemented for these preparations. Many parameters must be followed, such as the number of plants, possible combinations, flavor, or taste that must be tailored to the customer. The patient's age and condition should also be considered. The primary

varieties of aromatic and therapeutic plants used by humans can be categorized according to their principle of use **[1]**:

- Plants for herbal teas, hygienic and enjoyable beverages
- Plants used in cosmetics
    - Astringent plants
    - Softening plants
    - Healing plants
    - Capillary plants
    - Pigmentary plants
    - Anti-ecchymosis plants
- Plants for aromatic and condiment uses
- Plants for food use
    - Plants for beverages
    - Oilseed plants
    - Plants with proteins
    - Plants with carbohydrates and vitamins
- Perfume plants
- Plants for industrial use
    - Dyeing plants
    - Plants for textile fibers
    - Plants for insecticides
    - Plants for various use
- Medicinal plants
    - Plants with essential oils and resins
    - Plants with alkaloids
    - Plants with terpenes
    - Plants with sulfur heterosides
    - Plants with flavonoids
    - Plants with coumarinic heterosides
    - Plants with ranunculoside heterosides
    - Plants with anthracenic heterosides
    - Plants with tannin
    - Plants with bitter heterosides

- Plants with cardenolic heterosides
- Plants with saponisides
- Plants with mucilage
- Plants with estrogens

I.9 Common Mistakes in Medicinal Plant Use

Phytotherapy is an alternative medicine that makes use of the healing properties of plants. It is a discipline that requires only a basic understanding. Indeed, while the usage of plants is generally safe, it can become deadly if you are not careful... That is why it is critical to understand and avoid the most common mistakes in the use of medicinal herbs **[12]**.

Purchasing low-quality or non-organic plants*:* A medicinal plant is effective if its beneficial compounds are still present. These substances are more abundant and of higher quality in freshly chosen plants, but it is not always practicable or appropriate to choose your own medicinal herbs. Rather than purchasing them in the form of inexpensive herbal teas in supermarkets or without regard for their provenance. To have good quality medicinal plants, medicinal plants must be harvested, dried, and preserved in a precise manner in order to fully keep their properties. Also, it is critical to confirm that the person selling them to you is doing it correctly. Furthermore, a pesticide-free plant is simply healthier for your health. Additionally, medicinal plants should be preserved in the dark, which is why the various jars and drawers that adorn herbal shops are not made of glass.Finally, here are some tips to check the quality of medicinal plants **[12]**:

- Smell the plants: a high-quality medicinal herb is aromatic.
- Examine the vegetation: entire plants and blossoms are preferable to powder.
- Consider the container: buy loose plants rather than bagged plants, which may have been around for a long time.

Not distinguishing between the different form: There are hydrolats, essential oils, decoctions, infusions etc... Let us know that a hydrolat is not comparable to an essential oil. The method of extraction is not the same and each of them creates a different synergy between the different active principles of the plant, which can give very different properties to several products from the same plant **[12]**.

Improper storage of medicinal plants: Medicinal plants must be stored in airtight, opaque containers that are not exposed to light **[12]**.

Confusing active compounds and medicinal plant: A medicinal plant contains a variety of active compounds, sometimes several. It is unfortunate to use a plant for one of its active compounds when another may be more suitable. This combination of active compounds will work in synergy, which means that the balance formed by all of the active compound's present will be effective rather than a single isolated active ingredient **[12]**.

Replacing a medication: The use of medicinal plants is a form of medicine, albeit a gentle medicine. It is therefore strongly advised not to replace your doctor-prescribed treatment with a plant that may contain the same active principle. Substituting a plant for a drug's active ingredient without seeking medical advice is thus a mistake. Remember that a synthetic molecule and a natural molecule are not always equivalent **[12]**.

Neglecting the infusion time: It is the same for infusions and herbal teas. In order to be effective, an infusion should infuse for at least 10 minutes. This is the time it takes for the plant's beneficial properties to transfer to the water. We can also cover our cup while the plants infuse to keep the essential oils in our infusion from evaporating **[12]**.

II) Commercial and economic value of medicinal and aromatic plants

Since the 1980s, there has been a renewed interest in the cultivation of medicinal and aromatic plants in both developed and developing countries. In developed countries, medicinal and aromatic plants are used as a substitute crop for modern intensive agriculture, which is suffering from global overproduction. This type of agriculture is frequently thought to be well suited to disadvantaged areas. Aromatic medicinal plant cultivation is seen as a means of diversifying agricultural activity in developing countries. It is also regarded as a highly appealing activity for economically disadvantaged areas due to the employment opportunities it provides. Medicinal and aromatic plants are extremely valuable economically:

- Satisfy the needs of the herbal medicine pharmaceutical and cosmetic industries.
- Limit imports.
- Create a surplus for export.
- They intervene in the pharmaceutical industry and are used in popular medicine, providing public health guarantees. They are involved in the production of some drugs, such as joint analgesics, rheumatic infections, hypertension and atherosclerosis medications, and disinfectants.

- Fixed oil production when the seeds of some of these plants contain fixed oils that are used in certain medical preparations.
- Food processing, such as sunflower, flax, and castor seed oil, for the treatment of atherosclerosis and angina pectoris.
- These plants and their products are exported in large quantities, providing the foreign currency required to raise the country's economic level.
- plants grown in recently reclaimed areas, supplying food and fodder to former agricultural land.
- They enter the agricultural cycle to diversify crops and reduce the risk of reliance on a single crop, as well as to avoid overstressing the agricultural plot.
- These plants can be exported dried, and some can be exported fresh, increasing the possibility of exporting throughout the year and according to the needs of importers and foreign markets.
- Jasmine is a rose that is used in aromatherapy and perfumery.

III) Overview of cultivation of medicinal and aromatic plants in North Africa

The North African continent has the most ancient and diverse medicinal plant tradition. These plants are important to the residents of the region, particularly in rural areas where they are the only source of medication available, as the prices of modern medications rise and people return to traditional herbal medicine. Egypt **[13]**, Tunisia, Algeria and Morocco are interested in cultivating various types of these plants that are included in various uses and industries.

III.1 Algeria

Algeria is the largest country bordering the Mediterranean. It is distinguished by the diversity of its medicinal and aromatic plants, as well as their various popular uses throughout the country.

In the Hugger and in the absence of doctors, the Tuaregs treat and cure themselves with medicinal and aromatic plants whose secrets have been passed down from father to son. When there is snow and the roads are closed in Kabyle, the mountain people use medicinal and aromatic plants to treat themselves (fumigation of eucalyptus leaves against the flu). The white armoise is used by nomads in the steppe during transhumance to treat indigestion **[6]**.

The richness of the Algerian flora is thus undeniable, with 289 species classified as fairly rare, 647 rare species, 640 very rare species, 35 rare species, and 168 endemic species. These plants are abundant, but they are geographically dispersed and have a low yield potential; their control is difficult, and their exploitation is insufficient to meet the national needs for medicine, the environment, and the environment. Their control is difficult, and their exploitation is insufficient to meet the country's needs for medicine, pharmacy, and herbal medicine **[4]**.

III.2 Egypt

Egypt is known for its long history in the production and marketing of aromatic and medicinal plants and spices, with a flora that includes over 2100 spontaneous species, 350 of which are known for therapeutic uses. The area cultivated with these plants exceeds 30,000 hectares, accounting for less than 0.8% of total cultivated area. These plants are primarily grown in the regions of El Menya (34%), El Fayoum (20%), Beni swaif (17%), and Asyout (10%). The remaining 19% are grown in other parts of the world. chamomile, peppermint, marjoram, fennel, cumin, basil, black cumin, calendula, lemon grass are the most cultivated plants mainly for export **[7]**.

III.3 Morocco

Morocco has a diverse range of Mediterranean bioclimates, allowing for the development of a rich flora with over 4200 species and a diverse vegetation, as well as a high rate of endemism. There are 500 to 600 species of aromatic and/or medicinal plants, many of which are endemic.

Morocco's aromatic and medicinal plants sector, which is one of the world's largest traditional suppliers of aromatic and medicinal plants, exhibits the following key characteristics **[7]**:

The most widely used aromatic and medicinal plants fall into three categories.

- Coriander, cumin, fennel, and aniseed are some of the plants grown for their seeds.
- Plants grown for their leaves include verbena, mint, and parsley.
- Plants grown for other parts of the plant, such as saffron, rose, and jasmine.
- The cultivated plants in Morocco are distributed in various regions.

III.4 Tunisia

Tunisia's great diversity of edaphoclimatic conditions, as well as its dual nature, Mediterranean and Saharan, make it an ideal location for the development of a diverse flora, including an important potential in aromatic and medicinal plants. Tunisia, with

over 2160 vascular species, is a true phylogenetic reservoir in the Mediterranean. Despite their significant potential and floristic wealth, rosemary and myrtle are the only naturally occurring species that are organized for essential oil extraction. There are approximately 346,000 hectares of rosemary. The exploitable surface area would be around 160 000 ha. The myrtle layers cover approximately 40,000 ha. Only about 10,000 ha of the 22,000 ha put up for sale each year are used **[7]**.

The surface area of cultivated medicinal plants is expanding slowly due to a number of factors, including the lack of a sector development strategy. The total area set aside for medicinal plant cultivation is estimated to be around 1396 ha in 2011, up from 911 ha in 2002, a 53 percent increase. Since 2002, the surface area of aromatic plants and condiments has been steadily increasing, rising from 1274 ha in 2002 to 3154 ha in 2011, a 147 percent increase **[7]**.

IV) Examples of successful Arab experiences with medicinal plant cultivation

Morocco, Tunisia, and Egypt are examples of Arab countries that have succeeded in cultivating medicinal and aromatic plants and have exported them to the global market:

Among Egyptian agricultural exports, medicinal and aromatic plants rank fifth. Approximately 90% of the 50,000 tons of medicinal and aromatic plants harvested each year are exported. The United States is the largest foreign market for Egyptian production, followed by the European Union and Arab countries; Egypt supplies 44% and 34% of the EU's needs for Jasmine and Geranium essential oils, respectively; the value of Egyptian production in medicinal and aromatic plants accounts for only 0.02% of the global market **[7]**.

In Tunisia the average annual production of rosemary is estimated to be around 27,000 tons. Tunisia produces the most essential oils, with an annual average of 108 tons, or 41 percent of total production. The production of aromatic plants or condiments has evolved in proportion to the area. In 2011, 4558 tons of condiments were produced. Coriander and caraway account for 56% and 28% of total production, respectively. Tunisian medicinal and aromatic plants are primarily available in dried, fresh, seed, HE, and floral waters. These products are primarily distributed through supermarkets, traditional herbalists, specialty stores, weekly village markets, delicatessens, and national fairs held throughout the country each year **[7]**.

In Morocco, the medicinal and aromatic plants sector is expanding steadily, as is the value of exports. Between 2003 and 2008, the export value of dried plants (spices, aromatics, carob and its derivatives, medicinal plants, and perfume plants) averaged 86 million Euros per year. Between 2003 and 2008, the export value of spices (red and sweet pepper and its derivatives, coriander, cumin, and fenugreek) averaged 13 million Euros per year. The value of herb and herbal product exports (fresh mint, rosemary, thyme, verbena) is approximately 17 million euros. Carob and its derivatives (crushed carob, flour, and carob seeds) were exported at a value of 34 million euros between 2001 and 2006. The value of medicinal plant and perfume plant exports (iris, rosebuds, seaweed, olive leaves, Galittier seeds) is estimated to be around 22 million Euros. Europe (61%), Asia (19.7 %), and America (14.7%) are the top three export destinations **[7]**.

IV.1 Egyptian experience in growing medicinal plants in desert lands

Medicinal and aromatic plants are an ancient Egyptian non-traditional culture. They are a large plant group with 200 to 250 thousand species from over 200 plant families: Trees such as cinnamon and willow, or shrubs such as jasmine, henna, and castor, or perennial herbs such as mint, bardagosh, and thyme, or annual herbs such as coriander, spherical, anise, fennel, chamomile, and basil.

During the period (2006-2010), the total area of medicinal and aromatic plants reached 48138.25 acres. Minya governorate leads the governorates in the production of medicinal and aromatic plants. The average annual area grown is approximately 21836.25 acres, which represents approximately 45.36% of its Egyptian Republic counterparts during the period. This is followed by the governorates of Fayoum and Beni Suef, where the average annual area cultivated is approximately 9246.5, 7602 acres, representing approximately 19.21% and 15.79% of the average annual area of medical and aromatic plants, respectively. The average area under cultivation of medicinal and aromatic plants in old land is estimated to be 41647.5 acres, accounting for 86.52% of the total annual average area under cultivation. while the average cultivated area of new lands was estimated to be 6490.75 acres, accounting for 13.48% of total annual average agricultural area **[8]**.

In Egypt, Coriander is the most medicinal and aromatic plant grown, the average annual area under cultivation is estimated to be 11294 acres, which is equivalent to 23.32% of the total medicinal and aromatic plants, followed by Chamomile with an average area of about 9410 acres and 19.34%, and Caraway with an average area of about 5987.8 acres and 10.51%. follows marjoram, Cummins, Anise, Geranium, and Fennel,

with an average area of about one acre to the order of 9.31%, 7.71%, 5.93%, 5.65%, and 5.43% of the annual average planted space, respectively. Consequently, coriander, chamomile, Caraway, marjoram, Cummins, Anise, Geranium, and Fennel are the most important medicinal and aromatic plants cultivated in Egypt, accounting for approximately 87.29 percent of the total average annual area cultivated with medicinal and aromatic plants during the reporting period, or approximately 48422.4 acres **[8]**.as shown in table (1).

Table 1: The relative importance of the area cultivated with the most important medicinal and aromatic plants in Egypt (2006-2010) ***[8]***

Produce	Average (Acres)	percentage
Coriander	11294	23.32%
Chamomile	9410	19.34%,
Caraway	5987.8	10.51%.
Marjoram	4507	9.31%
Cummins	3731	7.71%
Anise	2872.3	5.93%
Geranium	2737	5.65%
Fennel	2630	5.43%
Other countries	6153.4	12.71%
Average	48422.4	100%

Egypt has become a great economic force as a result of its agricultural wealth, becoming one of the most important exporters of medicinal and aromatic plants in the Middle East, with the value of its exports increasing dramatically between 2000 and 2018 **[9]**, as shown in the table (2).

Table 2: Evolution of the value of Egypt's medicinal and aromatic plants ***[9]***

Year	value	year	value	year	value	year	value
2000	7.78	2005	5.94	2010	31.52	2015	12.55
2001	5.42	2006	8.78	2011	30.83	2016	16.35
2002	5.56	2007	10.86	2012	24.81	2017	19.29
2003	5.65	2008	14.13	2013	10.95	2018	27.49
2004	7.29	2009	30.92	2014	14.29	Average	15.28

Algeria, Germany, Bangladesh, the United States, Morocco, and Saudi Arabia are the top importers of Egyptian medicinal and aromatic plants in the spice seeds group. Algeria accounts for 18.13% of total world imports of medicinal and aromatic plants, followed by Germany at 9.85% **[9].** as shown in table (3):

Table 3: Value of imports of major importing countries ***[9]***

Importer	2016	2017	2018	Average	%
ALGERIA	3475955	4062973	3906171	3815033	18.131
GERMANY	2328360	1959938	1929734	2072677	9.850
BANGLADESH	1636786	2254258	1802503	1897850	9.019
UNITED STATES	1278685	778720	1138217	1065207	5.062
MOROCOO	1267056	785149	946787	999664	4.751
SAUDI ARABIA	626084	834705	1297653	919481	4.370
Total major importer	10612926	10675743	11021067	10769912	51.183
Other countries	5739.160	8610701	16466262	10272041	48.817
Word	16352086	19286444	27487329	21041953	100

Egypt has several aromatic plant species, which are divided into 91 widespread medicinal and aromatic plants, approximately 86 commonly used and exported, and 95 rare plant species, 70 of which are extremely rare **[15]**:

- Basil is the most important medicinal and aromatic plant exported from Egypt, and it is in high demand in markets such as Germany, Spain, the United States, and France.
- Mint is the second most popular medicinal and aromatic plant export to the markets of the United Kingdom, the United States, and France.
- Fennel is the third largest medicinal and aromatic plant exporter, with high demand in the markets of the United States, Bulgaria, Germany, and Italy.
- Caraway, an Egyptian medicinal and aromatic plant, ranks fourth in the markets of Canada, the United States, Turkey, and France.
- Egypt exports coriander of medicinal and aromatic plants to Saudi Arabia, the United Kingdom, Libya, and Jordan.
- Chamomile is on the export list of important medicinal and aromatic plants in high demand in Germany, Italy, Spain, and the United States **[15]**.

IV.2 General data on spearmint cultivation and export in Egypt

The mint grows in the Mediterranean basin. America, India, England, Morocco, Algeria, Turkey, Egypt, Hungary, and former Soviet Union countries are the main producers. Green mint cultivation is an economically significant crop in Egypt due to its uses, medical and aromatic industries.

For example, in Aswan Governorate, the average area cultivated with spearmint was about 1205.13 acres from 2012 to 2019, with a minimum of 621 acres in 2016 and a maximum of 2148 acres in 2015, representing a 1527-acre increase. In 2014, the average spearmint productivity was 7.49 tons/acre, with a low of 4 tons/acre and a high of 12.77 tons/acre. The average total mint production was 9228.13 tons, with a low of 1210 tons in 2013 and a high of about 17226 tons in 2015, representing a 16316-ton increase over the same period. The table (4) shows the average cultivated area, productivity, and total production **[11].**

Table 4: The development of cultivated area, productivity and total production of green mint in Aswan during the period 2012/2019 ***[11]***

year	Area (acres)	Productivity (tons/acre)	Total production (tons)
2012	720	12.77	9200
2013	295	4.10	1210
2014	1980	4	7920
2015	2148	8.15	17526
2016	621	6.18	3843
2017	1651	9.46	15624
2018	1574	9.29	14627
2019	652	5.94	3875
average	1205.125	7.490823	9228.125
Maximum	2148	12.77	17526
Minimum	621	4	1210

Spearmint is one of the most important plants exported around the world, and Egypt is a major exporter. As shown in table (5), the top importers of Egyptian spearmint are Germany, the United States, the United Kingdom, Spain, and others. Germany ranks first with exports of approximately 530465.2 thousand kg, followed by the United States, the United Kingdom, and Spain, with exports of approximately 189501.5, 202534.2, and 118998.7 thousand kg, respectively, during the period (2008-2013) **[13]**.

Table 5: Average quantity of green mint exports to major importers (2013 - 2008) ***[13]***

Country	Quantity (Kg)	Value (1000$)
Total World	1592957	4169.5
Germany	530465.2	1885.667
United States	189501.5	390
United Kingdom	202534.2	379.1667
Spain	118998.7	252.6667
Brazil	45677.5	83.16667
Russia	52332.17	156.1667
Italy	18541.5	52.5
Argentina	30631.83	64.66
Greece	16116.33	38
Hollande	49516.5	119.8333
Belgium	12545.83	34.8333
France	47096	138

V) The most important essential oils and their economic applications

Essential oils are used as a raw material in a variety of industries. In recent years, their popularity has skyrocketed. Indeed, there is a real industrial demand for these compounds with high added value, owing to the variety of applications in many industrial sectors and the consumer craze for these high-quality products Table (6) shows the top ten essential oil productions in the world. Orange essential oil is the most widely used, with a global production value of 49000 T, followed by Mint Arvensis, Lemon, Eucalyptus, Peppermint, and Lemongrass essential oils, with estimated production values of 42000 T, 42000 T, 4000 T, 3500 T, and 3000 T, respectively **[16]**.

Table 6: Top 10 essential oils productions in the world ***[16]***

Essential oil	Estimated production 2019	Estimated value of 2019
Orange	49000 T	294 M€
Mint Arvensis	42000 T	840 M€
Lemon	42000 T	225 M€
Eucalyptus	4000 T	88 M€
Peppermint	3500 T	112 M€
Lemongrass	3000 T	81 M€
Clove	2500 T	52 M€
Spearmint	2000 T	58 M€
Lavandin	1700 T	42 M€
Patchouli	1400 T	69 M€

The cosmetics, soap, and perfume industries consume the most essential oils. This industry is distinguished by a wide range of products in relatively small quantities and at often exorbitant prices. Essential oils are used in the food industry to improve flavor and preserve food due to the antimicrobial and antioxidant properties of some of their constituents. These natural agents reduce or replace harmful chemical or synthetic preservatives. they are also used in the food industry to improve flavor and preserve food due to the antimicrobial and antioxidant properties of some of their constituents. These natural agents reduce or replace harmful chemical or synthetic preservatives. Finely, Essential oils are a highly effective therapeutic tool that can be used to broaden the scope of conventional medical treatments. Essential oils can be used directly as therapeutic agents, but they can also be used as raw materials in the synthesis of active ingredients. As a result, economic applications for essential oils are:

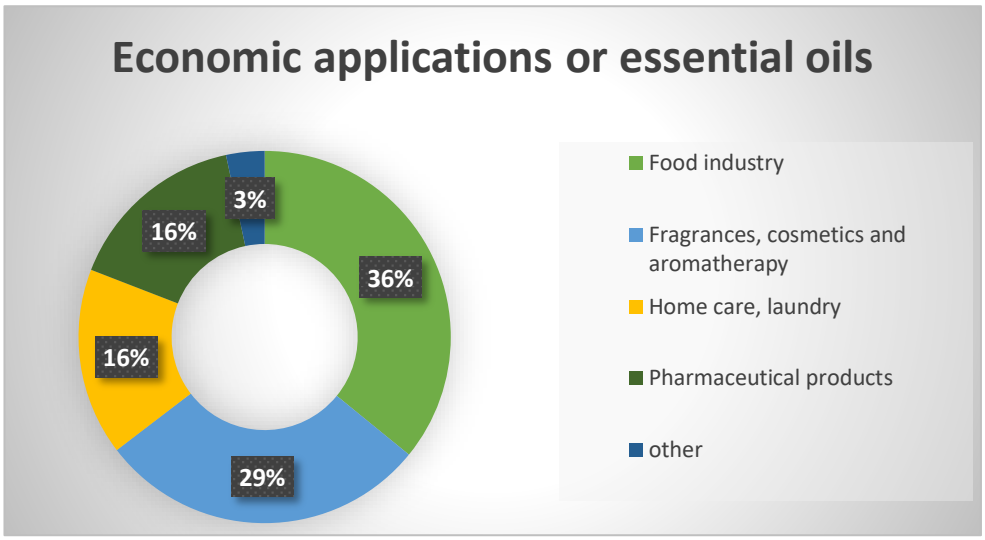

Figure 1 Economic applications or essential oils ***[16]***

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02 Bibliographic review

I) Generality on the Lamiaceae

It is one of the main families of dicotyledons, comprising approximately 258 genera and 6900 more or less cosmopolitan species, However, it is particularly widespread from the Mediterranean to Central Asia. Lamiaceae are usually herbaceous, annual or perennial aromatic plants, subshrubs and rarely trees or lianas. Lamiaceae have many species grown as condiments (e.g., sage, thyme, basil, mint, etc.). As a result, this family is an important source of essential oils for aromatherapy, perfumery and the cosmetics industry.

I.1 Green mint

Green mintis a member of the Lamiaceae (Mint family), which includes 260 genera and 7000 species that grow in a variety of agroclimatic condition. Mentha L. contains 42 species, hundreds of sub-species, and 15 hybrids, cultivars, and varieties **[32]**.

Mentha spicata, commonly known as Spearmint, is wildly grown around the world for its outstanding aroma and commercial value. In addition to traditional foods flavoring agent, M. spicata is well known for its traditional medicinal uses, especially for the treatment of colds, coughs, asthmas, fever, obesity, jaundice and digestive disorders **[32]**.

I.2 Botanical description

Perennial; stems erect, 40–90 cm long, glabrous or nearly so, green; sterile shoots only underground; leaves subsessile to sessile or short-petioled, glabrous or nearly so, ovate-oblong or oblong-lanceolate, sharply and unevenly serrate or dentate, acuminate, faintly netted-veined; inflorescences slender, cylindrical, spike-like, compact, interrupted; verticillate distant or the upper approximate; floral leaves resembling the bracts, not exceeding the calyx; calyx glabrous, slightly constricted at throat in fruit, the teeth triangular, equal, slightly connivant. Grows on river banks, meadows, and in fields **[41]**.

I.3 Taxonomical classification

- **Kingdom:** Plantae
- **Phylum:** Spermatophyta
- **Subphylum:** Angiospermae
- **Class:** Dicotyledonae
- **Order:** Lamiales
- **Family:** Lamiaceae
- **Genus**: *Mentha*

- **Species:** *M. spicata*

I.4 Morphological description

- **The vegetative apparatus**

Green mint is an erect perennial plant, less than a metre tall, with a pleasant, strong and very characteristic smell. It has a sweeter flavor than other wild mints. It has a sweeter flavor than other wild mints. It has a pivotal root which lasts over three years. Long creeping and hairy rhizomes and subterranean stolon's that give a lot of stems, ensure its vegetative reproduction **[15]**.

The stems are quadrangular (square) sections, almost hairless, erect (orthotropic) and generally branched. They are purple in color. The foliage is usually dark green on either side, but the young leaves are generally lighter. The leaves are embossed, sub-sessile, oval to oblong-lanceolate, 4-9 cm long. They are strongly serrated, pointed and hairless. They are opposed and decussated in pairs at each node. The base of the leaves slightly embraces the stem. These leaves have a characteristic smell and aromatic flavor **[15]**.

- **Reproductive system**

The inflorescences lie on the axis of the top leaves. They are condensed into glamorous and simulate a whirlpool of flowers around the stem. They consist of spikes short and obtuse terminals. Bracts are glabrous or hairy, linear, about equal to flowers. The pedicels Are also glabrous **[19]**.

The flowers are small, whitish to purple, with narrow pointed terminal spikes. They are zygomorphic and hermaphrodites. The tips are sparse, long, small and intermittent (per floor, spaced). They bloom from July to October **[15]**.

- **The Perianth**

The flowers have a bell-shaped calyx, glabrous at the base or ciliated. It is gamosepale, divided into five linear and unequal teeth.

The corolla is gamopetal and almost regular, short-tube. It is typically bilabiated, hence the name of Labiées given by the first botanists: an upper lip formed of two upper petals, the other of the three lower petals **[15]**.

The Androecium

The Androecium is four stamens that usually exceed the corolla. The stamens are prominent and of identical size.

The gynoecium

The flowers are hypogynous: the ovary is in superior positions. They consist, arranged in a nectar disk always present, two welded carpels which subdivide each by a false partition into two halves-lodges, each containing an egg. The unique style that seems from the base is said gynobasic: it is ended by two stigmata.

Floral Formula: (5S) + (5P) +4E) + (2C) Ovary is super

The fruit is a tetrakene. It is a dry and smooth fruit, lodged at the bottom of a persistent calyx, each half-carpel giving birth to an elementary achene.

I.5 Spearmint Floral Diagram

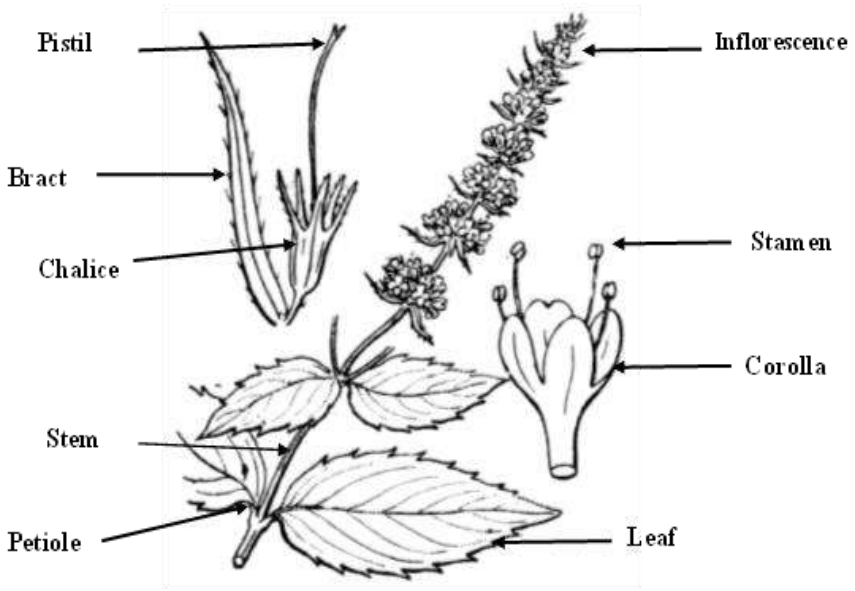

Figure 2: Spearmint Floral Diagram

I.6 Geographic distribution

The herbaceous plants of the genus Mentha are found all over the world in temperate and subtemperate climates. By freely crossing different members of these species, many intermediary forms can be produced **[4]**.

Spearmint is grown in Indiana and Michigan. Mentha spicata is grown in the United Kingdom, France, Italy, Bulgaria, Hungary, Yugoslavia, Russia, Vietnam, Thailand, and South Africa, among other places **[4]**.

I.7 Climate and cultivation of green mint

It is cultivated in temperate regions, in humid and shady grounds, but it bears the cold. It does not seem very demanding because it blooms from Scotland to the Sahara.

Vegetative growth is significantly reduced during cold periods (photoperiod of less than 10 hours and temperatures below 10°C and up to 25°C). The sensitivity of mint to temperature is accentuated by the perennial character of the plant which can last for more than 10 years. Field observations have shown that maximum temperatures in the order of 30°C produce optimum growth, provided there is sufficient nitrogen fertilization and irrigation **[15]**.

I.8 Therapeutic use of *Mantha spicata*:

Mint (*Mentha Spicata.*L) is one of the aromatic and medicinal plants that is widely used in pharmaceutical and medicinal fields such as:

(i) In the case of flatulence:

The data was gathered from publicly available international databases, traditional books, electronic resources, and unpublished data. *M.spicata* essential oil, the main component of which is carvone, is effective in the treatment of flatulence caused by indigestion, caesarean section, and dysmenorrhea. Furthermore, it can lessen the severity of pain during a colonoscopy or dysmenorrhea **[7]**.

(ii) Arthritis treatment

Essential oils are increasingly being used as analgesics. Several animal studies have revealed the analgesic effects of M. spicata essential oil and its main constituents, including carvone, limonene, and menthol, and the efficacy and safety of spearmint oil in reducing pain in patients with osteoarthritis have been confirmed **[7]**.

(iii) Nervous irritability and insomnia

Colombian studies have confirmed the use of M. spicata in the treatment of nervous irritability and insomnia not only in the Caribbean, but also in Colombia. Indeed, these plant species have been used for centuries in Europe, Asia, and America as sedatives or to treat anxiety and neurological disorders (insomnia, stress, and excitement). Furthermore, M. spicata is used for a variety of purposes in traditional medicine around the world **[7].**

I.9 Benefits of green mint

Mint is one of the traditional medicinal plants that man has used in his daily life as well as in some treatments since ancient times. Given the significance of this plant, we highlight some of its advantages:

- Mint is well-known for its digestive properties. Because of its high iron and vitamin C content, it soothes the stomach and stimulates the bile.

- It is very effective against unpleasant mouth odors due to the chlorophyll content. Mint reduces gastric reflux as a direct result of its digestive effectiveness.
- Mint has analgesic properties. It is used to treat insect bites and wounds. It is also used in first aid in the event of a violent shock or muscular pain.
- Mint helps the liver eliminate toxins effectively. As a result, it, like lemon, is an active detoxifier.
- Mint's freshness follows us through the seasons: in mojitos in the summer, teas in the winter, velvety soups in the fall, and spring rolls... in the spring **[62]**.

II) secondary metabolites

Secondary metabolites are complex organic molecules that plants synthesize and accumulate in small amounts; these products are abundant, with over 200,000 structures defined and an extraordinary structural diversity.

These molecules distinguish a species, a kind, or a family by their chemical composition, in this case, terpenes, alkaloids, acetylenic compounds, waxes, and phenolic compounds.

II.1 Classification of secondary metabolites

Secondary metabolites in plants are classified into four major categories:

- Phenolic substances.
- Saponins
- Nitrogenous compounds and alkaloids
- Terpenoid

a) Polyphenols

Polyphenols are molecules that plants produce as part of their secondary metabolism. They help plants defend themselves against environmental threats. They are distinguished by the presence of several phenolic groups linked together in more or less complex structures with a high molecular weight.

Polyphenols are water-soluble phenolic compounds with molecular weights ranging from 500 to 3000 Dalton and the ability to precipitate alkaloids, gelatin, and other proteins **[16, 49]** They range from simple molecules like phenolic acids to highly polymerized compounds like tannins **[23, 49]**.

Polyphenol classification

The main classes of phenolic components are: phenolic acids (caffeic acid, hydroxycinnamic acid, chlorogenic acid), flavonoids, which account for more than half

of the polyphenols, tannins, and coumarins **[28, 53]**. Polyphenols can be found in all parts of higher plants, including the roots, stems, leaves, flowers, and fruits.

i) Phenolic acids

Phenolic acids are rare in nature. They are organic compounds with at least one carboxylic function and a phenolic hydroxyl. They have interesting biological properties: anti-inflammatory, urinary antiseptics, antiradicals, cholagogues, hepatoprotections, choleretics, immunostimulants. These compounds are represented by two subclasses: hydroxybenzoic acid and hydroxycinnamic acid derivatives **[60].**

Phenolic aids isolated from *Mentha spicata*

Several studies have shown the presence of several types of phenolic acids represented in:

Table 7 : phenolic acids isolated from Mentha spicata

compound	Reference
Rosmarinic acid	**[18, 56]**
Caffeic acid	**[18, 58]**
Gallic acid	**[42,45]**
Vanillic acid	**[29, 42]**
p-Coumaric acid	**[29]**
Ferulic acid	**[42,58]**
Syringic acid	**[29]**
Chlorogenic acid	**[18, 58]**

ii) Coumarins

Coumarins are among the best-known phenolic compounds. They are substituted at C-7 by a hydroxyl. 7-hydroxycoumarin, known as umbelliferon, is the precursor of 6,7-di- and 6,7,8-trihydroxylated coumarins. At present, more than 1000 coumarin compounds have been isolated, of which more than 800 are from plants and microorganisms **[60].**

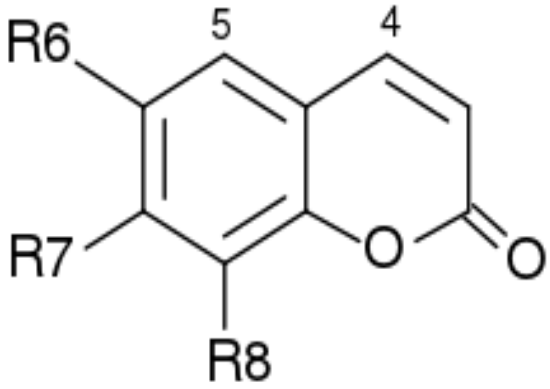

Figure 3: basic structure of coumarin

Detection of coumarins

1g of plant powder is extracted with 10 ml of a mixture of methanol and water, MeOH/H2O (7:3), under reflux for 30 min. The extract is diluted and a few drops of soda solution are added.

A few drops of this extract are deposited on a silica gel plate, using as eluent a mixture of toluene - ethyl acetate (8:1).

Green and yellow fluorescences are observed at visible light and other brown and blue ones at 366nm, which conforms to the precedence of furano and pyranocoumarins **[47].**

Coumarin pharmacological and biological properties

Coumarins, like other phenolic compounds, occur in nature as heteroside combinations. Some studies attribute umbelliferone with bacteriostatic activity, explaining its use in the treatment of brucellosis in veterinary medicine. veterinary science Traditionally, the drug is recommended to help with functions and digestion **[47].**

Coumarins isolated from *Mentha spicata:*

A study showed the existence of a type of coumarins in spearmint represented by **scopoletine [2].**

iii) Flavonoids

Flavonoids are widely distributed molecules in the plant kingdom. They are the most abundant class of phenolic compounds, which are the primary secondary metabolites of plants. They are almost universal plant pigments that are partly responsible for the coloring of flowers, fruits, and occasionally leaves. They are found in cell vacuoles as heterosides or as constituents of specific plastids, the chromoplasts. The basic structure of these compounds is formed by two benzene rings A and B linked by a ring

C, which is a pyranic heterocycle. Flavonoids' structures are generally represented by the C6-C3-C6 system. This molecule's rings can be attached to form a diphenyl propane structure with hydroxyl groups, oxygens, methyls, or sugars **[60].**

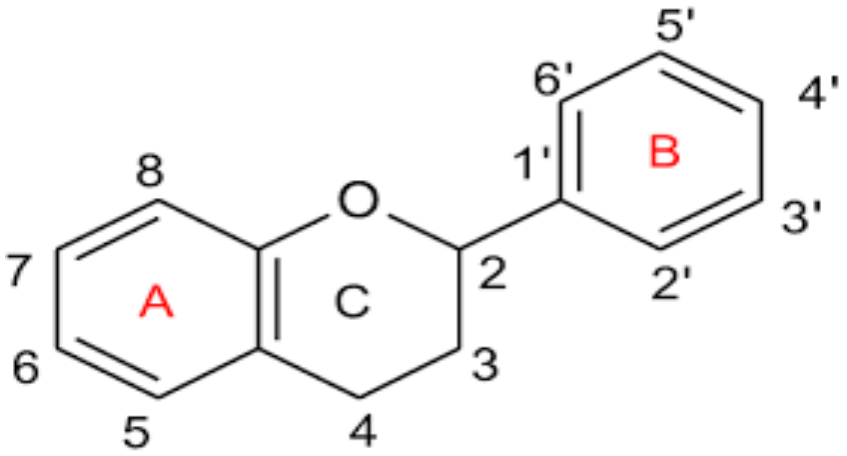

Figure 4: basic structure of flavonoids

Classification

Flavonoids are the most common type of polyphenol, accounting for nearly 6500 different compounds identified in the plant kingdom (i.e., approximately 50% of polyphenols), and their number is constantly increasing. These molecules are classified into several subclasses based on functional diversity at positions 2, 3, and 4 of the C rings.

The molecules in each class of flavonoid differ by the number and position of hydroxyl groups, the presence of a substituent on the genin (unsubstituted flavonoid), and the degree of polymerization.

1. **Flavones**

Flavones have a C6-C3-C6 structure with a double bond between carbons 2 and 3 of the flavan skeleton's heterocycle and a ketone function in position 4. (4-oxo). Position 2 is occupied by the aromatic ring B. These compounds can be found primarily in cereals and some vegetables.

2. **Flavonols**

Flavonols are flavones that have a hydroxyl group (OH) in position C-3, the central heterocycle C, and a double bond in C2-C3.

3. **Flavanones and dihydroflavonols**

Flavanones have distinct structures that distinguish them from other flavonoids due to the absence of a double bond between C2 and C3, as well as the presence of asymmetry centers at the 2-position.

4. Isoflavones

Isoflavonoids are a subclass of flavonoids distinguished by the C3 position on the aromatic ring B's central pyranic heterocycle C. It is a diverse group of compounds that includes isoflavones, isoflavanones, isoflavans.

5. Anthocyanins

Anthocyanins are flavonoids that have a charge on the central heterocycle C's oxygen. They are the most abundant pigments in plants. Their total number discovered thus far exceeds. These compounds are directly involved in plant-animal interactions, particularly in the attraction of pollinators by flower color.

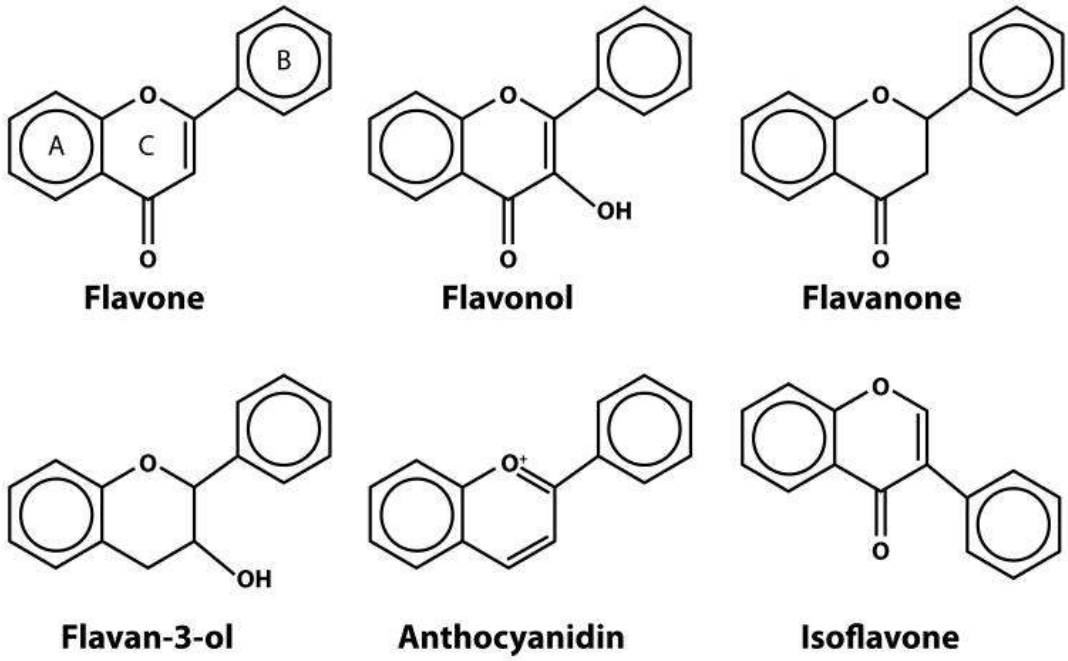

Figure 5: Basic structures of various types of flavonoids

Detection of flavonoids

To detect flavonoids, 1ml of Neu reagent is added to the methanolic extract. On the B ring, the ortho hydroxylated compounds appear yellow orange to orange, while the mono hydroxylated compounds appear green to yellow **[47]**.

Biological properties of flavonoids and applications

Flavonoids' properties are currently being studied in the medical field, where they are recognized as having anti-viral, anti-tumor, anti-inflammatory, anti-allergic, and anti-cancerous activities **[47].**

By inhibiting the enzyme aldose reductase, flavonoids can also prevent or at least reduce diabetes. According to Ong and Khoo, myricetin has a hypoglycemic effect in diabetic animals. Some flavonoids have been shown to reduce the risk of cardiovascular disease by inhibiting atherosclerosis. Flavonoids are found in almost all plant organs and play an important role in the defense system as antioxidants **[47].**

Flavonoids isolated from *Mentha spicata*

Several studies have shown the presence of several types of flavonoids represented in:

Table 8: flavonoids isolated from Mentha spicata

compound	Reference
Epicatechin	**[9, 58]**
Catechin	**[9, 45]**
Rutin	**[13, 58]**
Myricetin	**[9]**
Quercetin	**[42, 58]**
Naringin	**[9]**
Naringenin	**[9, 13]**
Hesperidin	**[22]**
Luteolin	**[9, 13]**
Apigenin	**[18, 45]**

iv) Tannins

Tannins are a type of polyphenol that is used to tan hides and skins. They have the ability to combine with proteins, and the degree of affinity varies from one protein to the next. Tannins are found in vacuoles and have a molecular weight of 500 to 3000 Da. Tannins are macromolecules with a diverse structure that can be found in a variety of plants, including tree barks and fruits (grapes, dates, coffee, cocoa...). Their structure is made up of monomeric repetitive units that differ in their asymmetrical centers and degree of oxidation **[60].**

Detection of tannin:

To 2 ml of aqueous decoctate, at 5%, are added a few drops of ferric chloride (FeCl3) at 5% in ethanol. A green-brown coloration develops, which reveals the presence of catechic tannins.

Tannin pharmacological and biological properties:

Decoctions and other preparations based on tannin-rich drugs are most commonly used externally against oral cavity inflammations, catarrhs, bronchitis, local hemorrhages, burns and chilblains, wounds, dermal inflammations, hemorrhoids, and excessive perspiration.

They are useful in the treatment of intestinal catarrh, diarrhea, and bladder infections, as well as an antidote (counter-poison) in the case of vegetable alkaloids poisoning **[47].**

v) Lignans

Lignans are formed when phenylpropane units condense. There are four groups to consider: lignans (bond between two carbons of the side chains of two units derived from phenylpropane), neolignans (only one -carbon is involved), "oligomers," (bonding between two -carbons), "oligomers," (condensation of 2 to 5 phenylpropane units), and norlignans with a skeleton in C17. The neolignans are particularly abundant in primitive species (Magnoliales, Pipérales), whereas lignans are frequently found in Gymnosperm wood and lignified tissues in Angiosperms **[46]**

Lignan isolated from *Mentha spicata*

Tow lignans are isolated from spearmint **"Spicatolignan" A** and **"Spicatolignan B" [61].**

b) Saponins

Saponosides are a type of heteroside that is found in plants and marine animals. They are steroidal or triterpenic glycosides with the ability to foam in the presence of water and precipitate cholesterol **[47].**

Detection of saponins

To detect the presence of saponosides at the plant level, the moss index.

Principle:

According to the procedure of the French pharmacopoeia. In a flask of 500 ml, containing 100 ml of boiling water, one introduces 1 g of crushed plant. A moderate boiling is maintained during 30 mn, one filters and one adjusts to 100 ml after cooling.

In a series of 10 test tubes of 20 cm height and 10 mm diameter, 1, 2, 3, ...10 ml of decoctate is successively introduced and the volume of each tube is adjusted to 10 ml with distilled water. Each tube is shaken for 15 seconds (two shakes per second). It is left to stand for 15 min and the height of the foam in each tube is measured **[47].**

I_m =1000/N

N: Number of tubes in which the foam height is 1cm.

Pharmacological properties of saponins:

Saponins have a unique property: they hemolyze red blood cells (erythrocytes), allowing them to release hemoglobin, which explains why some of them are toxic and should not be consumed. Saponins cause mucous membrane irritation, intestinal relaxation, and an increase in bronchial mucous secretions (are expectorants). They are diuretics and urinary tract disinfectants **[47]**.

c) Alkaloids

Alkaloids are natural compounds (usually plants) that are nitrogenous, more or less basic, have a narrow distribution, and have pharmacological properties at low doses. Common precipitation reactions with general alkaloid reagents confirm the alkaloid identity (e.g. Draguendorff reagent). They can be classified as follows:

- **Pseudo-alkaloids:** lack intra-cyclic nitrogen and incorporate nitrogen into the structure only in the final phase.
- **The proto-alkaloids:** In a heterocyclic system, nitrogen is not present. Examples include amino acids.
- **True alkaloids:** are classified based on the nature of their ring. A heterocycle contains a nitrogen atom. They are biosynthetically formed from amino acids and have significant pharmacological activity.

Detection of alkaloids:

25ml of hydrochloric acid solution 5. 10^{-2} N is added to 5g of the plant. plant. After a maceration of 24 h, the mixture is filtered. A few drops of Dragendorff's reagent to the macerate. The formation of a red precipitate reveals the presence of alkaloids.

d) Terpenoid compounds

Terpene compounds are classified as secondary metabolites in the plant kingdom. More than 30 000 different molecules have been identified; these compounds constitute a diverse group of natural products that are widely represented and of considerable chemical interest.

All of these substances are derived from a simple isoprene molecule with 5 carbon atoms. They are also called terpenic compounds or terpenoids. They include both low molecular weight, volatile molecules that are the main components of essential oils and highly polymerized molecules like rubber. Their gross formula is $(C_5H_8)_n$ **[60].**

Terpene compound classification

The number of repetitions of the basic isoprene unit is used to classify them. Although their structures vary, all of these molecules contain a multiple of five carbon atoms. These skeletons can be arranged in a linear or ring pattern; some are large, others are small; some are hydrocarbons, while others contain oxygen or nitrogen. Terpenes are classified into several classes:

i) Monoterpenes (C10) n=2:

The simplest constituents of terpenes, the majority of which are found in essential oils (90%), are monoterpenes. A monoterpene unit is formed by two isoprene units.

More than 900 known compounds are found in three structural categories: linear monoterpenes (acyclic), monoterpenes with a single ring (monocyclic), and bicyclic monoterpenes **[60]**.

ii) The sesquiterpenes (C15) n=2:

Sesquiterpenes are C15 molecules (three isoprene units) with the molecular formula $C_{15}H_{24}$. They are mostly found in plant aerial parts. They are also essential oils, such as savory, cinnamon, or lavender. lavender. This is the most diverse class of terpenes, which are classified into several structural categories, including acyclic, monocyclic, bicyclic, tricyclic, and polycyclic terpenes **[60]**.

iii) Diterpenoids (C20) n=4

Diterpenes are compounds that contain 20 carbon atoms (four isoprene units). With over 2700 diterpenes found in nature, these compounds have a wide structural range. They can be acyclic (retinol and retinal), bicyclic, or tricyclic (vitamin A). The most interesting pharmacologically are tricyclic diterpenes with a taxane ring, which are derived from different species of yew and are used in the treatment of resistant ovarian tumors that are resistant to other therapies, as well as lung and breast cancers. cancer of the breast **[60].**

iv) Triterpenes (C30) n=6

Triterpenes are C30 compounds (six isoprene units) formed by cyclizing epoxy-squalene or squalene [98-100]. In the C3, they are almost always hydroxylated. They contain over 4000 compounds with more than 40 different hydrocarbon backbones.

Steroids are tetracyclic triterpenes with at least three methyls removed. They have anabolic and anti-inflammatory pharmacodynamic properties **[60].**

v) Tetraterpenoids (C40) n=8

Tetraterpenes are formed by the joining of eight isoprenic units; carotenoids are tetraterpenes, with the most common being apocarotenoids, diapocarotenoids, and megastigmanes **[60].**

vi) Polyterpenes n>8

Polyterpenes, also known as polyisoprenes, are made up of more than 8 isoprene units. These terpenes are highly polymerized (500 to 5000 isoprene units), they are latex or natural rubber components, and they are frequently found in two isomeric forms, cis- and trans-isomeric forms. Vitamins E, K1 and K2 are among them **[60]**.

Pharmacological properties terpene compounds

Tetrpenoids are now used in a variety of industries. They are widely used in the human nutrition sector (aromas or flavors) and the perfume industry (e.g., santalols).

Terpenoids' great diversity of structures and functions has sparked interest in their use in both traditional and modern medicine. Terpenes' antimicrobial, antifungal, antiparasitic, antiviral, antioxidant, antiallergenic, antispasmodic, antihyperglycemic, and anti-inflammatory properties have been confirmed, as have the anticancer properties of some monoterpenes **[60]**.

Terpenoids isolated from *Mentha spicata*:

Several studies have shown the presence of several types of terpenoids represented in:

Table 9: Terpenoids isolated from Mentha spicata

Terpenoids	compounds	References
Carotenoids	Violaxanthin	**[58]**
	Antheraxanthin	
	Lutein	
	Zeaxanthin	
	13Z-β-Carotene	
	α-Carotene	
	E-β-Carotene	
	9Z-β-Carotene	
Triterpenes	α -Amyrin	**[33]**
	β-Amyrin	
	Oleanene	
Diterpene	Neophytadiene	**[33]**

e) Essential oil

Definition

Essential oils are volatile, refractive, optically active liquids with a distinct aroma, similar to oils. They are produced as co - products of secondary metabolism in many plants. Essential oils are natural complexes of volatile and odorous molecules produced by aromatic plants' secretory cells. They are kept in pockets in various organs **[47]**.

In turn, the A.F.NOR NF T 57-006 standard gave the following definition of an essential oil: "product obtained from a plant material, either by steam entrainment, or by mechanical processes from the epicarp of Citrus, or by dry distillation" **[14].**

Distribution of essential oils

Essential oils are found in many plant families, including Conifers, Myrtaceae, Umbelliferae, Labiatae, and Compositae. They are found in all plant organs, including flowering tops, bark, roots, rhizomes, fruits, wood, and so on. They can coexist in different organs of the same plant. The composition of essential oils can then differ depending on the organ **[47]**.

Essential oil extraction methods

Many different processes based on ancient techniques can be used to extract essential oils from plant material **[39]**:

i. **Distillation**

a) Hydro-distillation

This is the most basic and widely used method. It entails immersing the raw material raw material directly in water and then bringing the whole thing to a boil. The operation is typically carried out at atmospheric pressure. A refrigeration system condenses the formed vapors via water flow **[39]**.

b) Steam distillation

In this type of distillation, a stream of water vapors passes through the plant, attracting hydrophobic volatile substances. Decantation is used to separate the components after condensation. This method improves essential oil quality by reducing hydrolytic alterations **[39]**.

c) Distillation with organic solvents

Some essential oils have a density similar to water, and steam distillation cannot be used in these cases. The basic idea is to macerate the plant in the solvent to allow the odorous substances to pass through **[39]**:

- ***Petroleum based solvents***

Organic solvents such as pentane, hexane, heptane... are used in this method. It is only used for essential oils with a density similar to water.

- ***Forane 113***

Forane 113 (F2CCl-CCl2F) allows for the simultaneous extraction of essential oil and lipidic oil, allowing the plant to be valorized twice.

ii. Extraction by supercritical fluid

A high-pressure stream of CO_2 bursts the essential oil pockets in liquid or supercritical carbon dioxide extraction. Because the CO_2 becomes gaseous after extraction due to the decrease in pressure, we only recover the essential oil. This method outperforms hydro-distillation in terms of energy savings, yield, and product quality because carbon dioxide is colorless, odorless, non-flammable, and non-toxic. However, it is very expensive when compared to other methods **[39]**.

iii. Expression

The term "cold pressure" refers to the extraction of essential oils from citrus fruits such as lemons, oranges, and mandarins. It is a simple method that involves mechanically abrading the essence pockets located at the level of the peel or the pericarp of the fruit in order to collect the contents **[39]**.

Chemical structure

The composition of EOs is fairly complex. They typically contain a large number of constituents from two major chemical families: terpene compounds and aromatic compounds derived from phenylpropane **[47]**:

- **Essential oil terpene constituents**

Terpenes predominate in essential oils. They are mostly monoterpenes, with a few sesquiterpenes and a few diterpenes.

- **Aromatic compositions**

The majority of the constituents of essential oils are of terpene origin, with only a few essential oils containing the majority of its aromatic compounds. The degree of oxidation of the aliphatic chain also contributes to the expansion of the aromatic compound range.

Furthermore, the phenylpropanic motif is capable of cycling to give lactones. These latter are, for the most part, entertainable by water vapor, but they will also be present in some essential oils, which may also contain (C6-C1) compounds such as vanilline.

Composition of the essential oil of spearmint:

The main components of Mentha spicata essential oil are divided into two categories **[15]**:

- The ketones are dominated by carvone, followed by menthone and dihydrocarvone.
- Hydrocarbons dominated by limonene, followed by le β-myrcène et les α- et β-pinène

As in the majority of essential oils, we find more minority groups:

- Ethers containing 1,8-cineole.
- Alcohols and esters containing menthol and menthyl acetate.

The French pharmacopoeia defines a concentration between the following values for each of the essential oil's main components **[15]**:

- ***Limonene 2.0 to 25 %***
- ***Cineole less than 2.0 %***
- ***Menthone less than 2.0 %***
- ***Menthofuran less than 2.0 %***
- ***Isomenthone less than 2.0 %***
- ***Menthyl acetate less than 2.0 %***
- ***Menthol less than 2.0 %***
- ***Pulegone less than 0.5%***

- ***Carvone 55 to 67 %***

Comparison of the chemical composition of essential oils of *Mentha spicata* from different locations:

However, the compositions vary greatly depending on the harvesting locations and thus the climatic and harvesting conditions. As illustrated in the following tables:

Table 10: Comparison of the chemical composition of essential oils of Mentha spicata from different countries

chemical composition%	India [54]	USA [35]	Egypt [10]	Tunisia [50]	Algeria [27]
α-pinene	1.65	0.89	5.09	1.4	0.66
β-pinene	1.79	1.01	4.36	2.2	1.97
β-myrcene	5.11	7.03	4.77	1.1	0.77
Limonene	22.32	12.62		20.8	24.99
1,8 – Cineole	3.72	1.57	13.71	17	7.22
Carvone	52.06	53.99	31.33	40.8	52.60
Terpinen – 4 – ol	1.19			1.3	1.22
Pulegone				26.67	0.38
Menthone			0.41	0.3	
β– caryophyllene	0.44	2.39		1.2	
α- Humulène		1.79			0.25

Table 11: Comparison of the chemical composition of essential oils of Mentha spicata from different regions of Algeria

chemical composition%	Ghardaia [30]	Setif [12]	Tlemcen [8]	Laghouat [6]	Tipaza [27]
α-pinene	1.30	0.32	0.7	0.7	0.66
β-pinene	3.23	0.607	0.7	1.1	1.97
β-myrcene	5.11	0.379		0.8	0.77
Limonene	5.80	6.129	21.9	16.1	24.99
1,8 – Cineole	15.32	3.8		8.7	7.22
Carvone		59..4	54.1	49.5	52.60
Terpinen – 4 – ol		1.12	1.3	1.5	1.22
Pulegone		0.224			0.38
Menthone			0.41	0.3	
β– caryophyllene		2.969		2.7	
α- Humulene		0.187	0.2	0.2	0.25

Spearmint Properties

The presence of active compounds found in the flowering plants of Mentha spicata (or viridis) explains the properties of spearmint essential oil:

- Cholagogue (promotes biliary excretion);
- Antibacterial.
- Anti-inflammatory.
- Antioxidant.
- Calming and relaxing the ketones in spearmint essential oil have a relaxing effect on the nervous system (by inhibiting specific messengers), which helps to limit anxiety or chronic stress.

III) Biological activity of green mint

The different species of Mentha present considerable diversity in their essential oil chemical composition. For example, in M. spicata, the essential oil is rich in carvone and

has a characteristic smell of spearmint it has several biological uses, such as in insecticides, antimicrobials, antioxidants, antispasmodics, and anti-platelet.

III.1 Antioxidant activity

a) Generalizations about free radicals

Free radicals

A free radical is a chemical species, atom, or molecule with an unpaired electron on the external orbital. These unpaired electrons make these species very unstable and reactive, and they will try to pair their single electron to stabilize themselves **[26]**. All free radicals and their precursors are frequently referred to as reactive oxygen species (ROS) **[20]**.

Major free radicals

- **Superoxide anion $O_2^{\bullet -}$:** Is a reduced form of molecular oxygen that has received an electron. It is the first radical formed in the respiratory chain during electron transport **[24]**. Superoxide anion is essential for the formation of other free radicals such as hydrogen peroxide H_2O_2, hydroxyl radical •OH, and singlet oxygen $O_2^{\bullet -}$ **[52]**.
- **Peroxide H_2O_2:** Even though it lacks a radical structure, peroxide is classified as a reactive oxygen species (ROS) because it can initiate or propagate oxidative damage **[26]**. Hydrogen peroxide (H_2O_2) is formed by the spontaneous or enzymatic dismutation of the superoxide radical, with the enzymatic dismutation being primarily catalyzed by superoxide dismutase (SOD) **[40]**.
- **The hydroxyl radical •OH:** Is one of the most oxidizing chemical species, capable of quickly attacking most biological molecules **[38]**. The hydroxyl radical (•OH) is primarily formed by the degradation of H_2O_2 in the presence of transition metals in their reduced form; thus, H_2O_2 in the presence of ferrous iron causes the Fenton reaction.

$$Fe^{2+} + H_2O_2 \longrightarrow Fe^{3+} + OH^- + OH^{\bullet}$$

H_2O_2 can also react with superoxide radicals, producing OH once more; this reaction mechanism is known as the Haber and Weiss reaction **[51]**.

$$O_2^{\bullet -} + H_2O_2 \xrightarrow{\text{Fe (III)/Cu (II)}} O_2 + OH^- + OH^{\bullet}$$

- **Singlet oxygen $^1O_2$:** Is an additional highly reactive oxygen species. It is an excited molecule that can produce peroxides by reacting with various electron acceptors. Its biological targets include membranes, nucleic acids, and proteins.

The origin of free radicals

- **Endogenous source:** The soluble cellular constituents capable of activating molecular oxygen during auto-oxidation reactions are the most basic biological systems that generate ROS. Thiols, hydroquinones, flavins, catecholamines, tetrahydropterins, hemoproteins, and transition metals are all members of this class.
- **Exogenous origin:** ROS are produced as a result of environmental oxidants. Indeed, pollution (e.g., nitrogen oxides), the absorption of alcohol or certain drugs (e.g., catecholamines), prolonged sun exposure, and smoking are all situations that cause an increase in ROS production in our bodies **[38]**.

b) Antioxidants

The antioxidants are all substances that, when present in low concentrations relative to the oxidizable substrate, delay or significantly inhibit its oxidation, and the products of the reaction between the oxidant and the antioxidant must not be toxic and must not initiate the radical reaction **[55]**.

Antioxidant properties

A compound is considered an antioxidant in vivo when it requires the following properties **[48]**:

- It must react with biologically toxic reactive oxygen metabolites.
- The antioxidant-oxidant reaction product must not be more toxic to the organism than the metabolite eliminated.
- A sufficient concentration of the potential antioxidant must be present in the body.
- The antioxidant's half-life must be long enough for it to react with the oxidant.

Origin of antioxidants

Endogenous antioxidants

The body's antioxidant defenses can be divided into **[44]**:

primary defense system*:* composed of enzymes and antioxidant substances

- Superoxide dismutase (SOD): decreases the life span of the superoxide anion O_2.
- Catalase: catalyzes the conversion of hydrogen peroxide (H_2O_2) into a single molecule of water.

- Glutathione peroxidase (GPx): degrades hydrogen and lipid peroxides.
- Scavenger molecules include glutathione (GSH), uric acid, proteins with thiol groups, ubiquinone, and others.

secondary defense system: composed of proteolytic enzymes, phospholipases, DNA endonuclease and ligase, and macroxyproteinases.

Natural antioxidants:

Vitamin E*:* Is an important antioxidant that protects cells from free radical damage, thereby extending cell life and slowing the aging process. Vitamin E is not biosynthesized. It can be found in a variety of vegetable oils, most notably wheat germ, sunflower, soy, peanut, and olive oil. It is also present in small amounts in cereals, almonds, green vegetables, butter, margarine, and fatty fish **[48]**.

vitamin C (or ascorbic acid): It is one of the most abundant water-soluble antioxidants found in intra- and extracellular fluids. Vitamin C has the ability to react directly with reactive oxygen species such as $HO^{\bullet}$ or $O_2^{\bullet-}$ It can recycle -tocopherol, which aids in the prevention of lipid oxidation. Fruits are high in vitamin C **[48]**.

Carotenoids: Are a type of phytochemical found in vegetables and fruits, as well as in milk. The most important and well-known carotenoids are -carotene and -carotene, which prevents the initiation of free radical reactions by neutralizing singlet oxygen **[48]**.

Polyphenols: Polyphenols in nature range from simple molecules like phenolic acids to highly polymerized compounds like tannins. They have several other important biological activities in addition to antioxidant activity **[48]**.

Mechanisms of action of antioxidants

We identify at least five modes of antioxidant intervention **[43]**:

- Disruption of the chain of radical reaction propagation.
- Transition metal chelation
- Deactivation of reactive oxygen species.
- Inhibition of peroxidation enzyme activity.
- Lowering of the partial pressure of oxygen.

Many polyphenols have been shown in studies to act at one or both of these levels.

Antioxidant activity of green mint

The presence of phenolic acids, flavonoids, carvone, and ascorbic acid in spearmint leaves has been linked to antioxidant activity. Spearmint may become an alternative form of synthetic antioxidants with negative side effects **[57]**.

Table 7: Antioxidant activity of green mint

Extract type	Assay	Activity	Reference
Essential oil	DPPH	IC50: 9544.6 ± 196.2 µg/ml	**[13]**
	ABTS	IC50: 36.2 ± 3.2 µg/ml.	
	Reducing power	RP50: 452. 3 ± 0.4 µg/ml	
	Phosphomolybdate	RP50: 53.3 ± 2.84 µg/ml	
80% methanol	DPPH	EC50: 86.51 ± 5.45 mg/ml	**[21]**
	ABST	EC50: 45.74 ± 1.71 mg/ml	
	Reducing Power	EC50: 23.39 ± 2.66 mg/ml	
Ethyl acetate	ABTS	TA: 95% at 20 µg/ml	**[5]**
Hexane		TA: 41% at 50µg/ml	
Chloroform		TA: 53% at 50 µg/ml	
Water		TA: 84% at 30 µg/ml	
Methanol	DPPH	IC50: 47.3 µg/ml	**[34]**
	Superoxide	IC50: 38.9 µg/ml	
Essential oil	DPPH	IC50: 13.3 ± 0.6 µg/ml	**[25]**
Carvone		IC50: 19.4 ± 1.0 µg/ml	
cis-Carveol		IC50: 15.3 ± 0.8 µg/ml	
Essential oil	Linoleic acid system	Inhibition: 61.5 ± 2.1%	
Carvone		Inhibition: 51.7 ± 1.7%	
cis-Carveol		Inhibition: 58.8 ± 1.9%	
Essential oil	DPPH	IC50: 41.2 µg/ml	**[37]**

III.2 Antibacterial activity of *M. spicata:*

Several studies have shown that Mentha spicata essential oil has antimicrobial activity against Gram-positive, Gram-negative, and fungi pathogenic microorganisms. This activity is attributed to the presence of high concentrations of carvone; however, because essential oils contain multiple components, their antimicrobial activities are due to the additive, synergistic, or antagonistic effects of individual constituents. Table (8) Shows antibacterial activity of *M. spicata.*

Table 8: Antibacterial activity of M. spicata

Extract/ Essential oil/	Model	Highest activity	MIC/IC50/ Zone of Inhibition (ZI)	Reference
Essential oil	Microdilution	*Staphylococcus epidermidis*	MIC: 32 µg/ml	**[6]**
Essential oil	Diffusion	*Escherichia coli*	ZI: 21±0.90 at 10 %	**[37]**
Essential oil	Disc diffusion broth micro Dilution method	*Bacillus subtilis*	ZI: 27.1 ± 1.1 mm and MIC: 0.05 ± 0.00 (mg/ml)	**[25]**
Methanol **Ethanol** **Acetone** **Aqueous**	Agar disc diffusion	*Staphylococcus aureus*	ZI: 14.4 mm ZI: 15.3 mm ZI: 12.4 mm ZI: 10.6 mm	**[1]**
Essential oil	Agar disc diffusion	*Escherichia coli* *Enterobacter aerogenes* *Proteus mirabilis*	ZI: 28 mm and MIC: 40 (µg /ml) ZI: 24 mm and MIC: 40 (µg /ml) ZI: 24 mm and MIC: 40 (µg /ml)	**[30]**

III.3 Anti-fungal activity of *M. spicata*

Fungal diseases are emerged as a severe health issue, especially, in subtropical and tropical regions of the world. Due to microbial resistance against common antifungal drugs, there is prompt need for discovery and development of novel plant-based natural antifungal agents. The anti-fungal activity of Mentha essential oil is mainly due to the presence of terpenes and terpenoids. Several studies have shown that the Essential oil of *Mentha spicata* restricted significantly the mycelia growth of *Fusarium oxysporum* sp. *Radicis cucumerinum* in a dose-dependent manner. Table (9) shows some studies of antifungal activity of *M. spicata*.

Table 9: Anti-fungal activity of M. spicata

Extract/ Essential oil/	**Model**	**Highest activity**	**MIC/IC50/ Zone of Inhibition (ZI)**	**Reference**
Water root extract	Disc diffusion method	*Microsporum audouinii*	MIC: 16 µg/ml	**[3]**
Essential oil	Disc diffusion	*Candida albicans*	ZI: 26 ± 1.5 mm±SD	**[17]**
Essential oil	Disc-dffusion method	*Aspergillus flavus* NRRL 391	ZI: 36.0 ± 2.0 mm	**[13]**
Essential oil	Well diffusion	*Aspergillus niger*	ZI: 15±0.085 mm	**[59]**

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03 Feasibility study for the extraction and cultivation of Mentha spicata essential oil

I) Choice of plants

Spearmint is one of the most important ingredients for the preparation of the famous desert tea (mint tea), Ouargla has a large amount of recoverable agricultural land, which allows for the cultivation of medicinal and aromatic plants. Spearmint can grow in a variety of soil types, including sandy soils. It is also regionalized based on the state's climate. It is also known that the presence of spearmint in the southern regions is much greater, and thus the proportion of success of the investment is guaranteed.

According to data from the State Directorate of Agricultural Interests in the State of Ouargla. spearmint cultivation in the state covers a total area of 254 hectares spread over several palm fields, particularly through the municipalities of Ouargla, N'goussa, Sidi Khueld, Al-Alya Al-Hadjira, Tmassine, Al-nazala, Al-Mgarin and Sidi Suleiman.

Production during the current agricultural season (2016-2017) of green mint, which was harvested on an area of 175 hectares, amounted to 10,000 quintals with a return of about 60 quintals per hectare. Therefore, the development of the production of this plant is of utmost importance not only to provide raw materials for the food and pharmaceutical industry, but also to provide additional income for farmers interested in cultivating this aromatic plant, which occupies a special place in the cultivation of various types of aromatic and medicinal plants and spices in the state of Ouargla.

II) Planting and harvesting

Spearmint is a perennial herb that prefers rich, deep, cool soil. Soils that are deep and fresh. It develops aerial or underground stolons with bushy or creeping ports. Because spearmints spread quickly, it is best to plant slates vertically in the soil to control their spread **[3]**.

II.1 Organic agriculture

Definition

Organic agriculture is defined as an agricultural production and management system that combines a high level of biodiversity with environmental practices that preserve natural resources. It also includes strict animal welfare guidelines. It meets consumers' growing demand for natural products while also contributing to environmental preservation in the context of sustainable rural development. The term "organic agriculture" can only be applied to the products listed below **[4]**:

- Products that have not been processed include vegetables, cereals, fruits, cotton, flowers, animals, eggs, and milk.
- Human consumption processed products: cheese, bread, ready meals...
- Organic soybean meal for animal feed...
- Vegetative reproduction materials and seeds

In order to obtain and maintain organic farming certification, the operator must follow strict specifications that are tailored to each type of production while adhering to the following principles **[4]**:

- No use of "synthetic" chemical products (fertilizers, pesticides, etc.), though "natural origin" pesticides and fertilizers are permitted.
- GMOs are not used.
- Waste and organic waste recycling
- Crop rotation is used to regenerate soil.
- Biological pest control agents
- Extensive breeding with organic foods, as well as a focus on alternative medicine and prevention.
- Animal protection (surface of living spaces, outdoor runs, pasture, prohibition of above-ground breeding...).
- Environmental stewardship and resource conservation
- Biodiversity conservation and development (cultivation and breeding of various species, maintenance or planting of hedges, etc.).

It should be noted that converting a conventional farm to certified organic agriculture requires a transition period (up to three years depending on the type of production).

The misconception that organic farming does not use pesticides is widespread, but it is incorrect. Pesticides are used in organic farming. Organic farming regulations in France and Europe allow for the use of approximately a hundred fertilizers and inputs (pesticides, insecticides, or fungicides). The European Commission's Regulation (EC) No. 889/2008 contains a list of authorized inputs and pesticides for organic agriculture. Composts and manures are considered inputs, but so are pesticides and inputs such as Alumino-calcic phosphate, magnesium sulfate, sodium chloride, calcium polysulfide,

copper sulfate, and many others. Around 27 percent of the 68,000 tons of phytosanitary products sold in France are approved for organic agriculture **[4]**.

II.2 Soil characteristics

It appears oblivious to the pH of the soil. Because mint's root system is shallow, it requires soil that is loose, permeable, and slightly clayey. It grows best in deep, non-compact, humus-rich, well-drained soils with pH ranging from 5.5 to 8. A soil that is too acidic can be limed, but a soil that is too calcareous will be rejected **[1]**. The soil should not be overly humid because this will encourage rust attack on the plant. It is advised to restart the plantation after three years and not to cultivate the same plot for five years. for 5 to 6 years on the same plot Plants benefit from a previous crop of cereals or vegetables **[3]**.

II.3 Preparing the Soil

The soil must be prepared in the same way that wheat or other cereal crops are: it must be ploughed, harrowed, and fertilized. Weed control is less expensive when the soil is properly prepared. weeds.

In most cases, this is followed by stubble plowing to bury the stubble and prepare the surface for seeding. The cultivation is mostly done by hand, and it usually takes place between October and November, or in November or spring.

Because it is a perennial plant, it is recommended that a new plantation be established every three years. The soil will be plowed so that another seedling or plantation can replace the mint. substitute the mint

II.4 Irrigation

Mint has a taproot and many rhizomes, but it roots very shallowly, so it requires a humid soil and frequent watering: it requires about 1500 mm/year and we water when the top 10 centimeters of soil are dry. The ground is dry to a depth of a few centimeters **[2]**.

II.5 Harvest

Harvesting is possible all year, but especially from August to October. It can be done manually, using a small sickle, or automatically. Depending on the height of the stem, the cut is made at ground level or a few centimeters higher. The leafy stems are harvested prior to flowering. Depending on temperature and light conditions, two to three harvests per year are possible.

Because it is of poor quality, the first cut is usually discarded. It takes 40 to 50 days between two consecutive cuts in the hot season and more than 60 days in the cold season. The plant is harvested by cutting it at the ground level. With an average of 4 to 5 cuts per year, the yield is approximately 4 to 6 tons of dry matter per hectare.

III) Extraction by steam distillation

Hydro-distillation is a physical process that uses steam to extract essential oils from mint leaves. The process of steam distillation yields the highest quality without the use of any solvent. Steam flows through the tank containing the plants, carrying aromatic molecules with it. The steam condenses in the coil as it cools; the essential oil separates from the water and is collected in the essencier. Slow and prolonged distillation, or integral distillation, at low pressure allows for the extraction of all aromatic components. So, for every acre, spearmint produces 20 to 30 kg of essential oil.

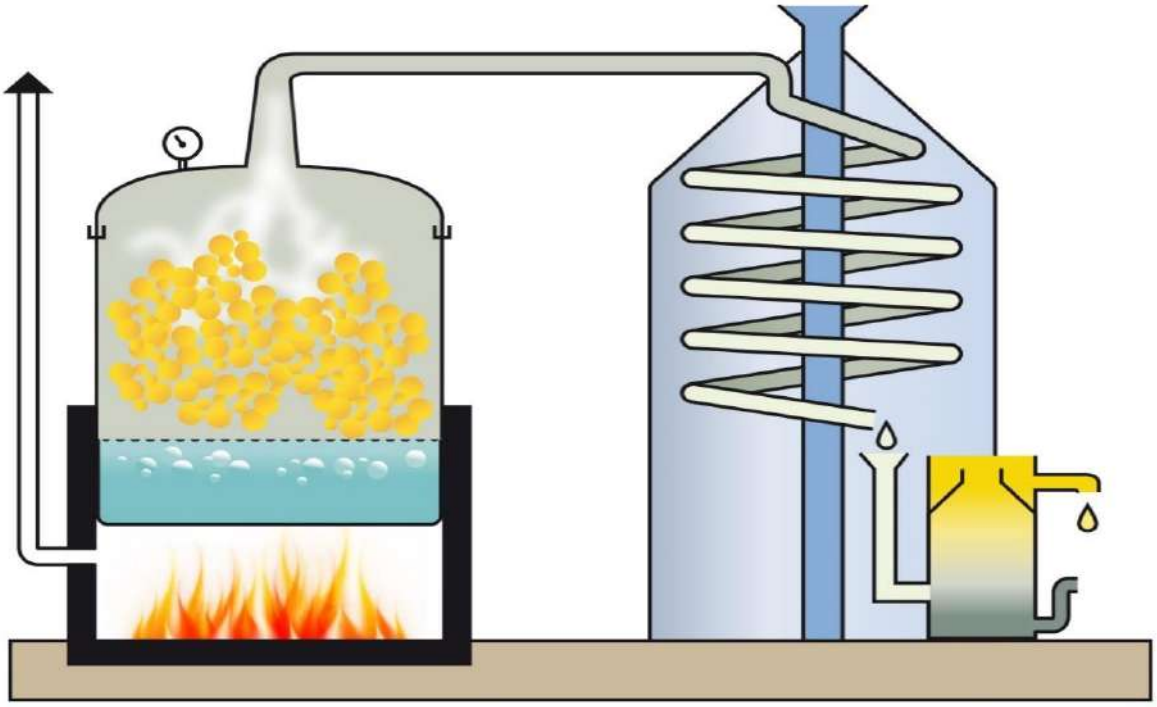

Figure 6: Extraction by steam distillation

IV) Analyses and characterizations

After the extraction process and the obtaining of the essential oil, an analysis must be made to determine the conformity of this oil with the international standards so that we can export it or sell it to factories. These analyses are:

- Analytical data subject to AFNOR standards
    - Denomination of the plant:
        - Commercial name: spearmint
        - Botanical name: *Mentha spicata*
        - Part of the plant treated: Arian parts
- Physico-chemical analysis
    - Appearance
    - Odor
    - Density
    - Rotatory power
    - Solubility in alcohol
    - Refractive index
    - Acid index
    - Ester index
    - Phenol index
    - Garbonyl index
    - Aldellyde content
- Chromatographic analysis
    - By gas chromatography (GPC) of the essential oil
    - GPC of the top products.
- Structural analysis:
    - GC (MS (Coupling with MS mass spectrometry), the most reliable and used at the moment.
    - NMR (Magnetic and Nuclear Resonance)
    - IR (Infra-Red).

V) Business plan

To ensure the success of a startup, its founder must have skills in marketing, human resources, legal, and purchasing. This will enable him/her to set the project's agenda, which will provide expectations of the institution's progress from an administrative and financial standpoint, and thus foresee problems and develop solutions before they occur.

Thanks to my participation in the **DjazairUP** incubator program, which is considered a support program for idea carriers and young startups and is run by ASI "Algerian Startup Initiative" with financial support from MEPI "Middle East Partnership Initiative.". I was able to set this business plan:

V.1 Descriptive part

Market needs:

- Organic spearmint essential oil is available on the market, but it is insufficient to meet domestic demand.
- As its consumption and use in industrial areas grows, so does market demand.

Current solutions

- The presence of institutions that extract green mint essential oil but not of high quality
- Mint essential oil is expensively imported from abroad.

Proposed solutions

To provide high quality spearmint essential oil in quantities covering the market needs.

Differentiation

- Provide 100% local product, with international standards.
- Reasonably priced sales with delivery services.

The competitors

In The State of Ouargla, there are no competitors from the same field because the majority are artisans interested in producing cosmetics.

Targeted clientele

- The food industry
- Medicine and the pharmaceutical industry
- The perfume and cosmetics industry

Strategy to conquer the market

- Working in cooperation with partners
- Direct sales

- Through distributors

Technology description

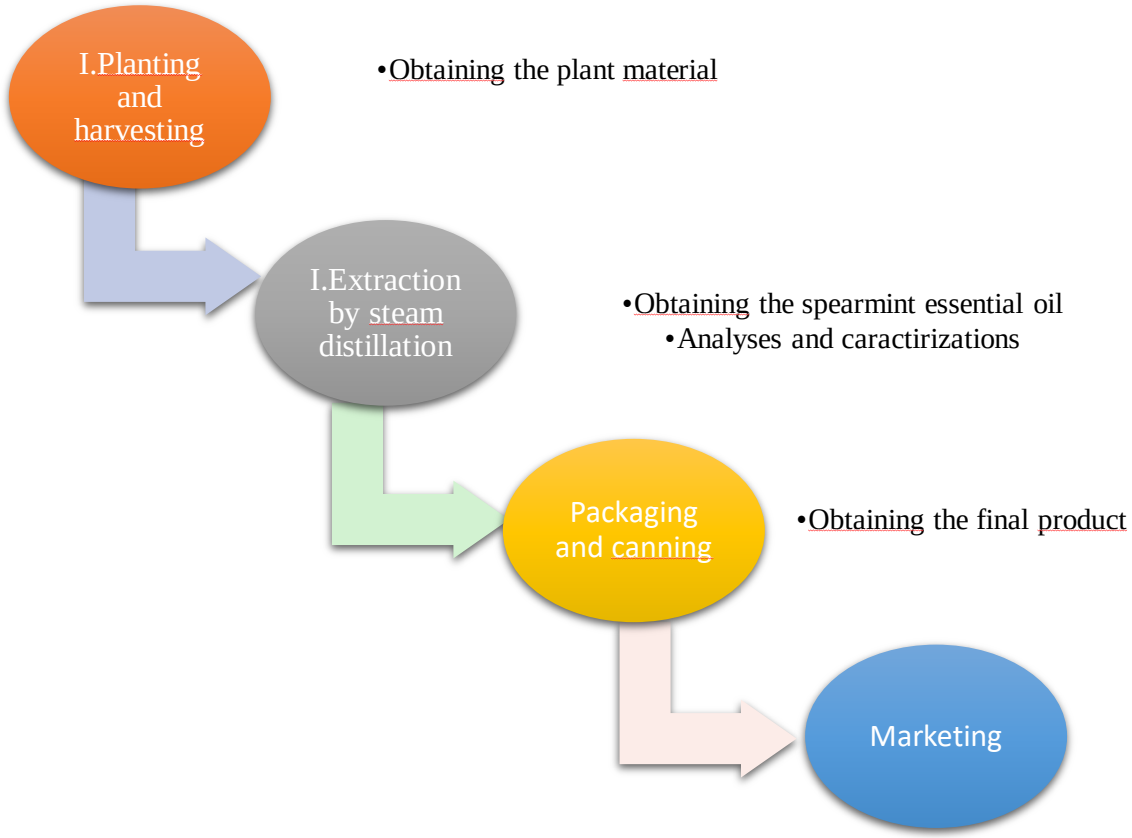

Figure 7: Technology description of production of spearmint oil

V.2 Financial Part

Investment and financing table

The investments include all of the commitments required to get the project started, such as real estate, raw materials, tools, and equipment.

Financing is the sum of investment values; this value is divided into self-financing, which is the value of investments that the entrepreneur can pay, and other financing, which is the amount that the entrepreneur expects from an investor or bank to contribute to the start of his project.

Table 12: Investment and financing

Investment	
Investment	**value**
Estates	2700000DA
Machines	680000DA
Equipment	200000 DA
Canning tools	50000 DA
Agriculture	300000 DA
Financing	
self-financing	2700000DA
other financing	1230000 DA

Expense and sales table:

For sales is the price of the quantity sold of essential oil of mint where the kilogram is about 40 000 DA. Expenses include expenses for raw materials, labor, electricity, transportation, advertising and marketing.

Therefore, to obtain the profit, we subtract the value of the expenses from the value of the sales.

Table 13: Expense and sales

	Year 01	**Year 02**	**Year 03**
Sales	6552000DA	13104000DA	26208000DA
Expenses	1022400DA	1087000DA	1161200DA
Raw materials	30000DA	30000DA	30000DA
Labor	842400DA	900000DA	967200DA
Electricity	10000DA	12000DA	14000DA
Transportation	10000DA	10000DA	10000DA
Rent	120000DA	120000DA	120000DA
Advertising and marketing	10000DA	15000DA	20000DA
profit	5529600DA	12017000DA	25046800DA

The profit value shown in the table represents the profit when cultivating a quarter of a hectare, and it is increasingly expelled with the planted area over three years. The first year, one-third of the area was planted; the second year, two-thirds of the area was planted; and the third year, all of the area was planted.

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Conclusion

Conclusion

Through previous studies, green mints have a great biological benefit, thanks to its secondary metabolites especially the essential oil that is mainly made from carvone, and the latter has great biological effectiveness, so medicinal and aromatic plants in general and green mint in particular should not remain trapped in academic studies, but should be exploited in the economic field through cultivation and extraction of oils because they have great importance in the market. World

Algeria has qualifications that if exploited to the fullest, it will make it one of the most important exporters of medicinal plants after it was a country dependent on the highway.

The cultivation of mint in The State of Ouargla, estimated at a total area of 254 hectares, is distributed over several palm fields in several municipalities of the state.

However, the production of green mint has declined significantly year after year due to the lack of a strategy for the development of this agriculture, which is one of the most important ingredients for the preparation of the famous desert tea is of the utmost importance not only to supply the food industry and the pharmaceutical industry with primary material but also to provide additional income of "value" for farmers interested in the cultivation of this aromatic plant, which occupies a special place with regard to the cultivation of various types of aromatic and medicinal plants and spices in a state of thinness.

Abstract

الملخص

Abstract

This work is a bibliographical synthesis gathering the results of some studies carried out on the phytochemical study and the biological evaluation of spearmint. Several studies have shown that green mint is rich in secondary metabolism compounds that are filled with polyphenols, terpenes and also essential oil. The spearmint essential oil is mainly made up of carvone and limonene. studies have shown that the effectiveness of green mint lies in the Carvone, where it has several biological activities such as Antibacterial, Anti-inflammatory and Antioxidant activities

In the second part, it is clear that mint cultivation and the extraction of its essential oil can be used to revive the economic aspect, which is because of the abundance of vast arable areas in the state of Ouargla, the perspective of spearmint use will change from mint used to prepare tea to mint, creating economic wealth.

Keywords: green mint, Mentha spicata, biological effectiveness, essential oil, economic wealth.

الملخص

هذا العمل عبارة عن توليف ببليوغرافي يجمع نتائج بعض الدراسات المتمثلة في الدراسة الكيميائية النباتية وبيولوجية للنعناع الأخضر. أظهرت العديد من الدراسات أن النعناع الأخضر غني بمركبات الايض الثانوي المليئة بمتعددات الفينول والتربينات وكذلك الزيوت الأساسية. يتكون زيت النعناع العطري بشكل رئيسي من الكارفون والليمونين. فقد أظهرت العديد من الدراسات أن فعالية النعناع الأخضر تكمن في الكارفون، حيث يحتوي على العديد من الأنشطة البيولوجية مثل الأنشطة المضادة للبكتيريا والمضادة للالتهابات ومضادات الأكسدة.

وفي الجزء الثاني، تبيين أن زراعة النعناع واستخراج زيته العطري يمكن استغلالها لإنعاش الجانب الاقتصادي، وذلك بسبب وفرة المساحات الشاسعة الصالحة للزراعة في ولاية ورقلة. وبهذا، سوف يتغير منظور استخدام النعناع من النعناع المستخدم لإعداد الشاي إلى النعناع يخلق ثروة اقتصادية.

الكلمات المفتاحية: النعناع الأخضر، *Mentha spicata*, الفعالية البيولوجية، الزيت الأساسي، الثروة الاقتصادية.