Throughout the ages, humans have relied on plants as a source of food, flavours, fragrances, and medicines. Even today a large number of people use traditional medicinal plants containing mixtures of various compounds acting individually, additively or in synergy to improve health.

In the developed world food consumption not only just satisfies hunger but also it is associated with a requirement for happiness and well-being. Eating is a social and cultural act, and consequent health benefits have an important role in food consumption (Carrillo et al. 2013). The term "functional food" was first introduced in Japan in the mid-1980s and refers to processed foods containing ingredients that aid specific biological functions in addition to being nutritive (Arai 1996). Functional foods may improve health in general, reduce the impact of illness, and delay the onset of disease (Luthria 2006). Therefore functional foods blur the distinction between a food and a medicine and serve as a connection between them. In contribution to that, the advice of Hippocrates (an ancient Greek physician, and he is considered one of the most outstanding personalities in the history of medicine; c. 460–c. 370 BC) can be used: 'Let food be thy medicine and medicine be thy food'.

### Functional foods

**Concept of functional foods.** Increasing interest in improving or maintaining health by intake of all-natural products in combination with lifestyle changes has created a desire for a more streamlined approach to nutrition. Growing consumer health awareness and available information about the usefulness of different diets and their impact on human health lead to the demand for functional food and beverages. The concept of functional foods includes foods or food ingredients that exert a beneficial effect on host health and/or reduce the risk of chronic disease beyond basic nutritional functions (Das et al. 2012). According to International Food Information Council Foundation (2011) there are several groups of
functional components: carotenoids, phenolic acids, flavonoids, plant stanols/sterols, dietary fibres, fatty acids, isothiocyanates, minerals, polyols, prebiotics, probiotics, phytoestrogens, soy proteins, sulphides/thiols, and vitamins.

Functional foods can include foods used to improve the nutritional quality of an otherwise nutrient-deficient food (e.g. calcium in orange juice) or to resolve public health issues (e.g. iodised table salt). It can take many forms; some may be conventional food that is consumed as a part of a usual diet and has physiological benefits or can reduce the risk of chronic disease beyond basic nutritional functions. Some may be fortified or enhanced foods as well as products isolated or purified from foods that are generally sold in application forms. They are not usually associated with foods having a physiological benefit and are called nutraceuticals (Monge et al. 2008), such as multivitamin pills. Therefore, consumers can already select from a wide spectrum of foods that contain functional components.

**Traditional functional foods.** Positive effects of various plant species on well-being and human health were acknowledged centuries ago and their use in healing various diseases is as old as the practice of medicine. The basic knowledge of foods and their nutritional values was gained and developed in ancient times in the process of looking for adequate foods. The concept of food as medicine was accepted worldwide, especially in China, Japan, and other Asian countries where it was understood that foods have both preventive and curative effects and are an important part of health. Numerous functional foods and corresponding recipes for combining specific foods with culinary and non-culinary herbs to produce healing remedies have been documented in the publications of Chinese traditional medicine. Garlic (*Allium sativum* L.) is one of the earliest documented examples of plants used for disease treatment and maintenance of health (Rivlin 2001). It has been used for a wide variety of medicinal purposes and represented a staple crop in the diets of numerous cultures. The Egyptians, Babylonians, Greeks, and Romans used it for many conditions, including blood pressure disorders, snakebites, and infections (Koch et al. 1996). Antimicrobial activity was discovered in 1858 by Pasteur and it was used as an antibiotic to prevent gangrene during World War I and II (Murray 1995). Peppermint (*Mentha piperita* L.) tea has a long history of use for digestive complaints and cranberries (*Vaccinium macrocarpon* L.) have long been known to maintain a healthy urinary tract, as their juice contains proanthocyanidins that inhibit the growth of *Escherichia coli* (Galland 2009). The health benefits of ginger (*Zingiber officinale* Roscoe) were documented 2000 years ago. It has been used in Chinese, Ayurvedic, and Unani-tibb herbal medicines all over the world, for a wide range of conditions including arthritis, rheumatism, sprains, sore throats, infections, digestion disorders, etc. (Ali et al. 2008). Curcumin from turmeric (*Curcuma longa* L.) has been used as spice as well as medicine in ancient traditional medicinal systems to treat gas, colic, toothaches, chest pains, stomach, and liver problems, to heal wounds and scars (Aggarwal 2007). Chinese herbal tonics prepared with ginger root, cinnamon bark (*Cinnamomum spp.*), and liquorice root (*Glycyrrhiza glabra* L.) have been widely used as a remedy for stomach ailments (Galland 2009).

During the second half of the twentieth century, new nutritional insights emerged and allowed the development of foods and beverages with a claimed health benefit, based on scientific evidence (Weststrate et al. 2002). So far, the functional food industry has focused mainly on ingredients that are inherent in vegetables, grains, and fruit. Examples for widespread foods that provide health benefits beyond basic nutrition are tomatoes (lycopene), green tea (catechins), cranberry juice (proanthocyanidins), and psyllium seeds (soluble fibre). Soybean grain is well-known for its functional components such as proteins, isoflavones, oligosaccharides, and phospholipids with beneficial effects on cardiovascular diseases, cancer, and diabetes (Dixit et al. 2011). Glucosinolates in broccoli (*Fabeck* et al. 2012), amino acids in red head chicory (*Herak Ćustić* et al. 2009), phosphorus (*Petek* et al. 2008), and proteins (*Petek* et al. 2012) in beetroot can also improve human health. Phytosterols found naturally in vegetable oils, beans, and nuts have proven cholesterol lowering properties. Pomegranate juice contains antioxidants at much higher levels than other fruit juices and its consumption provides several heart-protecting benefits. Carrots, pumpkins, sweet potatoes, cantaloupe, spinach, and tomatoes are rich in beta-carotene that neutralises free radicals, stimulates cellular antioxidants, and is a precursor in vitamin A synthesis. Phenolic acids (especially caffeic and ferulic acid), determined in apples, pears, citrus fruits, whole grains, and coffee, are able to bolster cellular antioxidant defences as well as support the maintenance of eye and heart health. Plant stanols/sterols, as those from maize,
soybean, and wheat, may reduce risks of the coronary heart disease (CHD) (International Food Information Council Foundation 2011).

Rediscovery of the connection between plants and health is responsible for launching a new generation of botanical therapeutics that include plant-derived pharmaceuticals, multicomponent botanical drugs, dietary supplements, functional foods, and plant-produced recombinant proteins (Raskin et al. 2002). There is an increasing number of studies that highlight the applicability of medicinal plants and herbs as sources of more potent or even innovative ingredients. They are an object of interest because many of them have been demonstrated that they possess antioxidant, antimicrobial, and cancer-protecting properties.

**Medicinal plants of the family Lamiaceae**

Plants have been the source for medicinal treatments for thousands of years. Traditional medicine uses plants for both their curative and their preventive properties. When used for preventive purposes, i.e. for the maintenance of overall good health, medicinal plants can be classified as functional foods and/or nutraceuticals. A good example is the use of spices that besides adding the flavour to foods can improve digestion or help in prevention of diseases.

The mint family (Lamiaceae) is an important medicinal plant family. It contains about 236 genera and more than 6000 species, and the largest genera are Salvia, Scutellaria, Stachys, Plectranthus, Hypitis, Teucrium, Vitex, Thymus, and Nepeta. It is a family of great diversity and variety with a cosmopolitan distribution. Species from the family inhabit different natural ecosystems and many members of the family are cultivated. The species of this family are easily recognisable by square stems and opposite leaves. The flowers are zygomorphic with five united petals and five united sepals, usually bisexual and verticillaster. Most of the species belonging to the family are aromatic and possess essential oils (Lawrence 1992). The aromatic essential oils are mostly present in leaves, however, they can be found in all aboveground parts of the plants. They are valuable in cosmetic, flavouring, fragrance, perfumery, pesticide, and pharmaceutical industries (Ozkan 2008). Some of the Lamiaceae species are used as culinary herbs and grown for edible leaves, e.g. basil (*Ocimum* spp.), mint (*Mentha × piperita* L.), rosemary (*Rosmarinus officinalis* L.), sage (*Salvia officinalis* L.), savory (*Satureja hortensis* L.), marjoram (*Origanum majorana* L.), oregano (*Origanum vulgare* L.), thyme (*Thymus vulgaris* L.), lavender (*Lavandula angustifolia* Mill.) and perilla (*Perilla frutescens* (L.) Britton) (Licina et al. 2013). The members of the family Lamiaceae also include plants that are widely used in traditional medicine as a cure for various disorders.

**Secondary metabolites.** The metabolic performance of living organisms can be distinguished into primary and secondary metabolism. Secondary metabolites represent features that can be expressed in terms of ecological, taxonomic, and biochemical differentiation and diversity. The presence of these compounds in the biochemistry of the plant is often difficult to explain as they are synthesised by the plants mainly as a part of their defence system against diseases and herbivores (Mazid et al. 2011). They can be found in roots, rhizomes, tubers, leaves, aerial parts, fruits, seeds, and stems. Different classes of secondary metabolites constitute the bioactive compounds in various plants which can be used as functional foods. They have attracted particular interest as many of them have demonstrated to be antiallergenics, antiabetics, antioxidants, antimutagens, anticarcinogens, antimicrobial, and anti-inflammatory agents, enhancers of the gastrointestinal function, immune-modulators and stimulators as well as blood pressure and cholesterol reducing agents (Vaishali Rai et al. 2013). The therapeutic application of medicinal plants is attributed to the presence of a wide range of secondary metabolites or phytochemicals such as alkaloids, saponins, flavonoids, glycosides, and phenols which all have various pharmacological activities classifying them as functional foods.

Phenols belong to the largest group of secondary metabolites in plants, foremost of the family Lamiaceae, and they exhibit multidirectional biological activity. Phenolic classes of pharmaceutical interests are: simple phenolic compounds (e.g. eugenol), tannins, quinones, flavonoids, lignans, and some terpenoids. Flavonoids are attracting interest due to the discovery of their anti-inflammatory, analgesic, anti-tumour, antimicrobial, antioxidant, and immunostimulant activities. Monoterpenes are the metabolites usually found in essential oils with anti-inflammatory properties. Saponins show various pharmacological activities e.g. anti-inflammatory, antitussive, expectorant, analgesic, and cytotoxic. Cardiotonic glycosides are used as drugs for the treatment of cardiac insufficiency (Vaishali Rai et al. 2013). Besides being natural
colouring agents for food substances and cosmetics, carotenoids are also used for the treatment of retinal disease and glaucoma.

Many authors have reported antioxidant, antimicrobial, and anti-inflammatory properties of Lamiaceae species. It is well known that each species has a special, complex mixture of bioactive compounds in which each component contributes to its overall bioactivity. Moreover, in cases of some species a direct food-related application has been established.

**Lamiaceae as antioxidants.** In hope to find natural antioxidants for the food industry and consequently efficient therapy for numerous present-day human problems the screening studies for antioxidant properties of plants have been very common in the last few decades. Plant antioxidants are very significant as their presence in the human diet can help the body to neutralise free radicals and reduce the oxidative stress damage. On the contrary, synthetic antioxidants have possible activity as promoters of carcinogenesis (SUHAJ 2006). The antioxidant activity of phenolic compounds depends on the structure and the nature of substitutions on the aromatic rings (BALASUNDRAM et al. 2005) while their health benefits depend on their absorption and metabolism (PARR & BOLWELL 2000). Edible antioxidants commonly found in plants are ascorbic acid, tocopherols, carotenoids, and several phenolic compounds (ARASH et al. 2006) such as phenolic acids, flavonoids, and tannins (KING and YOUNG 1999). Phenolic acids, for example caffeic, ferulic, and vanillic acids have been known as natural antioxidants widely distributed in the plant kingdom. Besides, naturally occurring polyphenols whose oxidation inhibiting activities have been known for a long time are tannins. Additionally, some studies have revealed that low amounts of tannins (0.15–0.2%) in the diet can be beneficial to human health and will create a more astringent feel to the taste, while at higher concentration, they inhibit the digestive enzymes and reduce the bioavailability of iron and vitamin B12 (KING-THOM et al. 1998). Most of the Lamiaceae sources of antioxidants belong to the subfamily Nepetoideae, including basil, lemon balm, marjoram, mint, oregano, rosemary, sage, etc. They contain rosmarinic acid and are frequently abundant in fragrant volatile terpenes (WINK 2003). Moreover, the extracts of rosemary were the first marketed natural antioxidants. In the study of KAFFER and MILNER (2008) thyme, sage, rosemary, and marjoram showed the greatest antioxidant capacity among the investigated herbs. ALBAYRAK et al. (2013) have shown that besides thyme, rosemary, and sage, peppermint, lemon balm, and basil also contain a considerable amount of phenolic compounds with strong total antioxidant and DPPH radical scavenging activities. The aforementioned species are among the most frequently investigated species of the family Lamiaceae and their antioxidant activity has been demonstrated in numerous studies (GONÇALVES et al. 2009; AHMAD et al. 2012; SODRÉ et al. 2012; TRAKOONTIVAKORN et al. 2012; LAGOURI et al. 2013; LICINA et al. 2013).

**Lamiaceae as antimicrobial agents.** Due to the overall usage of commercial antimicrobial drugs, multidrug resistance in both human and plant pathogenic microorganisms has developed (ELDEEN et al. 2005). Therefore, scientists are trying to find new antimicrobial sources from plants which can be used in food industry, pharmacy, and medicine.

It is well documented that the majority of the investigated species belonging to the family Lamiaceae, e.g. lemon balm (SARAC & UGUR 2007), mint (TORGLOU 2009), basil (CAROVIC-STANKO et al. 2010; RAO et al. 2011), oregano (DORMAN & DEANS 2004), and rosemary (TORGLOU 2009), possess antimicrobial properties. Thymol and carvacrol are the main components responsible for these actions (properties) as they interfere with cellular metabolism after penetrating into the cell (MARINO et al. 2001). Plants have such important biological and pharmacological activities also due to the triterpenic acids that also exhibit anti-inflammatory, antiviral, cytotoxic, and cardiovascular effects (E SILVA et al. 2012). For example *Eriope blanchetii* produces considerable amounts of betulinic acid, as well asoleanolic and ursolic acids which are triterpenoid compounds that widely occur in nature in free acid form or as an aglycone precursor for triterpenoid saponins (JESUS et al. 2015). One of the most famous Lamiaceae species rich in ursolic acid is rosemary which was the subject of numerous studies. The SHARMA and BHADANGE (2013) study showed that basil (*Ocimum gratissimum* L. and *Ocimum kilimandscharicum* Baker ex Gürke) and *Pogostemon benghalensis* Kuntze possess antimicrobial activity against bacterial (*E. coli*, *S. aureus*, *S. typhimurium*) and fungal (*C. albicans* and *A. niger*) strains. Lemon balm, mint, basil, Brazilian boldo (*Plectranthus barbatus* Andrews), and rosemary were the subject of the ARAÚJO et al. (2014) study and they have shown antibacterial activity to Gram-positive and Gram-negative bacterial strains (*E. faecalis*, *S. aureus*, *S. mutans*, *E. coli*, *K. pneumoniae*, and *P. aeruginosa*).
Table 1. List of most used Lamiaceae species which can be used as a functional food

<table>
<thead>
<tr>
<th>No.</th>
<th>Species</th>
<th>Medicinal properties due to biological activity</th>
<th>Edible part</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Achos arvensis</em> (Lam.) Dandy</td>
<td>antimicrobial (JOVANOVIC et al. 2005)</td>
<td>leaves</td>
</tr>
<tr>
<td>2</td>
<td><em>Ajuga reptans</em> L.</td>
<td>antibacterial and antitumour (YILDIRIM et al. 2013)</td>
<td>leaves and young shoots</td>
</tr>
<tr>
<td>3</td>
<td><em>Agastache mexicana</em> (Kunth.) Link. &amp; Epling</td>
<td>anti-nociceptive and anti-inflammatory (GONZALEZ-RAMIREZ et al. 2012); vasoactive and antioxidant (IBARRA-ALVARADO et al. 2010)</td>
<td>leaves and flowers</td>
</tr>
<tr>
<td>4</td>
<td><em>Betonica officinalis</em> (L.) Trevis. syn. <em>Stachys officinalis</em> L.</td>
<td>antioxidant (SLIUMPAITE et al. 2013); anti-inflammatory effect of Stachys species (HÁZNAGY-RADNAI et al. 2012); antimicrobial, antioxidant, and antifungal (HÁZNAGY-RADNAI et al. 2012)</td>
<td>leaves and flowering tops</td>
</tr>
<tr>
<td>5</td>
<td><em>Calamintha officinalis</em> Moench.</td>
<td>antidiabetic and antioxidant (SINGH et al. 2012)</td>
<td>leaves</td>
</tr>
<tr>
<td>6</td>
<td><em>Clinopodium vulgare</em> L.</td>
<td>antibacterial (STEFANOVIC et al. 2011); antitumour (DZHAMBRAZOV et al. 2002)</td>
<td>leaves</td>
</tr>
<tr>
<td>7</td>
<td><em>Coleus forskohlii</em> Briq. syn. <em>Plectranthus barbatus</em> Andrews</td>
<td>activator of adenyl cyclase (weight-loss) (MOHAMED 2013); antioxidant (KHATUN et al. 2011); antibacterial (ARAÚJO et al. 2014)</td>
<td>leaves, tubers</td>
</tr>
<tr>
<td>8</td>
<td><em>Dracocephalum heterophyllum</em> Benth.</td>
<td>antimicrobial and antioxidant (ZHANG et al. 2008)</td>
<td>roots</td>
</tr>
<tr>
<td>9</td>
<td><em>Elsholtzia splendens</em></td>
<td>carcinative, stomachic, and stimulant (ARJIT &amp; ARPITA 2013); antimicrobial, toxicity (XU et al. 2013)</td>
<td>flowers and leaves</td>
</tr>
<tr>
<td>10</td>
<td><em>Hyptis suaveolens</em> (L.) Poit.</td>
<td>antioxidant and anthemolytic (ALINEZHAD et al. 2013); antimicrobial (ROTA et al. 2004)</td>
<td>whole plant</td>
</tr>
<tr>
<td>11</td>
<td><em>Hyssopus officinalis</em> L.</td>
<td>antioxidant (LEE et al. 2013); anti-bacterial, anti-inflammatory, antioxidant (GUO et al. 2012)</td>
<td>flowers and leaves</td>
</tr>
<tr>
<td>12</td>
<td><em>Isodon japonicas</em> (Burm.) Hara.</td>
<td>anti-bacterial and anti-cancer, for gastrointestinal disorders (SUN et al. 2006)</td>
<td>leaves</td>
</tr>
<tr>
<td>13</td>
<td><em>Lamium album</em> L.</td>
<td>antimicrobial (CHIPEVA et al. 2013); antioxidant (PEREIRA et al. 2012); free radical scavenging (YALCİN et al. 2007)</td>
<td>young shoots, leaves, and flowers</td>
</tr>
<tr>
<td>14</td>
<td><em>Lamium purpureum</em> L.</td>
<td>antimicrobial and free radical scavenging (YALCİN et al. 2007)</td>
<td>leaves</td>
</tr>
<tr>
<td>15</td>
<td><em>Lavandula angustifolia</em> Mill.</td>
<td>anti-inflammatory and analgesic (HAJHASHEMI et al. 2003); antimicrobial (ROTA et al. 2004); antioxidant (BLAZEKOVIC et al. 2010)</td>
<td>leaves, petals, and flowering tips</td>
</tr>
<tr>
<td>16</td>
<td><em>Lecus aspera</em> Willd.</td>
<td>antimicrobial (ANTONY et al. 2013); antiinociceptive, antioxidant, and cytotoxic (RAHMANN et al. 2007); hepatoprotective, antioxidant (BANU et al. 2012)</td>
<td>shoots and leaves</td>
</tr>
<tr>
<td>17</td>
<td><em>Lycopus europaeus</em> L.</td>
<td>antimicrobiral (RADULOVIC et al. 2010)</td>
<td>roots</td>
</tr>
<tr>
<td>18</td>
<td><em>Marrubium vulgare</em> L.</td>
<td>antibacterial, antifungal, and cytotoxic (ZARAI et al. 2011); anti-diabetic (BOUDJELAL et al. 2011); gastroprotective (PAULA DE OLIVEIRA et al. 2011); vermifuge-respiratory-purgative (JOUDI et al. 2011); anti-inflammatory (EL ABBOUYI et al. 2013)</td>
<td>leaves</td>
</tr>
<tr>
<td>19</td>
<td><em>Melissa officinalis</em> L.</td>
<td>digestive, tranquiliser, antimicrobial, antioxidant (SODRÉ et al. 2012); antibacterial (SARAC &amp; UGUR 2007)</td>
<td>aerial part</td>
</tr>
<tr>
<td>20</td>
<td><em>Mentha arvensis</em> L.</td>
<td>analgesic, antiseptic, antispasmodic, carminative, antimicrobial (AKRAM et al. 2011); antioxidant (AHMAD et al. 2012)</td>
<td>leaves</td>
</tr>
<tr>
<td>21</td>
<td><em>Mentha x piperita</em> L.</td>
<td>antimicrobial, sedative, analgesic, carminative (SALLER 2004); antioxidant (AHMAD et al. 2012; GONÇALVES et al. 2009); antimicrobial (TOROGLU 2011)</td>
<td>leaves</td>
</tr>
<tr>
<td>22</td>
<td><em>Micromeria fruticosa</em> (L.) Druce</td>
<td>anti-inflammatory and gastroprotective (ABU-GHARBIIEH et al. 2013); antimicrobial (TOROGLU 2011)</td>
<td>aerial part</td>
</tr>
<tr>
<td>No.</td>
<td>Species</td>
<td>Medicinal properties due to biological activity</td>
<td>Edible part</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>23</td>
<td><em>Monarda fistulosa</em> L.</td>
<td>antioxidant, antitumour, and anti-inflammatory (Zhitkova et al. 2009)</td>
<td>leaves and flowers</td>
</tr>
<tr>
<td>24</td>
<td><em>Nepeta cataria</em> L.</td>
<td>antibacterial (Naghib et al. 2012); antioxidant, antifungal, antioxidant (Formisano et al. 2011)</td>
<td>leaves</td>
</tr>
<tr>
<td>25</td>
<td><em>Ocimum americanum</em> L.</td>
<td>antibacterial (Carović-Stanko et al. 2010); antioxidant (Trakoonthivakorn et al. 2012); antiviral (Yucharoen et al. 2011)</td>
<td>leaves</td>
</tr>
<tr>
<td>26</td>
<td><em>Ocimum basilicum</em> L.</td>
<td>antioxidant (Alzoreky &amp; Nakahara 2003; Carović-Stanko et al. 2010); antioxidant (Trakoonthivakorn et al. 2012); antiviral (Carović-Stanko et al. 2010); antibacterial and antifungal (Rao et al. 2011)</td>
<td>leaves, flowers, and seeds</td>
</tr>
<tr>
<td>27</td>
<td><em>Ocimum tenuiflorum</em> syn. <em>O. sanctum</em> L.</td>
<td>antioxidant (Trakoonthivakorn et al. 2012); antiviral (Yucharoen et al. 2011); antimicrobial and antioxidant (Joshi 2013); antibacterial and antifungal (Rao et al. 2011)</td>
<td>leaves</td>
</tr>
<tr>
<td>28</td>
<td><em>Origanum majorana</em> L.</td>
<td>antioxidant, antibacterial, expectorant, sedative, carminative, and stimulant (Chih-Chien et al. 2011)</td>
<td>leaves</td>
</tr>
<tr>
<td>29</td>
<td><em>Origanum vulgare</em> L.</td>
<td>antioxidant and antimicrobial, against cold, for digestive, and respiratory problems (Licina et al. 2012); antimicrobial antioxidant (Dorman &amp; Deans 2004); antibacterial (Alexopoulos et al. 2011)</td>
<td>leaves</td>
</tr>
<tr>
<td>30</td>
<td><em>Perilla frutescens</em> (L.) Britton</td>
<td>antioxidant, induction of perspiration and dispelchills, regulation of stomach function (HONG et al. 2011); antidepressant (Yi et al. 2013)</td>
<td>leaves, inflorescence</td>
</tr>
<tr>
<td>31</td>
<td><em>Phlomis lychnitis</em> L.</td>
<td>anti-inflammatory (Aligieri et al. 2013); antioxidant (Lopez et al. 2010)</td>
<td>flowered aerial part</td>
</tr>
<tr>
<td>32</td>
<td><em>Phlomis pungens</em> Willd.</td>
<td>antibacterial and antitumour (Yildirim et al. 2013); antibacterial, antifungal, and antiviral (Ozcelik et al. 2010); antioxidant (Keser et al. 2012)</td>
<td>aerial part</td>
</tr>
<tr>
<td>33</td>
<td><em>Prunella vulgaris</em> L.</td>
<td>antibacterial (Sarac and Ugur 2007); antioxidant and antancer (Hwang et al. 2013)</td>
<td>leaves</td>
</tr>
<tr>
<td>34</td>
<td><em>Rosmarinus officinalis</em> L.</td>
<td>anti-inflammatory, anti-inflammatory, antispasmodic, hepatoprotective, anti-diabetic, anti-ulcerogenic, antidepressant, and antioxidant (Yosr et al. 2013); antimicrobial (ROTA et al. 2004; TOROGLU 2011); antioxidant (LAGOURI and ALEXANDRI 2013)</td>
<td>aerial part</td>
</tr>
<tr>
<td>35</td>
<td><em>Salvia fruticosa</em> Mill.</td>
<td>antioxidant and anticholinesterase (Topcu et al. 2013); antimicrobial and antioxidant (Giweli et al. 2013); antioxidant (ERDogan et al. 2011); antimicrobial (ASKUN et al. 2009)</td>
<td>leaves</td>
</tr>
<tr>
<td>36</td>
<td><em>Salvia hispanica</em> L.</td>
<td>antioxidant (Reyes-Caudillo et al. 2008); prevent cardiovascular diseases, inflammatory and nervous system disorders, and diabetes (Munoz et al. 2013)</td>
<td>seeds</td>
</tr>
<tr>
<td>37</td>
<td><em>Salvia officinalis</em> L.</td>
<td>antimicrobial (ROTA et al. 2004); antibacterial, allelopathic, and antioxidant (BOUAJAJ et al. 2013); gastroprotective, anti-diabetic, anti-obesity, anti-inflammatory, antispasmatic, virucidal, fungicidal, and bactericidal (JUG-DUJAKOVIC et al. 2003)</td>
<td>leaves and flowers</td>
</tr>
<tr>
<td>38</td>
<td><em>Salvia sclarea</em> L.</td>
<td>antimicrobial (ROTA et al. 2004); antioxidant and antiviral (OGUTCU et al. 2008)</td>
<td>leaves</td>
</tr>
<tr>
<td>39</td>
<td><em>Salvia tomentosa</em> Mill.</td>
<td>antioxidant (ERDOGAN et al. 2011; DINCER et al. 2013); antimicrobial (ASKUN et al. 2009)</td>
<td>leaves</td>
</tr>
<tr>
<td>40</td>
<td><em>Satureja hortensis</em> L.</td>
<td>antinociceptive and anti-inflammatory (Hajhashemi et al. 2002); antioxidant (DINCER et al. 2013); antioxidant (YESILOGLU et al. 2013)</td>
<td>leaves</td>
</tr>
</tbody>
</table>
Within the aforementioned properties, a common need is the availability of natural extracts with preservative action, aimed to avoid oxidation and spoilage by microorganisms combined with pleasant taste or odour. Moreover, the scientific verification of the biological activity of plants with potential antimicrobial activities is needed, but unfortunately most of the medicinal and aromatic plants have not yet been exploited for their bioactivities.

**Lamiaceae as anti-inflammatory agents.** Even today many people, foremost in rural areas, depend on herbal medicines to treat inflammation-related conditions such as rheumatism, muscle swelling, cut wounds, accidental bone fractures, insect bites, and other common ailments. The Lamiaceae family, known for its aromatic and medicinal properties, plays a significant role in traditional medicine.

---

**Table 1 to be continued**

<table>
<thead>
<tr>
<th>No.</th>
<th>Species</th>
<th>Medicinal properties due to biological activity</th>
<th>Edible part</th>
</tr>
</thead>
<tbody>
<tr>
<td>41</td>
<td>Satureja montana L.</td>
<td>antimicrobial (ROTA et al. 2004); antibacterial (NEDOROSTOVA et al. 2011; SFEIR et al. 2013); cytotoxic, antioxidant, and antimicrobial (MILADI et al. 2013); antioxidant and antimicrobial (CAVAR et al. 2008)</td>
<td>leaves and flowered aerial part</td>
</tr>
<tr>
<td>42</td>
<td>Scutellaria baicalensis</td>
<td>antioxidant and antiinflammatory (SEOK et al. 2016); cardiovascular, kidney, and liver diseases (LAI et al. 2016)</td>
<td>leaves</td>
</tr>
<tr>
<td>43</td>
<td>Scutellaria indica L.</td>
<td>antitumour (MIN et al. 1997); antioxidant (KIM et al. 2009)</td>
<td>leaves</td>
</tr>
<tr>
<td>44</td>
<td>Sideritis scardica Griseb.</td>
<td>expectorant, pulmonary emphysema, urogenital diseases, immunostimulant (IVANOVA et al. 2005); anti-inflammatory, gastroprotective, and cytotoxic (TADIC et al. 2012); antioxidant (KOLEVA et al. 2003)</td>
<td>leaves, flowers</td>
</tr>
<tr>
<td>45</td>
<td>Stachys byzantina C. Koch.</td>
<td>antimicrobial, antioxidant, and antifungal (CONFORTI et al. 2009)</td>
<td>leaves and flowering tops</td>
</tr>
<tr>
<td>46</td>
<td>Stachys chrisantha Boiss. &amp; Heldr.</td>
<td>antimicrobial, antioxidant, and antifungal (CONFORTI et al. 2009)</td>
<td>leaves and flowering tops</td>
</tr>
<tr>
<td>47</td>
<td>Stachys cretica L.</td>
<td>antibacterial (SARAC &amp; UGUR 2007); antimicrobial, antioxidant, antifungal, antiradical, and cytotoxic (CONFORTI et al. 2009)</td>
<td>leaves and flowering tops</td>
</tr>
<tr>
<td>48</td>
<td>Stachys inflata Benth.</td>
<td>antiinflammatory (Joudi et al. 2011); antimicrobial, antioxidant, and antifungal (CONFORTI et al. 2009)</td>
<td>leaves and flowering tops</td>
</tr>
<tr>
<td>49</td>
<td>Stachys laxa Boiss. and Buhse.</td>
<td>antimicrobial, antioxidant, and antifungal (CONFORTI et al. 2009); citotoxic (KHANAVI et al. 2012)</td>
<td>leaves and flowering tops</td>
</tr>
<tr>
<td>50</td>
<td>Teucrium chamaedrys L.</td>
<td>antibacterial (ELDEEN et al. 2005; DIABOU et al. 2013); antioxidant (STANKOVIC et al. 2010)</td>
<td>flowered aerial part</td>
</tr>
<tr>
<td>51</td>
<td>Teucrium polium L.</td>
<td>antibacterial (ELDEEN et al. 2005; DIABOU et al. 2013); antibacterial (ZERROUG et al. 2011); antioxidant (D’ABROSCA et al. 2013)</td>
<td>leaves and flowering aerial part</td>
</tr>
<tr>
<td>52</td>
<td>Thymbra spicata L.</td>
<td>antioxidant (YILMAZ &amp; YILMAZ 2012); antimicrobial (MARKOVIC et al. 2011)</td>
<td>flowered aerial part</td>
</tr>
<tr>
<td>53</td>
<td>Thymus serpyllum L.</td>
<td>antibacterial (NEDOROSTOVA et al. 2011; JOSHI 2013) antibacterial, antioxidant, antimalarial, and antiproliferative (HUSAIN et al. 2013); antioxidant and antihypertensive (MIHAIOVIC-STANOJEVIC et al. 2013)</td>
<td>leaves</td>
</tr>
<tr>
<td>54</td>
<td>Thymus vulgaris L.</td>
<td>antioxidant (CERDA et al. 2013); antifungal (SELLAMUTHU et al. 2013); antimicrobial (ALINEZHAD et al. 2013)</td>
<td>flowered aerial part</td>
</tr>
<tr>
<td>55</td>
<td>Ziziphora clinopodioides Lam.</td>
<td>antioxidant and antibacterial (ALIJKARLU &amp; SHAMELI 2013); antibacterial (AGHAJANI et al. 2008)</td>
<td>aerial parts</td>
</tr>
<tr>
<td>56</td>
<td>Ziziphora tenuior L.</td>
<td>anti-diarrhea, febrifuge, and pectoral effects (Joudi et al. 2011); antioxidant and antibacterial (ALIJKARLU &amp; SHAMELI 2013)</td>
<td>aerial parts</td>
</tr>
</tbody>
</table>
etc. Discovery of natural inflammatory agents and further development of novel dietary supplements with anti-inflammatory activities is of considerable public health relevance, since malnutrition (modern dietary habit) is linked to inflammation, aging, and other degenerative processes (Charami et al. 2008). The species of the family Lamiaceae are a great source of phenolic compounds of multidirectional biological activity, including anti-inflammatory one. The main classes of phenolic compounds reported to be present in the family Lamiaceae are phenolic acids, mainly caffeic and rosmarinic acid and flavonoids. The species of the family Lamiaceae known to possess anti-inflammatory activity are Mexican giant hyssop (Agastache mexicana (Kunth.) Link. & Epling.) (Gonzalez-Ramirez et al. 2012), lavender (Hajhashemi et al. 2003), rosemary (YSor et al. 2013), sage (Jug-Dujakovic et al. 2012), savory (Hajhashemi et al. 2002), and horehound (Marrubium vulgare L.) (El Abbouyi et al. 2013).

Lamiaceae and other activity of contained substances. In addition, the Lamiaceae species are an important source of preventive agents for the treatment of global health problems. For diabetes Gmelina arborea Roxb. (Nayak et al. 2013), Marrubium vulgare L. (Boudjelal et al. 2011), Salvia hispanica L. (Munoz et al. 2013) have proven to be effective, while Salvia elegans Vahl. (Jimenez et al. 1988), Thymus capitatus (L.) Hoffmanns & Link (Yvon et al. 2012), Salvia hispanica L. (Mihailovic-Stanojevic et al. 2013), and Thymus serpyllum L. (Jovanovic et al. 2005) can be used for hypertension.

Due to their chemical composition, species of the family Lamiaceae indicate a great potential as functional foods. Numerous studies have shown their properties that can be relevant to the promotion of health and the prevention or treatment of some diseases. Therefore, the most commonly used species with a sound scientific basis for the relationship between foods and health benefits are summarised in Table 1, while the more detailed list of species and their health claims is given in the Suplementary material.

Consumer well-being

The Lamiaceae as natural antioxidants, antimicrobial, and anti-inflammatory agents are assumed to be safe. However, the consumption of functional foods or food ingredients with health claims should be based on sound scientific evidence. Even if there is evidence that certain functional foods or food ingredients can play a role in the prevention or treatment of illnesses, safety considerations should be in the first place. As it is permitted to make statements on food labels related to the health benefits of functional foods, interest in developing such products for the health and wellness market is growing. However, we cannot be certain that all the foods in the market which are labelled as functional truly are. Claims about the health benefits from functional foods must be communicated effectively to consumers and should be based on scientific criteria including safety studies. Herbs and spices are normally accepted as safe, at least at concentrations normally present in foods. Still, many of such species and their bioactive components are studied for potential disease prevention at concentrations which exceed those usually present in food. It is therefore important to identify any potential safety concerns associated with the use of various dosages which range from doses commonly used for culinary purposes to those used for medicinal purposes (Kaefer & Milner 2008).

CONCLUSION

The intention of this review is to present the reported beneficial effects of Lamiaceae species from scientific literature. General inspection of the literature suggests that these species possess antioxidant, antimicrobial, and anti-inflammatory properties. In addition, most of them have been reported to possess several beneficial properties suggesting that this type of knowledge could affect overall interest in Lamiaceae as functional foods and encourage the production and consumption of these species. It could help in addressing specific consumer needs as healthy diet is a part of the lifestyle that maintains or improves overall health. Since the availability of this type of food in the market is relatively new, its popularity depends on publications directed at consumer education and development and widespread use of new and improved functional properties by the food industry.

References


doi: 10.17221/504/2015-CJFS


Received: 2015–10–23
Accepted after corrections: 2016–06–20

doi: 10.17221/504/2015-CJFS

Czech J. Food Sci., 34, 2016 (S): 377–390