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Diversity, Chemical Compositions and Beneficial Effects of Some Spices and Aromatic Leaves Consumed in Benin and in the World: Critical Review

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Abstract

Spices and aromatic plants are products of plant origin used in food. They are used for the preparation of remedies, for seasoning dishes or for preserving food. This review takes stock of the diversity of spices and aromatic herbs, the chemical composition, the different properties and forms of use of six spices and aromatic herbs commonly used in Benin and around the world. These are *Zingiber officinalis* (ginger), *Curcuma longa* (curcuma), *Syzygium aromaticum* (clove) and three aromatic herbs *Petroselinum crispum* (parsley), *Rosmarinus officinalis* (rosemary), and *Laurus nobilis* (laurel). The methodology used is that of documentary research oriented towards the consultation of previous scientific documents that have highlighted the different pharmacological activities of the different species of spices and aromatic plants targeted. It is important to note that more than twenty plant species are used as spices and aromatic plants in Benin and around the world. Chemically, these different spices and aromatic herbs contain certain secondary metabolites such as flavonoids, tannins, coumarins, alkaloids, steroids, terpenes, saponins, and polyphenols. This diversity of secondary metabolites alone or in a possible synergy may be responsible for many beneficial properties attributed to spices and aromatic herbs.

Keywords

Spices, Aromatic Leaves, Pharmacological Effects, Humans

1. Introduction

The history of spices begins 4000 years before our era, in the southwestern region of India. This man, who first identified pepper to improve the taste of his rice, was far from imagining that spices would become such an object of lust. It is almost the entire history of humanity that scrolls through the quest for spices [1]. These spices, most of which are exotic, were among the most expensive commercial products during Antiquity and the Middle Ages [2].

Coming from the Latin word "spices" meaning quite simply species or substance, spices are parts of aromatic plants with a strong flavor or preparations, in particular mixtures made from these plants, used in small quantities in cooking and also serve as seasoning for food [3]. In addition, aromatic plants play a very important role in the agrifood industry sector, in perfumery and especially in the pharmaceutical industry [4]. The use of aromatic plants to prevent or cure diseases was one of the first therapeutic practices in human history [5].

Aromatic plants are a great source of antioxidants and natural antibacterial for the food industry [6]. As for spices, these are aromatic substances of plant origin used to season dishes [7]. These are substances that are added to foods to modify their organoleptic characteristics, making these foods much more appetizing and tasty and, therefore, allow greater benefit to be obtained. Spices play a very important role in food standards because of the prophylactic and curative properties attributed to them [8].

In recent years, the link between human health and nutrition has been clearly established [9]. Studies have now shown that several foods (fruits, vegetables and spices) contain nutrients and bioactive compounds that influence the functioning of the body [10] [11]. This property is due to their antioxidant content, in particular vitamin C, vitamin E, carotenoids and polyphenols (flavonoids, catechins, isoflavones, glucosinolate) [12].

In Benin, aromatic plants and spices are used in many traditional culinary recipes not only to enhance the taste of food but also for their nutritional and medicinal qualities, of which populations have empirical knowledge [13]. They are part of the traditional vegetables whose different plant organs (leaves, flowers, fruits, stems, bark, roots, bubbles) are used in food preparations [14] [15]. However, the use of spices and aromatic plants has not yet succeeded in supplanting that of seasoning broths rich in Monosodium Glutamate (MSG). But unlike these plant species, the regular use of these food broths could lead in the long term to many diseases such as cancer [6] [16].

To contribute to a better knowledge of these spices and aromatic leaves, it is essential to take stock of the spices and aromatic herbs which have antioxidant, antimicrobial and anti-inflammatory activities for a better valuation. Therefore, this present review explores three major spices and three aromatic herbs used in Benin and in the world with the aim of providing a reference document to researchers who are involved in improving the nutritional and health status of humans.

2. Some Data on Importance of Aromatic Plants and Spices

Aromatic plants and spices have been used for centuries for their medicinal and culinary properties. They contain a variety of essential oils, flavonoids, and other phytochemicals that are responsible for their distinctive flavor and aroma, as well as their health benefits [17]. The importance of aromatic plants and spices is of various orders:

- **Economic importance:** According to a report by Mordor Intelligence, the global market for spices and seasonings was valued at $17.27million in 2023 and projected to register a CAGR (Compound AnnualGrowth Rate) of 4.96% over the upcoming five years.. This demonstrates the significant economic impact of these products on the global market [18].
- **Medicinal properties:** Aromatic plants and spices have been traditionally used for their medicinal properties. For example, turmeric, a spice commonly used in Indian cuisine, contains curcumin, which has anti-inflammatory and antioxidant properties, and may help to support a healthy immune system [19]. Studies have shown that curcumin may help to reduce the risk of chronic diseases such as cancer, diabetes, and Alzheimer's disease [20] [21] [22]. Ginger is rich in antioxidant compounds such as gingerol and shogaol, which have anti-inflammatory and antioxidant properties [23]. Clove oil has been used for pain relief for centuries. Studies have shown that it has analgesic and anti-inflammatory properties [24] [25]. In recent years, there have been many studies conducted on the medicinal properties of parsley and rosemary. It can be noted that these aromatic herbs has anti-inflammatory and antioxidant properties through their chemical composition [26] [27] [28]. Garlic has been shown to enhance the activity of immune cells, such as macrophages and natural killer cells, and may help to prevent and treat infections [29].
- **Culinary properties:** Aromatic plants and spices are widely used in cooking to add flavor and aroma to dishes. For example, cinnamon is a popular spice that is used in sweet and savory dishes, and is also used to make tea. It has been shown to have antioxidant and anti-inflammatory properties, and may help to lower blood sugar levels [30] [31]. Laurel leaves are widely used in cooking for their intense aroma and warm flavour. They are commonly added to meats, soups and sauces to enhance the flavour [32]. Certain compounds can also be found in laurel leaves such as, linalool and *in* cineole, which have antimicrobial effects against bacteria and fungi [33]. The laurel has been shown to help regulate blood sugar in diabetic animals, probably due to their antioxidant and anti-inflammatory effects [34].
- **Preservation properties:** Aromatic plants and spices have been used for centuries to preserve food. For example, the essential oil of oregano contains compounds that have antimicrobial properties and can inhibit the growth of bacteria and fungi [35].

In a general way, many spices and aromatic herbs have immune-boosting

properties due to their high content of various phytochemicals, such as flavonoids, terpenoids, and alkaloids, which have been shown to modulate the immune system [36] [37]. So, aromatic plants and spices have significant economic, medicinal, culinary, and preservation properties, which make them an important part of our daily lives.

3. Diversity of Spices and Aromatic Herbs Consumed in Africa and Around the World

The dried leaves and EO (of Spain type and Morocco-Tunisia type) of *Rosmarinus officinalis* L. are listed as plant drugs in the European Pharmacopoeia 11th edition. According to the European Pharmacopoeia, the whole dried leaf of Rosmarinus officinalis L. must have a minimum content of:

- 3% of total hydroxycinnamic derivatives, expressed as rosmarinic acid ($C_{18}H_{16}O_8$; Mt 360.3) (anhydrous drug)
- 12 mL/kg of EO (anhydrous drug).

The cultivation of spices spread under the influence of colonial empires. Spices are classified as medicinal plants [3]. Considering the doses used for cooking, it has been observed that all spices are good for your health. In Benin, a study showed that in the Collines department twenty-seven (27) plant species are used as aromatic plants and spices. These species are divided into 22 genera and are distributed in eighteen (18) families, the most diverse of which are the Annonaceae, Lamiaceae, Asteraceae, Amaryllidaceae, Myrtaceae, Solanaceae and Zingiberaceae [38]. Aromatic plants and spices contribute to the prevention and treatment of ten (10) diseases, the most cited of which are infections, digestive disorders and malaria [38].

According to other researchers, sixteen (16) spices and seven (7) aromatic herbs are commonly used by the people in Benin [39]. These spices and aromatic herbs are listed in **Table 1** according to their common names, their local names and their scientific names.

They are of exotic origin; they are characterized by their aromatic and gustatory power; they make food more digestible and more appetizing. These are products rich in germs, when they have not undergone anti-bacterial treatment. Certain spices can be considered as aromatic herbs or spices depending on their uses: whole or powder. The popularity of spices and aromatic herbs has been, and remains, closely linked to their organoleptic properties [40].

Of course, the least objectionable classification is that based on the morphological characteristics of plants. However, it has the drawback of grouping plants without any proximity of flavor. However, in the field of food industries and gastronomy, it is on the contrary more interesting to group spices and aromatics plants according to their organoleptic properties (color, odor, aroma and flavor) [40].

Taking into account the use, using a tabular representation (**Table 2**) we have presented the biological properties and the different classifications of herbal spices containing some spices and herbs used in Benin Republic and the world.

Table 1. Spices and aromatic herbs commonly used in Benin [39].

	Common name	Local name	Scientific name
Spices	Anise	Pleple	*Pimpinella anisum*
	Chile	Takin	*Capsicum sp*
	Cinnamon	Cinnamon	*Cinnamomum zeylanicum*
	Clove	AtinkinKpadotà	*Eugenia caryophyllus*
	Cumin	Ha	*Cumynum cyminum*
	Dill	Sokounnou	*Anethum gravealens*
	False nutmeg	Sassagbakun	*Monodora myristica*
	Garlic	Ayo	*Allium sativum*
	Guinea pepper	Kpédjlélékun	*Xylopia aethiopica*
	Ginger	Dotè	*Zingiber officinalis*
	Nutmeg	Salikun	*Myristica fragrans*
	Onion	Mansà	*Allium cepa*
	Pepper	Linlinkun	*Piper nigrum*
	Star anise	star	*Illicium verum*
	Sweet pepper	Pepper	*Capsicum annuum*
	Thyme	Tein	*Thymus vulgaricus*
Aromatic herbs	African basil	Tchioyo, tchiayo	*Ocimum gratissimum*
	Celery	Celery	*Apium gravealens*
	Citronela	Timan	*Cymbopogon citrates*
	Laurel	Lorieman	*Laurus nobilis*
	Mint	Manti	*Aquatic mentha*
	Parsley	Parsley	*Petroselinum crispum*
	Rosemary	Rosemary	*Rosmarinus officinalis*

Spices and aromatic herbs are increasingly used by the Beninese population alone or mixed in cooking and for the preparation of herbal teas; moreover, studies continue to show the richness of these spices and aromatic herbs in bioactive compounds endowed with several therapeutic properties. It is important to promote the enhancement of spices and aromatic herbs of plant origin used in food through the identification of the various chemical compounds likely to be used to prevent or delay diseases with a nutritional component. Among all its spices and aromatic herbs mentioned in this review, the three spices and three herbs that were chosen have an antioxidant power, several virtues and are among the most used in Benin Republic and in the world.

Table 2. List of some spices and aromatic herbs commonly used in the world [41].

N°	Common name	Scientific name	Biological properties	Use
1	Dill and Fennel	*Anethum graveolens* L. *Foeniculum vulgare Miller.*	Dill is a diuretic and excellent for digestion. Its chemical properties stimulate bile secretion, thus facilitating the digestion of fat. In addition, it relieves insomnia, digestive disorders, anxiety, nervous fatigue and reduces bad breath	Fennel leaves are used to season salads, vegetables and cheeses. The ground seeds flavor sauces, soups. They are also used in liquorice in the manufacture of anisette, fenouillette.
2	Star anise or star anise	*Illicium verum*	Star anise is a eupeptic, it inhibits intestinal fermentation.	It is used for the manufacture of liqueurs (anisette, absinthe).
3	Cinnamon	*Cinnamomum zeylanicum*	The essential oil extracted from the bark is a cardiac and respiratory stimulant. It is also a strong antimicrobial.	Cinnamon is used in rolls or powder for drinks, confectionery, cooking. The oil is also used in the synthesis of vanillin.
4	The Caper	*Capparis spinosa* L.	Caper is a stimulant.	It is mainly used as a condiment.
5	Cardamom	*Elettaria cardamomum* (L.)	Cardamom may help lower blood pressure, possibly due to its antioxidant and diuretic properties (Verma *et al.,* 2009). Cardamom may be able to kill common oral bacteria and prevent cavities (Kubo *et al.,* 1991)	Cardamom is used as a flavoring and condiment. She enters the composition curry. It is also used to treat bad breath and is part of some chewing gum
6	Clove	*Syzygium aromaticum* (L.)	In pharmacy the clove is used for its stimulating, digestive and analgesic properties. It is also bactericidal and insecticidal.	Cloves are used whole or in powder in the diet. It is also used in perfumery and
7	Coriander	*Coriandrum sativum* L.	Cilantro is a stomachic, remarkable for its high content in vitamin A.	The fruits are used as a condiment in broths, canned vegetables, cold cuts, meats in sauce, Greek mushrooms and marinades.
8	Cumin	*Cuminum cyminum* L.	Cumin also aids digestion. The whole world loves cumin for its digestive properties (Johri, 2011). It also helps strengthen bones and stimulate the production of healthy red blood cells.	Cumin is a commonly used spice in Arabic cuisine. It is used in the composition of curry and flavored certain cheeses.
9	Turmeric	*Curcuma longa* L.	Turmeric is known for its properties anti-inflammatories, cholagogues and stimulants.	It is used as a coloring in foods and textiles, but also as a condiment in curry (It is called Indian saffron).
10	Ginger and the Galangal	*Zingiber officinale Roscoe and Alpinia galanga* (L.)	Ginger is a stimulant, cholagogue and antiemetic.	Ginger is also used in liquorice (ginger ale or ginger beer) and as a condiment in pastries, jams, marmalades and even in sauerkraut.
11	The mustard	*Sinapis alba* L.	Mustard is a stimulant	It is mainly used as a spice or condiment. The seeds can be used whole in salads, pickles, sauerkraut or powdered (mustard English).
12	The Nutmeg	*Myristica fragrans Houtt.*	In Chinese medicine, it is used as a stomachic and an anti-diarrhea. In high doses, it can be hallucinogenic.	Nutmeg is a spice with stimulating properties. Nutmeg butter is used in an anti-rheumatic ointment.

Continued

13	Peppers and Paprika	*Capsicum sp*	The small, very hot peppers can be used as a repellant to treat rheumatism, lumbago and neuralgia. Chili peppers stimulate the appetite and stimulate digestion. Paprika contains several nutrients that can improve eye health, including vitamin E, beta-carotene, lutein, and zeaxanthin (Rasmussen & Johnson, 2013)	Paprika is a versatile spice that can be incorporated into a multitude of dishes. It is made from dried peppers.
14	The pepper	*Piper nigrum* L.	Pepper is a stimulant of digestive secretions and the nervous system. It is a bactericide, an insecticide and an antioxidant.	Black pepper is a staple on every kitchen counter and on every table.
15	Licorice	*Glycyrrhiza glabra* L.	Licorice root has properties anti-inflammatory, cough suppressants and anti-ulcer drugs used in the treatment of coughs and digestive disorders.	Licorice has been used medicinally for at least 500 BC
16	Saffron	*Crocus sativus* L.	Saffron is a stimulant and can be abortive in high doses.	In food, it is used as a coloring and a spice.
17	Vanilla Andrews	*Vanilla planifolia*	Vanilla helps fight against physical and intellectual fatigue and promotes muscular effort. Vanilla calms stress and can also be used in cases of insomnia. It is also recommended against hysterical attacks or episodes of melancholy. It opens the appetite and then stimulates digestion.	Vanilla is used in cooking in many preparations (pastries, dairy products and sweets) and in perfumery.
18	Rosemary	*Rosmarinus officinalis* L.	Rosemary therefore activates the digestive functions, in particular the work of the gallbladder, the substances in rosemary limit the development of certain pathogens	The leafy branches of rosemary are best used fresh, but can also be stored dried.
19	Common sage	*Salvia officinalis* L.	It also has varying degrees of antispasmodic, emmenagogues (beneficial action on menstruation), febrifuge, antiperspirant properties.	In cooking, the leaf of fresh or dried sage has been a condiment used since antiquity, it is particularly appreciated with fatty meats and pork. Sage has been used by various cultures for teeth whitening.
20	Thyme, common thyme	*Thymus vulgaris* L.	Traditionally, thyme honey is used to sweeten evening herbal teas because it is soothing and promotes sleep. Recognized antiseptic, it is recommended for the prevention and treatment of infectious, respiratory or digestive diseases.	The leaves of common thyme are used in the form of infusion, essential oil or alcohol.

4. Chemical Composition of Some Spices and Aromatic Leaves Consumed in Benin and in the World

Herbs and spices have no real nutritional value but are rich in bioactive compounds, polyphenols, alkaloids, terpenes and carotenoids, all molecules endowed with properties that allow the plant to adapt to its environment [42]. The medi-

cinal and therapeutic virtues of spices and aromatic herbs are due to their richness in secondary metabolites called active ingredients which act directly on the body [43] [44] [45]. As discussed above, there are a variety of spices and aromatic herbs. In order to better refine the data and according to their frequent use, the remaining part of this study focused on three major spices (Ginger, Clove, Turmeric) and three herbs (Parsley, bay leaves, Rosemary).

4.1. Chemical Composition of Ginger (*Zingiber officinale*)

Ginger (*Zingiber officinale*) of the Zingiberaceae family is a species of herbaceous plants with white or red flowers, native to Asia, whose fleshy and aromatic rhizome is used in cooking and in traditional medicine. This rhizome, with a spicy taste, is used fresh, candied in sugar or in powder. **Figure 1** shows ginger rhizomes. This rhizome with raw skin has a lemony, clean, fresh aroma. *Zingiber officinale* Roscoe is Ginger whose rhizome is a condiment. It is also used in medicine [46].

The chemical composition of ginger is complex: in addition to the starch which represents a large part of the weight of the plant (about 60%), we can distinguish the presence of oleoresin, rich in pungent compounds and lipids; and from 10 to 40 mL/kg of essential oil, containing many odorous molecules; proteins, vitamins and minerals are also present [47]. The identification of oleoresin compounds by high performance liquid chromatography (HPLC) has made it possible to isolate more than 100 molecules. Among them, the 1-(3'-methoxy-4'-hydroxy-phenyl)-5-hydroxy-alkan-3-ones are in the category commonly called gingerols, their lateral carbon chain is of variable length (between 7 and 16 atoms of carbon). Thus, we distinguish (6)-gingerol, the main representative, from (3)-gingerol, (5)-gingerol. The chemical structure of gingerols is shown in **Figure 2**.

Figure 1. Photo of Ginger rhizome.

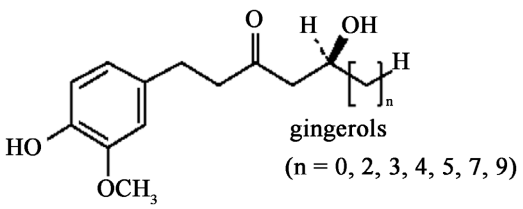

Figure 2. Chemical structure of gingerols [48].

These phenolic compounds, responsible for the pungent flavor of ginger, are the subject of extensive research regarding their chemical and pharmacological properties. Dry ginger rhizomes contain products resulting from the dehydration of gingerols and also exhibiting interesting pharmacological properties: shogaols, or 5-deoxy-4,5-dehydrogingerols [47].

The greater the desiccation of the rhizome, the more the proportion of shogaols increases, and conversely, the more the proportion of gingerols decreases [48].

The richness and variety of chemicals found in *Zingiber officinale* rhizomes are responsible for the taste, aroma and healing properties of ginger. The specific constituents of ginger extracts depend on the origin of the variant and whether the rhizomes are fresh or dried [49] [50].

Studies carried out on *Z. officinale* Roscoe dried in the microwave at different powers (180, 360, 540, 720, 900W) have shown after the extraction of phenolic compounds in ethanol. The content of phenolic compounds in ginger varies from extract to another. The extract obtained at the power 540W (P60) contains the largest amount of total polyphenols (18.3 mg EAG/g MS) and Flavonoids 14 mg (EQ/g). Also for carotenoids at a value of 53 mg/100g obtained at the power 180W (P20). For antioxidant power, it is the extract obtained at a power of 180W (P20) which is more active with an inhibition percentage of 69.75% [51].

Yellow to brown in color, ginger essential oil contains many fragrant volatile compounds. Their content varies greatly depending on the geographical origin of the plant and the extraction methods. The total essential oil content remains low: between 0.25% and 5% [52]. In ginger, Gas Chromatography can analyze more than a hundred components including non-volatile pungent compounds (**Figure 3**).

4.2. Chemical Composition of Turmeric (*Curcuma domestica*)

Curcuma longa L. belongs to the vegetable kingdom, angiosperm, monocotyledon, division Magnoliophyta, class Liliopsideae, order Zingiberales, family Zingiberaceae, genus Curcuma. The part used is the rhizome which is shown in **Figure 4**. These rhizomes must be harvested 7 to 8 months after planting, when it begins to dry [54].

The chemical study of *Curcuma domestica* reveals the existence of curcuminoids responsible for the coloring and pharmacological properties of this spice, of an essential oil containing a multitude of terpene compounds and various secondary compounds. Curcumin actually refers to a set of yellow coloring matters called curcuminoids (or curcumins). These molecules structurally attached to a diarylheptane have a content that varies greatly depending on the cultivar and can reach 8% [4]. Curcuminoids were separated by chromatography on a silica column and isolated from the beginning of the 20th century [55]. There are three related pigments:

- The major compound of the whole is curcumin 1 (50% to 60%) or (E, E)

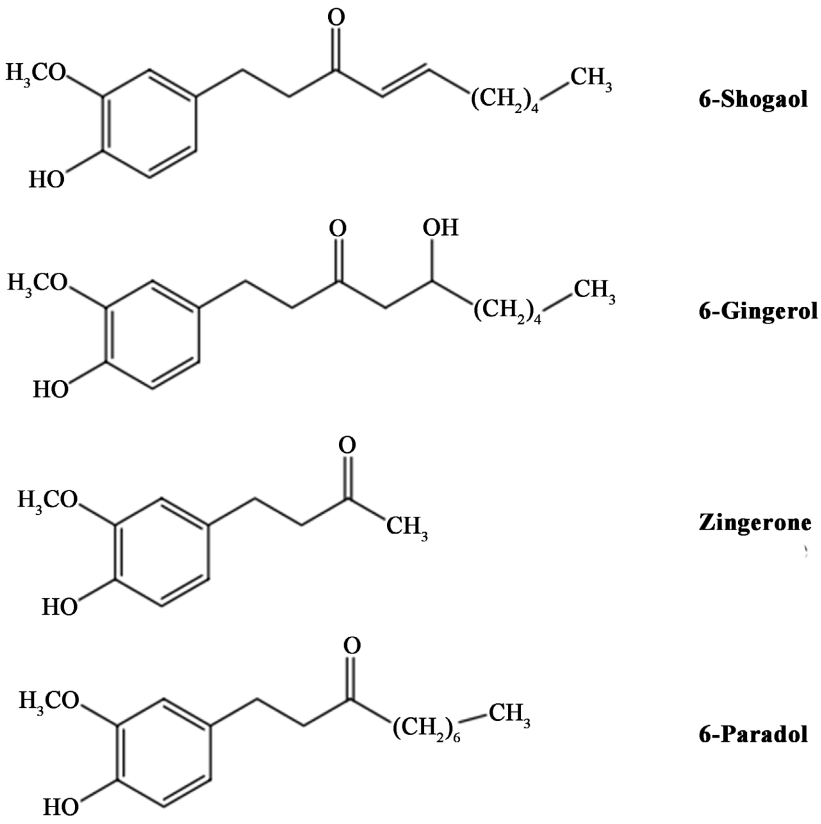

Figure 3. Non-volatile pungent compounds of ginger [53].

Figure 4. Photo of *Curcuma longa L* rhizomes.

1.7-bis-(4-hydroxy-3-methoxyphenyl)-1.6 heptandiene-3.5 dione. It is a symmetrical unsaturated diketone that can also be called diferuloyl methane (ferulic acid is hydroxy-4-methoxy-3-cinamic acid).

- The other weighty important pigments are curcumin II or demethoxycurcumin (bis-(4-hydroxycinnamoyl)-methane}, accounting for 24% of all curcumin.
- Finally, bisdemethoxycurcumin curcumin III (=feruloyl-(4-hydroxycinnamoyl) -at 14% [56].

These yellow pigments are often accompanied by dihydrocurcumin (1.7-bis-(4-hydroxy-3-methoxyphenyl)-1-heptene-3.5 diane).

Other studies have highlight a new curcuminoid called cyclocurcumin or curcumin IV [57]. This compound having the same crude formula as curcumin 1 (C21 H2006) would have nematocidal properties.

4.3. Chemical Composition of Cloves (*Syzggium aromaticum*)

The Clove tree (*Syzggium aromaticum*) from the *Myrtaceae* family is native to Indonesia and is now cultivated in Madagascar, the Caribbean and South America. It is an evergreen tree that can reach a height of about 12 to 15 cm. Clove (*Eugenia caryophyllus* or *Syzygium aromaticum*) is obtained by harvesting the flower buds before they bloom. The corolla whose petals are folded back at the top of the clove is called the "nail head" [58] [59]. **Figure 5** shows some cloves.

Syzygium aromaticum essential oil is made up of many different compounds, with the primary ingredients being: eugenol (49% - 87%), β-caryophyllene (4% - 21%) and eugenyl acetate (0.5% - 2%). Minute amounts of α-humulene are also present, as well as traces (<1%) of 25 to 35 other constituents [59]. **Table 3** shows the chemical constituents of *Syzygium aromaticum.*

Figure 5. Photo of Clove.

Table 3. The main chemical constituents of *Syzygium aromaticum* [60].

Family of constituents	Detail of constituents
Tannins (12%)	Galic and ellagic tannins, gallic acid, protacatechic acid, eugenin, casuarictin, 1,3-di-O-galloyl-4,6-(S)-hexahydroxydiphenoyl-beta-D-glucopyranose, tellimagrandine
Flavonoids (0.4%)	Quercetin, kaempferol, rhamnetin, eugenitin
Chromones	Biflorine, isobiflorine, glycosides chromone
Fat body	Sterols, sterolic glycosides, fatty oil (10%)
Others	Phenol acids, triterpenes

Some works also showed that the characterization by CPG-SM of the essential oil of clove obtained by hydrodistillation indicates that the major components of this oil are: Eugenol (80.83%), eugenyl acetate (10.48%), β-caryophyllene (7.21%) and α-humulene (0.87%) [61].

4.4. Chemical Composition of Laurel (*Laurus nobilis*)

The noble laurel, *Laurus nobilis* L., belongs to the *Lauraceae* family. It is also known under the name of bay leaves or laurel-sauce or still laurel of Apollo. *Laurus nobilis* is a large shrub with gray bark that can reach 2 to 6 m in height, even 15 m in the wild. In order to simplify its harvest, it is frequently pruned into a shrub. Pyramidal in appearance, it presents dense dark green and persistent foliage. Its growth is generally slow, around 5 to 6 m in twenty years. He can easily become a hundred years old [62]. **Figure 6** shows some fresh bay leaves.

In recent years, laurel has been the subject of numerous phytochemical studies [63]. The main interest is the medicinal use of this plant, in particular the leaves and berries. Laurel produces a remarkable essential oil still too little used in aromatherapy. It is a very pale yellow liquid oil, with an aromatic, spicy odor with a eucalyptus background. Laurel essential oil consists of various family compounds of oxides, terpenes, monoterpenols, phenols, monoterpenes, sesquiterpes and terpene esters are the various secondary metabolites identified in noble laurel cited in the literature [64].

Several flavonoids and their derivatives have been determined in bay leaf extracts such as flavonoids O-glycosides or C-glycosides, catechins, procyanidins and anthocyanins [65] [66].

Other compounds have also been identified such as sesquiterpene lactones, alkaloids and vitamin E [67] [68] [69].

4.5. Chemical Composition of Rosemary (*Rosmarinus officinalis*)

Rosmarinus officinalis L. is an aromatic plant of the *Amiaceae* family that can

Figure 6. Laurel leaves.

attain about 2 meters in height, with brown branches erect upwards or rarely curved downwards. Sessile leaves 15 to 40 mm length, 2 to 3.5 mm wide, straight, alongside-straight, leathery, with rolled edges, of a shiny green and rough on the upper side, white and hairy on the lower side [70]. Some leafy stems of rosemary are shown in **Figure 7**.

The chemical composition of the plant as a whole depends on the place of growth and harvest as well as the time of harvest in the vegetative cycle [71].

In order to determine the chemical composition of the leaves and flowering tops of Rosemary, other researchers carried out a survey based on several studies, they were thus able to calculate average values for the molecules most often cited (**Table 4**) [72].

According to some studies, the essential oils obtained do not have the same chemical composition [73]. There is a relatively large difference in composition, in particular of the essential oils extracted from *Rosmarinus officinalis* from the study stations (Draa Hammam and Ammacha) compared to those of the study satation of Youkous from the region of Hammamet (Tébessa-Algeria). The results obtained by chromatographic analysis (CPG/MS) of rosemary collected from study stations in the Hammam region indicate that the essential oil of the Draa Hammam sample contains 20 chemical components; that of the Ammache sample comprises 18 components and that of Youkous includes only 8 components as shown in **Table 5**.

Moreover, it is important to note that the chemotype with a high percentage of the essential oils studied is 1.8 cineole with respectively: 72.91% sample of Youkous; 32.59% sample from Draa Hammam and 32.76% sample from Ammacha.

The quantitative and qualitative comparison of essential oils of *Rosmarinus officinalis* native (central part of northern Morocco region Skoura M'Daz, Eastern

Figure 7. Leafy stem of *Rosmarinus officinalis* L.

Table 4. Chemical composition of *Rosmarinus officinalis*: synthesis of several scientific articles [72].

Phenol acids
o rosmarinic acid: 1.7% - 2.83% on average o caffeic acid: cited (=no value specified) associated with chlorogenic acid tricyclic phenolic diterpenes o carnos (ol) ic acid ≈ 0.35% o carnosol = picrosalvine: cited (variable value, up to 4.6% or majority) o rosmanol: cited o rosmadial: city
Triterpenes:
o ursolic acid: 2% - 4% on average and 5% ursolic acid derivatives o oleanolic acid: ≈ 10% o *α*- and *β*-amyrins: cited
Methylated flavones:
o luteolin: cited o genkwanine: cited
Essential oil (monoterpenes)
o *α*-pinene: 3.48% - 27.1% on average o 1,8-cineole: 12.84% - 42.9% on average o camphor: 10.22% - 31.4% on average o free and esterified borneol: cited o camphene: 3.53% - 9.8% on average

Table 5. Chemical composition of essential oils of rosemary from study stations in the Hammamet region (Tébessa-Algeria) [73].

Locality			**Youkous**	**Draa Hammam**	**Ammacha**
No.	Compounds	IR	Percentage (%)	Percentage (%)	Percentage (%)
1	*α*-Pinene	932	-	3.39	3.41
2	Camphene	949	-	14.40	14.47
3	Sabinene	980	2.40	15.93	16.01
4	*β*-Pinene	987	-	-	1.47
5	p-Cymene	993	-	1.58	1.59
6	1.8 cineole	1032	72.91	32.59	32.76
7	*γ*-Terpinene	1047	-	1.74	-
8	*α*-Terpinolene	1088	0.50	1.19	1.19
9	Linalool	1094	-	0.10	0.10
10	Camphor	1144	17.16	4.46	4.48
11	Pinocamphone	1154	-	6.17	6.20
12	Borneol	1169	4.18	9.68	9.73
13	Terpinene-4-ol	1178	1.88	3.64	3.66

Continued

14	1-Dodecene	1183	-	0.09	0.09
15	1-*α*-Terpineol	1188	0.96	3.31	3.32
16	Verbenone	1228	-	1.02	1.02
17	OR	1229	-	0.15	0.15
18	OR	1253	-	0.11	-
19	Bornyl acetate	1287	0.01	0.30	0.31
20	*α*-Copaene	1378	-	0.04	0.04
21	Tetradecene	1386	-	0.12	-

IR: retention index (min); NI: not identified.

Middle Atlas) obtained by different methods revealed during chemical analyzes carried out by gas chromatography (GC), 11 components representing more than 99.64% of the essential oil and indicate that the chemotype is 1,8 cineole and varies according to the method of obtaining DI (Industrial distillation): 48.83%, DA (Artisanal distillation): 41.28% and DC (Hydrodistillation by laboratory Clevenger): 51.77%).

4.6. Chemical Composition of Parsley (*Petroselinum crispum*)

Parsley is a biennial plant 25 to 80 cm high, with a characteristic odor and very aromatic when crumpled. Its stems are striated and its leaves are hairless. The shiny green leaves are usually doubly divided, especially those at the base, with the upper leaves often having only three narrow, elongated lobes. The flowers, a greenish yellow tending to white color in full bloom, are grouped in compound umbels comprising −8 to 20 rays. The umbellules have an involucel with many bracts [74]. We find some leafy stems of parsley in **Figure 8**.

Parsley (*Petroselinum crispum*) belongs to the *Apiaceae* family. Parsley is one of the most produced plants in the world [75]. Parsley is cultivated and consumed for its leaves and roots and has three common varieties: *Petroselinum crispum ssp*. tuberosum (large rooted or tuberous); *Petroselinum crispum ssp*. crispum (curly leaf); *Petroselinum crispum ssp*. neapolitanum (flat-leaved) [76]. The characteristic odor of parsley is due to the presence of monoterpene hydrocarbons, mainly *β*-phellandrene, p-mentha-1,3,8-triene, 4-isopropenyl-1-methyl benzene and terpinolene. The characteristic odor of parsley is due to the presence of monoterpene hydrocarbons, mainly *β*-phellandrene, p-mentha-1,3,8-triene.

Parsley Contains significant amounts of vitamins, especially vitamin C, minerals, essential oils, chlorophyll, polyphenols, carotenoids and other bioactive compounds, it has high antioxidant activity [76] [77].

Among the polyphenols, flavonoids are particularly present, including apigenin, apiin, 6'-acetylapiine and catechins [77] [78]. Another study demonstrated the presence of apigenin-glucuronide, lucenin-2 and lithospermic acid, as well as

Figure 8. Leafy stem of parsley (*Petroselinum crispum*).

p-coumaric acid derivatives [79]. This plant is one of the main sources of apigenin, a flavone with chemo-preventive properties. Parsley also has high levels of quercetin, a flavonoid involved in reducing the risk of neurodegenerative disorders, cancers, cardiovascular diseases, allergic disorders, thrombosis, atherosclerosis, hypertension and arrhythmia, thanks to its pronounced antioxidant and anti-inflammatory properties [80].

5. Biological Properties and Beneficial Effects of Some Spices (Ginger, Turmeric, Clove) and Some Aromatic Herbs (Laurel, Parsley, Roumarin)

- ***Zingiber officinalis*** **(ginger)**

Ginger is one of the most frequently used spices around the world, especially in Southeast Asian countries. It is also a medicinal plant that has been used extensively in Chinese, Ayurvedic and Greek medicine [81].

Ginger extracts have demonstrated antimicrobial activity against a wide range of pathogenic microorganisms; these include both Gram-positive and Gram-negative bacteria including *Staphylococcus aureus*, *Streptococcus pyogenes* and *Haemophilus influenzae* and the yeast *Candida albicans* [82] [83] [84] [85].

The chemo-preventive effects of ginger against cancer have been observed in studies of cancer of the skin, gastrointestinal tract, colon and breast. These effects involve a mechanism that contributes to free radical scavenging, antioxidant pathways, alteration of gene expression, and induction of apoptosis, thereby resulting in decreased initiation, promotion and progression tumor [86] [87].

Since ancient times, the ginger rhizome has been used in the Greek, Roman, Asian, Indian, Sri Lankan, Tibetan, Mediterranean, and Arab alternative medicine systems. In these systems of medicine, ginger is used to treat colds, headaches, nausea, stomach upset, arthritis which are also symptoms of Covid-19, the

pandemic of our time.

It has been recommended for use as a carminative, diaphoretic, antispasmodic, expectorant, circulatory stimulant, appetite stimulant, anti-inflammatory and diuretic.

According to the some research results obtained by, the interest brought to the characterization of the chemical compounds of *Zingiber officinale* and their effects has provided scientific proof for a use hitherto rather confidential in the West, although part of the daily life of Eastern civilizations since the dawn of time [49]. Indeed, the results showed that the phenolic compounds of oleoresin, gingerols and shogaols in the lead, have a pharmacological action in many fields. The sesquiterpene compounds of the essential oil are also a source of interest. If the anti-nausea and digestive effects are now recognized and are the subject of indications of several food supplements, other actions, in particular anti-diabetic and lipid-lowering, are still unknown but deserve to be further explored.

- ***Turmeric longa*** **(Turmeric)**

Turmeric is recognized in traditional Indian and Chinese medicines and in the West for its antioxidant properties. It helps the body to fight against stress and to maintain the effectiveness of the natural defenses. It has also been used for a very long time as an anti-inflammatory by Indian Ayurvedic medicine.

The biological activities were tested from various extracts of *Curcuma domestica*, namely the ethanolic extract, the aqueous extract, the essential oil or from curcumin. The major part of these listed activities is attributed to curcumin, and this in particular for the anti-inflammatory, antioxidant and anti-cancer properties [88]. Curcumin is a powerful antioxidant that is more active than vitamin E [89]. Antioxidants are compounds that protect the body from damage caused by free radicals: free radicals are very reactive molecules that are believed to be involved in the development of cardiovascular diseases [90]. They are also believed to be involved in certain cancer and other diseases due to aging [91]. In a study, turmeric ranks fifth in terms of its antioxidant content among more than a thousand elements analyzed. The anti-inflammatory action of *Curcuma domestica* has been known for a long time [92].

At the time, traditional medicine recommended a paste made from ground turmeric rhizome, applied externally, to treat sprains [93]. Different authors attribute to curcumin a chemoprophylactic activity. Indeed, in many experimental models, it turns out to inhibit the chemical carcinogenesis induced in the different tissues. Thus, some work has demonstrated that curcumin is able to inhibit skin tumor initiation induced by benzo-apyrene and dimethylbenzoanthrecene (DMBA) in mice [94]. Similarly, the administration in rats of a diet supplemented with curcumin (0.4%), per os, decreases the incidence of colon tumor induced by an injection of azoxymethane [95]. Recently, other authors studied the effects of the rhizomes of *Curcuma domestica* and curcumin on rats rendered diabetic by intraperitoneal injection of alloxan. The results are convincing. *C. domestica* seems to have good prospects, and while waiting for other therapeutic innovations, the abundant use of turmeric in the daily food consumption is a good way

to benefit from its virtues [96].

- ***Syzygium aromaticum*** **(Clove)**

Clove is a powerful antiseptic. In the past, it was customary to prick an orange with cloves in order to limit the contagion of infections. Moreover, the destruction of clove plantations by the Dutch in the 17th century gave rise to new devastating epidemics, which were hitherto unknown on these islands [98].

Clove essential oil has many properties, the main ones of which are:

- anti-infectious: powerful broad-spectrum antibacterial (gram negative and gram positive bacteria), antiviral, antifungal;
- odontalgia;
- general stimulant;
- uterine tonic in preparation for childbirth;
- eupeptic and antispasmodic [97].

The clove has effective antifungal properties on various mycoses (cutaneous, oral, ungual). *S. aromaticum* is an inhibitor of the proliferation of *Candida albicans* (MIC = 0.156 mg/ml) as demonstrated in several study [98].

Cloves have many beneficial properties for the body. Moreover, a study has shown the action of *S. aromaticum* during erectile dysfunction. The mode of action resides at the level of Rho-kinase 2 (ROCK II). The Rho A/Rho-kinase enzyme system regulates the contraction or relaxation of smooth muscle in the cavernous body. This system is altered with aging, Rho-kinase 2 then remains activated and contracts the cavernous body, preventing erection [99]. The plants in this study, including *S. aromaticum*, can inhibit this enzyme and cause smooth muscle relaxation, and therefore erection.

By studying separately the plants composing the mixture of the 5 Chinese spices, certain researchers found that cloves had a strong antioxidant power. It could therefore be used to prevent and/or reduce chronic diseases such as cardiovascular diseases, namely cancers and diabetes. Recent research on clove has shown the strong antioxidant power of this plant, and the many benefits it provides to the body [100].

- ***Laurus nobilis*** **(Laurel)**

The essential oil of Laurel noble, very harmonious biochemically, is obtained by distillation of its leaves with water vapor. It has multiple properties that make it an essential EO in aromatherapy: antispasmodic, analgesic, anti-infectious, mucolytic, nervous system regulator [101].

The EO of Laurel noble has a notable anti-infectious activity. This can be considered moderate compared to other HE, but nevertheless interesting in therapy. Moreover, numerous studies confirm its broad spectrum antimicrobial activity in vitro, by virtue of its high concentration of 1,8-cineole associated in particular with eugenol or its methyl. A Tunisian study tested noble laurel EO on *Escherichia coli* and *Lactobacillus plantarum* and another showed efficacy on *S. typhymurium*, *S. aureus* and *E. coli* [102] [103]. Noble Laurel EO is used as an anti-epileptic in traditional Iranian medicine and has been the subject of studies in this context [104]. The plant has a notable psychic activity, in line with the sym-

bol of victory with which it is associated. Noble Laurel EO has significant repellent activity on Culex pipiens: up to 83% repellency at 315 seconds of exposure for a dose of 10 Ml [105] [106]. Noble Laurel EO has shown an antiproliferative action on cells found in chronic myelogenous leukemia (CML).

In addition, it makes it possible to obtain a synergy of antitumor action when it is combined with chemotherapies based on cytarabine [107]. A significant impact is observed on a breast tumor cell line [108]. Noble Laurel EO is very versatile and can be used locally on the skin, including in young children, but always after a skin test has been performed [109] [110].

- ***Rosmarinus officinalis*** **(Rosemary)**

The antimicrobial power of two EO samples from *Rosmarinus officinalis* from Sardinia (with very different contents of *α*-pinene, verbenone and cineole) showed low activity against the following strains: *Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus* and *Staphylococcus epidermidis* with MIC values between 2.5 and 4 mg/ml [111]. Similarly, a low activity of the EO of *R. officinalis* with respect to the same strains (MIC greater than 900 µg/ml) as well as with respect to *Candida albicans* was mentioned [112]. The antifungal activity was tested against *Botrytis cinerea*, *Fusarium oxysporum, F. culmorum* and *Rhisoctonia solani*. An antimicrobial action of EO was observed against *F. graminearum* [113].

R. officinalis EO exerts hepato-protective effects (at doses of 5 mg/kg and 10 mg/kg) by decreasing the activities of ASAT and ALAT up to 2-fold in the serum of rats with hepatic lesions induced. It prevents the increase in lipid peroxidation induced in liver homogenates. Rosemary EO, in addition to exhibiting free radical scavenging activity, also mediates its hepato-protective effects through the activation of physiological defense mechanisms [114]. A review showed that natural antioxidants including Rosemary have in some cases an antioxidant activity equivalent to or greater than that of synthetic antioxidants [72]. Extract of *R. officinalis* could prolong the latency period of tumor appearance, decrease tumor incidence, tumor burden and tumor yield. Thus, at a dose of 500 mg/kg of body weight/mouse, oral administration of rosemary extract significantly protects against tumorigenesis of stage 2 skin through to its toning effect on the skin. With its stimulating action on biliary function, Rosemary is highly valued in stomach laziness, inflammation of the gallbladder and congestion of the liver accompanied by painful crises [115]. Rosemary leaves in infusion have an antispasmodic action. They also have a diuretic effect by increasing the volume of urine and facilitating the evacuation of toxins by the kidneys [116].

Rosmarinic acid is an anti-inflammatory *in vitro* and has a marked antioxidant activity, also by diterpenes and flavones [117]. His bud has a Hepatoprotective action that is to say, the young rosemary shoots are more active in liver protection than adult plant preparations. The Rosemary plant has demonstrated pharmacological actions: relaxation of bronchial and intestinal smooth muscles, anti-inflammatory effect by reduction of leukotrienes and increased production of PGE2, inhibition of complement and lipid peroxidation, prevention of carci-

nogenicity linked to formation of DNA adducts [118].

- ***Petroselinum crispum*** **(Parsley)**

Parsley has been a plant known for many years, whether for its medicinal properties or for its condition as a spice used in the preparation of many very varied dishes. Through to all the nutrients it contains, parsley would be diuretic (it would at the same time eliminate toxins such as uric acid), antianemic (due to its amount of iron), anti-inflammatory (in case of insect bite) and deodorant (chewing fresh leaves would give better breath) [119] [120]. It would also reduce gastric oxidative stress [121]. Parsley is said to have pro-apoptotic effects (which stimulates programmed cell death) on certain melanomas and would inhibit the proliferation and migration of cancer cells in breast cancer [122]. Parsley contains a flavonoid, apigenin, known for its antioxidant and anticancer properties in vitro. The effects of apigenin in parsley have not been directly evaluated. On the other hand, in an intervention study in which people received 20 g of fresh parsley daily for a week, it was shown that the apigenin contained in parsley was absorbed by the body in a variable manner from one individual to another (the effects of apigenin in parsley have not been directly evaluated [123]. Cancer cells are abnormally immortal, they resist their programmed death (apoptosis). A study shows that the apigenin in parsley allows cancer cells to become lethal again [124]. In addition to its antioxidant power, apigenin in parsley may help regulate blood sugar levels [125]. Indeed, researchers administered parsley extracts to diabetic rats for several days and noticed a decrease in blood sugar levels in the latter.

A study showed that apigenin would have beneficial effects on the brain [126]. It would act directly on neurons by promoting their formation as well as by strengthening the connection between them. Besides apigenin, the main antioxidant compounds in parsley are said to be lutein and beta-carotene. Fresh parsley contains a significant amount of these two compounds which are part of the carotenoid family, known in particular for their benefits on eye health [78].

6. Forms of Use of Spices and Aromatic Herbs

Different areas call for the use of spices. The latter being used sparingly, they do not contribute, from a nutritional point of view, to the diet, but they often contain active ingredients which make it possible to protect foodstuffs against microbial and oxidative degradation. As they add variety and flavor to staples and sauces, which stimulates the appetite and allows for more eating. They are part of the natural resources from which the population draws directly to improve their income and continue to constitute the bulk of the therapeutic arsenal used by traditional healers. Aromatic plants are a great source of antioxidants and natural antibacterials for the food industry [6]. As for spices, these are aromatic substances of plant origin used to season dishes [7].

In the countries where bay leaves originate, it is common to make infusions with one to two teaspoons of dried bay leaves or flowers at mealtime to stimulate

digestion after a heavy meal. This makes it possible to increase the secretion of gastric juices necessary for a good assimilation of food. Laurel infusions are also useful for their expectorant, antispasmodic, emmenagogue action or against hot flashes. The bay of laurel also has stimulating properties on the digestion [127]. In external use, a concentrated decoction of bay leaves can be used as a gargle to treat canker sores as well as inflammation of the gums or sore throat. The bay of laurel, for its part, is known on the one hand to relieve rheumatic pain and on the other hand to treat skin inflammations such as acne, eczema or abscesses [128].

Clove is a powerful antiseptic. In the past, it was customary to prick an orange with cloves in order to limit the contagion of infections. Moreover, the destruction of the clove plantations by the Dutch in the 17th century gave rise to new devastating epidemics, which were hitherto unknown on these islands [96].

The rhizome of *Curcuma domestica* is widely used in traditional medicines from the countries of origin both internally and externally. In India, this plant is used for many medical applications. It is used as a stomachic, tonic, blood purifier and antiseptic, for itching dermatoses (psoriasis, pemphigus) and purulent ophthalmia. The natives cover the eyes affected by this affection with compresses soaked in a decoction of *Curcuma domestica* [93]. Traditional Chinese and Ayurvedic medicine uses it in painful abdominal manifestations with or without biliary or hepatic disorders. It is also an ancestral remedy against gastric acidity [129].

In Benin, The aromatic plants and spices are used in many traditional culinary recipes not only to enhance the taste of foods but also for their nutritional and medicinal qualities of which populations have empirical knowledge. In the Collines department of Benin, the plant organs used are leaves, seeds, bulbs, tubers, fruits and flowers, and the root cortex. The use of different plant organs varies from one ethnic group to another, but the use of leaves is dominant in all ethnic groups [13].

7. Aspects Still Poorly Studied in Spices and Aromatic Herbs

Through our literature search, we noticed that there has been extensive research on the benefits and uses of spices and aromatic herbs. Nevertheless, there are still several areas that are relatively under-studied. Some of these include:

- **Synergistic effects:** Most studies have focused on the individual compounds found in spices and herbs, but there is a need for more research on how these compounds interact with each other to produce synergistic effects;
- **Mechanisms of action:** While the health benefits of spices and herbs are well-documented, the mechanisms by which they exert these effects are not fully understood;
- **Dosage and safety:** There is a lack of standardized dosages for the use of spices and herbs as medicine, and more research is needed to determine their safety and potential side effects;

- **Interactions with medication:** There is limited research on how spices and herbs may interact with prescription medications, and more studies are needed to determine any potential risks;
- **Quality control:** The quality of spices and herbs can vary widely, and there is a need for better quality control measures to ensure that products are safe and effective.

8. Conclusion

Taken together, this review further established that spices and aromatic plants are classified as medicinal plants and are widely used for human consumption, thus contributing to food security. The different chemical compounds contained in the spices and aromatic herbs highlighted in this review have many beneficial potentials to prevent and diseases with a nutritional effect. They contain chemical groups which can alone or in a possible synergy of action give it therapeutic properties, antiseptics, antioxidants and organoleptics. Considering the diversity of spices and aromatic herbs, it seems clear that many aspects have been poorly studied. Thus, despite the abundant bibliography on spices and aromatic herbs, many attributes still remain poorly studied, which would in future offer more interesting prospects for research.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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