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Natural Product Diversity and its Biomolecular Aspects in Flavors and Fragrances

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1.1 Introduction

In pharmaceutical, food, cosmetic, and nutraceutical industries, flavors and fragrances play a vital role. The natural selection method or processes facilitate unique as well as wide chemical diversity with optimal interactions with other biological macromolecules. Moreover, since a millennium, it is observed that the introduction of continental and conventional selective breeding efforts has resulted in land race, elite cultivars that could not only adapt to globally diverse habitats but also ensure vivid quality and productivity in flavors and fragrances worldwide. However, unraveling the genomic basis of these vivid adaptations remains indecipherable. For example, the world's oldest and most popular caffeine-containing beverage, the tea, comes along with immense medicinal, economic, and cultural virtues. Constant research will definitely pave way for a diverse metabolic, functional, and genomic refinement for the evaluation of their biosynthetic pathways [1]. Although it is well recognized that the differential accumulation of the three major characteristic constituents in tea tree leaves largely determines the quality of tea, little genomic information is currently available. Sequencing of the tea tree genome would facilitate to uncover the molecular mechanisms underlying secondary metabolic biosynthesis with the promise to improve breeding efficiency and thus develop better tea cultivars with even higher quality. The development of tea clones with more desirable quality traits and enhanced stress resistance becomes a necessity. Strategizing such crop improvement procedures based on miRNAs requires a detailed understanding of the miRNA–mRNA modules associated with stress tolerance and quality in tea plants [2].

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Biosynthesis of aroma compounds involves metabolic pathways in which the main precursors are fatty acids and amino acids, and the main products are aldehydes, alcohols, and esters. Some enzymes are crucial in the production of volatile compounds, such as lipoxygenase, alcohol dehydrogenase, and alcohol acyltransferase. Composition and concentration of volatiles in apples may be altered by pre- and postharvest factors that cause a decline in apple flavor [3]. Among the volatile aroma compounds produced by ripe apples, esters account for the majority. For example, among the volatile aroma compounds of Golden Delicious and Starking Delicious, esters account for 80% [4]. This chapter discusses the genetic resources and plant breeding, agricultural diversity, conservation of agrobiodiversity, and the economically useful natural products used as flavors and fragrances.

1.2 Genetic Resources and Plant Breeding

From time immemorial, the breeding and domestication of plant varieties and/or species for flavor, aroma, and other characteristics have been a constant and ongoing process. Novel heterogeneity in concentration and combination of secondary metabolites has been a constant source to develop new varieties of flavors and fragrances. These variations in the composition of secondary metabolites are affected by human preferences and domestication in flavors and aromas [5]. Moreover, the need for a higher nutrition crop or fruit variety in terms of sustainable agriculture has put into limelight the genomic breeding approaches inclusive of marker-assisted selection, backcrossing, haplotype breeding, and genomic prediction methods in synergy with artificial intelligence and machine learning to increase the speed of these breeding approaches. Figure 1.1 depicts an example of the use of an integrated framework of genomic resources [7].

1.3 Agricultural Diversification

Globally, in an agricultural system, aromatic plants are those with aromatic compounds. These aromatic plants synthesize secondary metabolites to produce essential oils, which provide relief from biotic and environmental stress. In addition, these essential oils are used in diverse applications like flavors, perfumes, and fragrance, which will provide economic returns to farmers and manufacturing industries. The increasing interest of research scholars worldwide encourages agricultural activities like proper land utilization as well as focuses on economic returns for aromatic crops. The ecological applications of these aromatic plants in agricultural systems lie in soil erosion control, carbon sequestration, phytoremediation, utilization of low-quality water, pest and disease management, and augmentation of soil properties [8]. The sensory evaluation or validation of spices depends on dominant attributes like color, aroma, and pungency, which is heavily influenced by the varieties, primary processing cultivation, and the processed products.

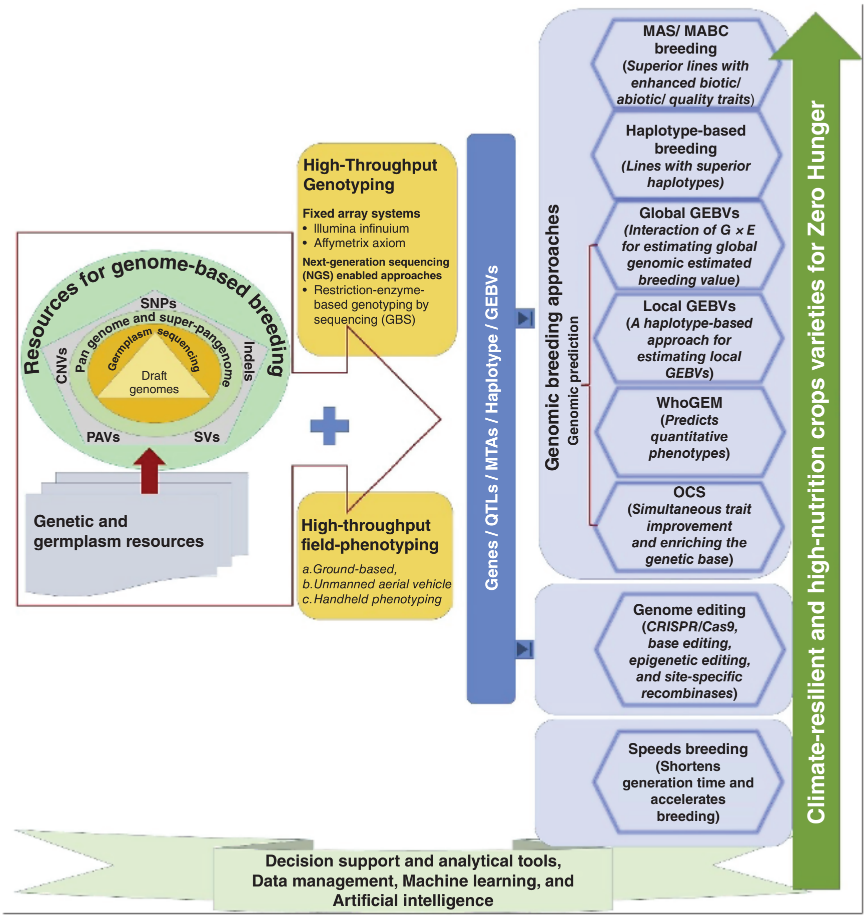

Figure 1.1 A unified framework of using genomic resources for genomic breeding to tailor climate resilient and high nutrition crops. Source: Adapted from Ashry et al. [6].

1.4 Conservation of Agrobiodiversity

The natural product diversity witness difficulties at economic level due to denial of traditional collective seed ownership, make people helpless to grow, harvest, and channel sufficient surplus food. There are many internationally acclaimed reciprocated responses that work in favor of the intellectual property law of farmers. Furthermore, the United States of America have designed vivid grassroot agricultural and biodiverse conservation projects to regulate the open pollinated seeds within fraternities of similar interest. This project involves exploration of the functions of pollinated seeds and focuses on various other strategies for agricultural biodiversity conservation. There are research projects that collectively disseminate and document open-pollinated seed around Appalachian Mountains and Ozark highlands of southeastern United States. The research methods involve an anthropology team who can conduct ethnographic interviews and make participant observation that cover the growing and sharing of seed varieties with local farmers, seed savers, gardeners, and activists with a definite aim of constructing more integrated, sustainable, and sovereign local food systems.

1.4.1 Strategies for Conservation of Medicinal Plants

The conservation strategies of near-to-extinct species of medicinal and food or aroma importance can be determined through social and scientific actions. The strategies for conservation of medicinal plants to be used for vivid purposes can be classified into (i) the importance of genebanks, (ii) molecular-based phylogenetics, and (iii) chemosystematics [9].

1.4.1.1 Importance of Genebanks

To compensate the emergent loss of genetic diversity in medicinal crops, the establishment and maintenance of large *ex situ* plant genetic resources (PGRs) was started where systemic breeding was developed by using genetically uniform cultivars to substitute traditional land races around the world. The seeds stocked in genebanks were considered as vital due to the fact it gave an insight of the historical background of the agriculture [10]. To illustrate, *Elettaria cardamomum*, which is an economically important crop, faces limitation in its genomic analysis because of the limitation of inefficient nucleic acid extraction due to its high polysaccharide and polyphenolic content. Therefore, genebanks provide an extraction protocol for nucleic acids that help to develop genetic markers for cardamom, perform gene expression, clone cardamom genes, analyze small RNAs, and clone cardamom-infecting viral genes [11].

1.4.2 Molecule-Based Phylogenetics

Cryptic diversity is often not recognized due to the incapability of recognizing the distinguishable morphological traits and because of inability to quantify the chemical communication systems. For certain plants or animals, species-level taxonomy is obstructed because of its distortion upon preservation and morphological plasticity. The morphological characteristics to differentiate likely related species using these methods become difficult, but recent advances in morphological characteristic-based studies imply several differences in the phenotypes. The revisions in taxonomic as well as molecular-based phylogenetic studies have proved to be promising to garner information related to large species groups with different genera [12].

1.4.3 Metabolomic-Based Phylogeny or Chemosystematics

The initial part of the last century witnessed the evolution of metabolomics-based phylogeny or chemosystematics that eventually gained its popularity in the 1970s [13]. However, these studies centered on the intrafamily classification at the species level as well as the measurement of particular components of single biochemical families, especially alkaloids, in accordance with the technologies of that period. For example, the chemical systematics of the family Rutaceae and the order Rutales received immense research attention. The authenticity of chemosystematic classification was proved by comparison with the phylogeny determined by molecular polymorphism analyses.

1.5 Economically Important Natural Products Used in Flavors and Fragrances

The economically most important plants serving the purpose of flavors and fragrances are cardamom, cinnamon, cocoa, fenugreek, marigold, nutmeg, vanilla, paprika, rosemary, davana oil, olibanum carterii/serrata, lavender, vetiver, and so on (Tables 1.1 and 1.2)

1.5.1 Flavors

1.5.1.1 Cardamom

Cardamom (*Elettaria cardamomum*) has been associated with numerous pharmacological properties [14]. This aromatic plant is one of the most expensive species in the world. India provides the most favorable warm humid climate with loamy-rich organic soil, well-distributed rainfall, and unique cultivation and processing methods that result in unique aroma, flavor, size, and green color. It has been used in culinary, confectionary, sweets, and medicines since time immemorial [33].

The diverse metabolites impose restriction to provide a standard method for RNA isolation for the available plants. The polysaccharide and polyphenol content of cardamom tissues obstruct the RNA extraction procedure. However, the combination of commercial kits as well as conventional cetyl trimethylammonium bromide (CTAB) method yields RNA with higher yield, good purity, and good integrity. The total RNA isolated from this approach was found compatible for small RNA analysis and transcriptome through next-generation sequencing platforms [34].

1.5.1.2 Cinnamon

Globally, cinnamon is a valuable source as an antioxidant compound [35]. Cinnamic aldehyde is widely used as a flavoring agent in foods and dentifrices [36] due to their antibacterial effects of cinnamon essential oil, cinnamon extracts, and pure compounds against different oral pathogens [37]. It is known for its aroma and essence in culinary, perfumes, and medicinal products. The active constituents of cinnamon, which are found in its essential oils, are cinnamaldehyde and trans-cinnamaldehyde that constitute its immense biological activities and fragrances. Cinnamon bark contains catechins and procyanidins. The components of procyanidins include both procyanidin A-type and B-type linkages. These procyanidins extracted from cinnamon and berries also possess antioxidant activities [36].

Table 1.1 Economically important plants and their ingredients.

Plant source	Active ingredients	Economic importance
Cardamom [14]	1,8-cineole, α-pinene, α-terpineol, linalool, linalyl acetate and nerolidol, and the ester constituent α-terpinyl acetate	Antioxidant, antimicrobial, antibacterial, anti-inflammatory
Cinnamon [15]	Cinnamaldehyde, trans-cinnamic acid, *o*-methoxycinnamaldehyde, eugenol, and monoterpenoids	Antioxidant, anti-inflammatory, antidiabetic, antimicrobial, anticancer, lipid-lowering, and cardiovascular-disease-lowering compound
Cocoa [16]	Theobromine, serotonin, anandamide, phenylethylamine	Antioxidation, anticancer, anti-microbial, anti-inflammation, anti-diabetes, cardioprotective, physical improvement, antiphotoaging, antidepression, and blood glucose regulation
Fenugreek [17]	Carbohydrates, proteins, lipids, alkaloids, flavonoids, fibers, saponins, steroidal saponins	Hypocholesterolemia, lactation aid, antibacterial, gastric stimulant, for anorexia, antidiabetic agent, galactagogue, hepatoprotective effect, and anticancer
Marigold [18]	Carotenoids, flavonoids, saponins, sterols, phenolic acids	Anti-inflammatory, anti-edematous activity, antioxidant, antibacterial and antifungal activity, immunostimulant activity, genotoxic and antigen-toxic activity, spasmogenic and spasmolytic activity, hepatoprotective activity
Nutmeg [19]	Terpenes (α-pinene, *p*-cymene, sabinene, camphene, myrcene, and γ-terpinene), terpene derivatives (terpinol, geraniol, and linalool), and phenylpropanes	Antioxidant activity, immuno-modulatory and radioprotective activities, anti-carcinogenic and hepatoprotective activity, anti-inflammatory activity, antimicrobial activity
Paprika [20]	Carotenoids	Antioxidant activity, antifungal activity Anti-inflammatory properties
Rosemary [21]	Triterpenes, phenolic diterpenes rosmarinic acid, carnosic acid, rosmanol, carnosol, ursolic acid, betulinic acid	Anti-depressant, antispasmodic antimicrobial, anti-inflammatory, anti-tumorigenic
Black pepper [22]	Piperine, alkaloids, amides, essential volatile oils	Anti-inflammatory, antioxidant improves blood sugar control, antithyroid activity
Oregano [23]	Carvacrol, β-fenchyl alcohol, thymol, and γ-terpinene	Antioxidant, antimicrobial
Annatto [24]	Carotenoids, Terpenoids, and terpenes	Anti-inflammatory, antibacterial, anti-endemic, and antifungal activity
Turmeric [25]	Curcumin	Anti-inflammatory, antioxidant, antimicrobial

Table 1.2 Important aromatic plants and their bioactives.

Fragrance source	Active ingredients	Properties
Davana oil [26]	Davanone, bicyclogermacrene, linalool, caryophyllene oxide, phytol	Antioxidant, antibacterial
Olibanum Carterii/ Serrata [27]	Boswellic acid	Anti-inflammatory, antifungal activity, antibacterial activity, antioxidant activity, anti-arthritic activity
Lavender [28]	Linalool, linalyl acetate, 1,8-cineole, β-ocimene terpinen-4-ol, and camphor	Antifungal activity, antibacterial activity, ascaricidal activity
Vetiver [29]	cedr-8-en-13-ol, β-guaiene Cycloisolongifolene	Antifungal activity, antibacterial activity, antioxidant activity
Red Sandalwood [30]	Carbohydrates, flavonoids, terpenoids, phenolic compounds, alkaloids, saponins, tannins, glycosides	Antibacterial activity, hepatoprotective, hypolipidemic activity, angiogenesis, and wound-healing activity
Lemongrass [31]	Myrcene, limonene, citral, geraniol, citronellol, geranyl acetate, neral, nerol	Anticancer and chemopreventive activity, anti-inflammatory, antifungal activity, antibacterial activity, antioxidant, allelopathic, insect repellent, anthelmintic activities
Elemi [32]	Elemol, limonene, elemicin, coumarins, furans, phenols	Hepatoprotective activities, antifungal activity, antibacterial activity, antioxidant, analgesic Antidiabetic
Myrrh [6]	Myrrhol, Myrrhin	Antihealing, antiseptic, antimicrobial

1.5.1.3 Cocoa

Cocoa seeds are a valuable food as well as a wellness product. These fruits are the main source of chocolate that is relished all over the world. The major producer of cocoa is Brazil [38]. The protein fractions of cocoa have an influence on the sensory and bioactive potential of cocoa products. The possible modifications during ripening, maturation, and post-harvest processing (drying, roasting, fermentation, and alkalization); composition of the phenolic compounds; and modifications in manufacturing processes are well documented [39, 40].

The phenolic compounds of cocoa contain antiradical and antioxidant properties with different biological properties like protection against cardiovascular diseases. Clovamide, a minor component of cocoa, is effective against oxidative stress induced in the rat cardiomyoblast cell line as compared to rosmarinic acid, other bio-isosteric forms, and epicatechin. All these three components were analyzed with DNA fragmentation, annexin V positivity, and caspase release as well as activation and were found to be effective to inhibit the production of reactive oxygen species and apoptosis [40].

1.5.1.4 Fenugreek

Trigonella foenum-graecum (fenugreek), belonging to the family Fabaceae, is a legume cultivated as a semiarid crop in India, Canada, Northern Africa, and Mediterranean region. This spice is known worldwide to enrich the sensory quality of foods and has high nutraceutical value. The presence of alkaloids, steroid saponin, and fiber in *Trigonella* seeds shows antidiabetic activity. Other bioactive compounds like trigonelline, orientin, isoorientin, isovitexin, and vitexin were quantified by high-performance liquid chromatography (HPLC). Other compounds identified by ultrahigh-performance liquid chromatography-hybrid electrospray triple quadrupole linear ion trap mass spectrometry were trigonelline, pinitol, isoorientin, sarsapogenin, and isovitexin [41]. The bioassay-guided isolation revealed 1 new pterocarpan and 12 known pterocarpans. These pterocarpans are important in terms of nutritional value as functional foods, foods, or antioxidants [18]. Moreover, fenugreek gum, a natural galactomannan, originates from the endosperm of *Trigonella foenum-graecum* seeds. This gum is composed of (1 → 4)-β-D-mannose (Man) backbone attached to a single α-D-galactose (Gal) group at the O-6 position with a Gal/Man ratio of 1 : 1 or in few cases of 1 : 2. It has been over a decade that fenugreek gums are used in food and pharmaceutical industry as a stabilizing and thickening agent [13, 42].

1.5.1.5 Marigold

Tagetes (marigold) is mainly found in America and is also cultivated in Europe, Asia, and Africa. Many species of this plant, including *T. erecta*, *T. patula*, *T. minuta*, and *T. tenuifolia*, are researched as medicinal plants. The major bioactive components of marigold are carotenoids, which are lipophilic pigments and well recognized as health-promoting agents. Although the native profile of carotenoids is not much studied because of the difficult analysis of carotenoid esters, it is observed that the hydroxyl carotenoids are found in both esterified and free form in numerous plant matrices. These carotenoids are used as supplements or marigold with no saponification process. The marigold petals contain lutein esters as major compounds. 18 caratenoids, 20 monoesters, 30 diesters (zeaxanthin, auroxanthin, violaxanthin, zeinoxanthin, and β-cryptoxanthin) were identified [43]. Various parts of the plants of *Tagetes* species are used to treat dental, stomach, and digestive disorders as well as anxiety and depression. These plants are also used for their fungicidal, bactericidal, insecticidal, anti-inflammatory, antioxidant, and enzyme inhibitory properties. They likewise find applications as a food additive and for their antimicrobial activities [43].

1.5.1.6 Nutmeg

Nutmeg is a plant found in tropical regions and its seeds are known for the unique flavor, nutritive value, and medicinal properties [44]. Occurrences of misuse have been accounted for nutmeg, including a family zest produced by crushing the seeds of *Myristica fragrans*, inferable from its stimulating properties [45]. A review of tangible metabolite dispersion in nutmeg has given a most far-reaching guide of its tactile metabolites. The key flavoring agent myristicin (40% in organic products) and 53 volatiles were differentiated in various classes, namely fragrant ethers, monoterpenes, and sesquiterpenes. In any case, monoterpene hydrocarbons are considered significant unstable structures in seeds [44].

1.5.1.7 Vanilla

Beginning from the locale of Mexico, *Vanilla planifolia* is a blooming climbing orchid that is internationally appreciated for the “vanilla” flavor created from its cases. The plant is distributed everywhere, particularly in tropical countries, for example, Madagascar, Uganda, Papua New Guinea, Indonesia, India, and islands like Comoros, Mayotte, Tahiti, and La Réunion. In addition to producing vanillin, the significant compound of vanilla concentrate, vanilla cases are the main wellspring of the more mind-boggling vanilla flavor. The photosynthesis process of *V. planifolia* also known as “Crassulacean Acid Metabolism (CAM) plant” involves the intake of carbon dioxide during the evening and its eventual stockpiling in cell vacuoles as malate. The very next day, during daytime, malate is secreted from the vacuoles, and carbon dioxide is produced by malate decarboxylation that enters the Calvin cycle and is utilized as a substrate for Rubisco to produce sugars and different carbohydrates for the plant. Albeit many investigations have been conducted on the natural chemistry of vanilla beans and the vanillin biosynthetic pathway, very little work has been performed on vanilla leaf metabolites [46]. Sun et al. detailed the presence of *p*-ethoxymethylphenol, *p*-butoxymethylphenol, vanillin, *p*-hydroxy-2-methoxycinnamaldehyde, and 3,4-dihydroxyphenylacetic compounds in the ethanol concentrate of vanilla leaves as well as stems. Tokoro et al. (1990) detailed the presence of bis[4-(*b*-D-glucopyranosyloxy)-benzyl]-2-isopropyltartrate (glucoside A) and bis[4-(*b*-D-glucopyranosyloxy)-benzyl]-2-(2-butyl)-tartrate (glucoside B) in vanilla leaves and stems. [47].

During the restoring process of Hainan vanilla beans, the key vanilla flavors, vanillin antecedents, and principal catalysts are removed. During handling, vanillin content increased, while glucovanillin content decreased, and vanillic content is found in beans; however, this content is decreased in drying beans. Both p-hydroxybenzaldehyde and p-hydroxybenzoic compounds show the highest content in restored beans. The ferulic compound is fundamentally produced in dry beans and is decreased in restored beans. The content of the *p*-coumaric compound is increased during the restoration process. During the relieving stage Vanillyl liquor in drying beans (0.22%) is subjected to hydrolysis of glucoside, that then changes. Besides, the enzymatic action of β-glucosidase is not observed in whitened and perspiring beans. But after drying, peroxidase activity reduces by 94% during relieving in restored beans. Polyphenol oxidase activity is low in early stages, while cellulose activity in handled beans is higher than in green beans, apart from restored beans. This study unfolds the biosynthesis pathway of vanillin [48].

Vanillin is the main flavor compound in the vanilla unit. *V. planifolia* vanillin synthase (VpVAN) catalyzes the transformation of ferulic compound and ferulic glucoside into vanillin and vanillin glucoside, respectively. Desorption electrospray ionization-mass spectrometry imaging (DESI-MSI) of vanilla case areas shows that vanillin glucoside is especially restricted inside the mesocarp and placental laminae, while vanillin is especially limited inside the mesocarp. Immunoblotting, a neutralizer intended for visualizing the C-terminal arrangement of VpVAN. Through this neutralizer it is seen that VpVAN is a developed structure (25 kDa) and contingent upon the tissue and seclusion system. In addition, limited quantities of the youthful natural structure (40 kDa) and putative oligomers (50, 75, and 100 kDa) are also seen. The VpVAN protein is confined inside chloroplasts and detached chloroplasts named phenyloplasts, as determined during the course of unit improvement. Detached chloroplasts were shown to convert [14C] phenylalanine and [14C] cinnamic compounds into [14C] vanillin glucoside, demonstrating that the whole vanillin biosynthetically changes phenylalanine completely to vanillin glucoside, which is available in the chloroplast [47].

1.5.1.8 Paprika

Red pepper and its dietary items contain varieties of carotenoids, which might add to the carotenoids, for example, of human blood and tissues. The yellow-orange shades of stew pepper natural products are essentially because of the accumulation of α-and β-carotene, zeaxanthin, lutein, and β-cryptoxanthin. Carotenoids, for example, capsanthin, capsorubin, and capsanthin-5,6-epoxide present red tones. [49]. Capsaicin is the essential bioactive substance in red chili peppers, which delivers the sharp flavor. Capsicum natural products are famous overall and are utilized in cuisines around the globe. With its various varieties, structures, and uses, the capsicum spice adds to the whole range of tangible experience variety as finely ground paprika powder or concentrate in sausages, goulash, cheddar, and snacks; both sharpness and variety as the numerous forms of chilies utilized in Mexican, African, Indian, and southeast Asian foods; variety, smell, and gentle sharpness as the new green chilies utilized in a considerable quantity in developing nations; and appearance, variety, fragrance, and surface as a new natural product in servings of mixed greens and as a cured and canned item [50]. Sharpness as a particular gustatory insight, alongside different characteristics are accordingly seen for carotenoids, volatiles, as well as total capsaicinoids [51].

Capsicum species produce organic products that incorporate and collect carotenoid shades, which are responsible for the yellow, orange, and red tones of the natural products. The methods for measuring the content of carotenoids, chlorophyll, polyphenols, tannins, and flavonoids in red paprika (RP) were developed in Korea, which include light treatment of water (W) and ethanolic (Et) extracts under high tension sodium (HPS) and light emitting plasma (LEP) lights (RPControl, RPHPS, and RPLEP). The results of this study showed that of all the compounds, chlorophyll and carotenes were the most noteworthy in RPHPS (10.50 ± 1.02 and $33.90 \pm 3.26\,\mu g\,g^{-1}$ dry weight [DW]). The paprika ethanolic extracts show lower values in their bioactivity than the water extracts. The cytotoxicity capacities of all polyphenols in paprika are accounted together. The paprika tests can be utilized as an aid to cell reinforcements [52].

1.5.1.9 Rosemary

Rosemary oil (RO) is famous in the Mediterranean region as a culinary added substance, which protects sensitive organs like the liver, cerebrum, and heart. Rosemary (*Rosmarinus officinalis*) are broadly utilized in the food, nutraceutical, and restorative regions. Their major bioactive show antioxidant, anti-inflammatory, antimicrobial, antitumorigenic, and chemopreventive properties [53]. The active molecules obtained from rosemary oil are 1,8-cineol (15–20%), camphor (15–25%), borneol (16–20%), α-pinene (25%), and acetic acid derivative (up to 7%); moreover, the oil contains minor amounts of β-pinene, linalool, camphene, sabinene, myrcene, α-phellandrene, α-terpinene, limonene, *p*-cymene, terpinolene, thujene, terpinen-4-ol, α-terpineol, caryophyllene, methyl chavicol, and thymol. The distillation fraction generally contains α-thujene, α-pinene, camphene, β-pinene, and 1,8-cineol, while camphor and bornyl acetic acid derivatives comprising the major part were extracted later after refining. Rosemary leaves and flowering tops have numerous culinary purposes: mutton preparations, lamb roast, marinades, baked fish, bouquet garni, rice, soups, mixed greens, sporadic use with egg preparations, dumplings, apples, summer wine cups, and fruits cordials and use in vinegar and oil [54].

The new and dried leaves of rosemary are used in Mediterranean foods as they have a harsh astringent taste and fragrance. Dried and powdered leaves are added to cooked meat, fish, poultry soup, stews, sauces, dressings, jelly, and sticks. The leaves are additionally utilized in pork preparations. At the time of consumption, the leaves emit a unique mustard smell. Rosemary is the best spice with a wide scope of purposes in food handling. In Europe and the USA, rosemary is economically accessible for use as a cancer prevention agent; however, it is not actually recorded as a normal additive or as an antioxidant, particularly in Europe [55]. Rosemary has broad applications in subsiding warmed flavor [56]. The bioactives in rosemary are carnosic acid, 12-methoxy carnosic acid, and carnosol as well as the diterpenes, like, epirosmarinol, isorosmanol, rosmaridiphenol, rosmariquinone, and rosmarinic acid [57].

The antioxidant properties of rosemary are attributed to its capacity to savage superoxide radicals, lipid antioxidation, metal chelating, and so forth. Essential oils and extracts of rosemary can be utilized to stabilize fats, oils, and fat-containing food varieties, for example, margarine, against oxidation and rancidity and to settle matured meat items [58, 59]. A helpful audit by Yanishlieva-Maslarova and Heinonen examines the antioxidant properties of rosemary and sage, covering their chemistry, including properties, extraction, and application [55]. Commercial antioxidants, deodorized liquid of rosemary, either as mono-home grown or as polyherbal (rosemary, thyme, sage, and oreganum) details, for example, "Herbor 025" and "spice Cocktail," are found [60]. Rosemary oil likewise has applications in preservation of raw meat. The expansion of rosemary oleoresin to ground chicken affected crude meat appearance during storage and on the kind of the cooked meat [61]. The antioxidative property of rosemary oleoresin is well known [21]. However, the addition of rosemary oleoresin to ground chicken affected crude meat appearance during storage and even cooked meat [61].

1.5.2 Fragrances

There are countless fragrances which are used in numerous foods, savories, cosmetics, and perfumes, including davana, olibanaum, lavender, and vetiver, as depicted in Table 1.2.

1.5.2.1 Davana Oil

Davana (*Artemisia pallens*) is an annual branched herb. The plant grows knee-high and looks much like a small fern. It is most fragrant at maturity, when it produces tiny flowers that are rich in essential oils. India is the sole source of *A. pallens*. The crop can be found in southern India, namely Tamil Nadu and Karnataka, with the outskirts of Bangalore producing the largest volumes [62]. Davana's reddish brown essential oil boasts a potent, exquisite scent. Its characteristic is shockingly reminiscent of old spirits like cognac, with sharp, dry fruit notes, and a full body with thick honey herbaceous notes. Davanone, a sesquiterpene ketone, is the major component and quality driving factor of davana oil [63]. High-quality material usually boasts of a davanone content at or above 50%. Davana is first and foremost a flavor ingredient. Fine fragrance perfumer Ilias Ermenidis (Firmenich) began using davana with Givenchy Pour Homme and Givenchy Pour Homme Blue Label. Since that time, it became one of his favorite ingredients in men's fragrances. In rose formulations, davana is used to round the fragrance and to tame the minty metallic edge of geranium; it is used more for its low-dosage effect than for its characteristic itself [64].

1.5.2.2 Olibanum Carterii/Serrata

Frankincense, or olibanum, is a characteristic oleo-gum-tar made out of around 5–9% medicinal balm, 65–85% liquor solvent resins, and the leftover water-dissolvable gums. Frankincense is harvested as tears or as the size of a pea to that of a walnut. It is light yellow or pale golden in variety. The scent of frankincense is depicted as new balsamic, dry and resinous, marginally green smell with a natural product top note and a diffusive note of green, unripe apple strip. Frankincense is utilized by perfumers as an outright (by liquor extraction), oil, or resinoid (by hydrocarbon extraction) [65]. It is utilized in Oriental bases, ambers, "powder" scents, flower aromas, citrus colognes, flavor mixes, violet fragrances, male scents, and so on. It mixes well with flavor oils, labdanum, mimosa, neroli, muguet bases, woody notes, and other balsamic notes. The main bioactives of frankincense is ß-boswellic acid, one of the super dynamic parts of frankincense. These are a portion of the synthetic mixtures present in frankincense: · Acid sap (56%), dissolvable in liquor and having the recipe $C_{20}H_{32}O_4$ · Gum (like Gum Arabic) 30–36% · 3-Acetyl-beta-boswellic acid (*Boswellia sacra*) · Alpha-boswellic acid (*Boswellia sacra*) · 4-O-methyl-glucuronic acid (*Boswellia sacra*) [66]·

Incensole acetic acid derivative · Phellandrene. Olibanum is portrayed by a balsamic-fiery, somewhat lemon, and regular aroma of incense, with a marginally conifer-like feeling. It is utilized in aroma as well as beauty care products and pharmaceutical industry [67].

1.5.2.3 Lavender

Lavender (*Lavandula angustifolia*) is a spice found in northern Africa and the Mediterranean mountains, and its extract is frequently used in medicinal ointments. It is likewise developed for the production creation of its natural oil, which comes from the refining of the bloom spikes of specific lavender species. The lavender oil has cosmetic purposes, and its few therapeutic uses are additionally accepted. The biological advantages of utilizing lavender are utilized to treat hair loss, wound, anxiety, and fungal infections. Lavender is not utilized to treat high blood pressure, menstrual pain, eczema, nausea, and other different circumstances. This spice is not approved by the Food and Drug Administration (FDA) and should not be assumed as a replacement of endorsed and recommended medications [67]. This class Lavandula is generally rich in phenolic constituents, with 19 flavones and 8 anthocyanins (Harbourne and Williams, 2002). The family normally contains different glycosides of hypolaetin and scutellarein. Triterpenoids incorporate ursolic acid [68]. The spice lavender is widely used in skin products, hair shampoos and as aroma agents. It can be bought from the pharmacy counter [69]. A few variants of lavenders are utilized to add flavors to prepared products and food varieties. This spice likewise contains numerous therapeutic properties. Lavender smells are fit for modifying depressive states and may show that the utilization of scents is useful in diminishing uneasiness in dental patients [70]

1.5.2.4 Vetiver

Vetiveria zizanioides is a kind of spiky sinewy grass with rhizome-like roots of 2 m or more in length. Vetiver oil is among the best, thick light brown, and most positive perfumery fixings. Generally appreciated for its trademark refined and sweet woody amber smell, it shows up in over 33% of all aromas. It has a rich green-woody natural and nut-like aroma. Less fortunate grades produced in China and Java by nearby ranchers with crude gear are oftentimes more obscure in variety and have smoky back notes. It is an exceptionally valued oil and has broad usage in fine perfumery for its richness and profundity. Vetiver is likewise utilized for the partition of its main alcohol – vetiverol – for an even cleaner note. Vetiverol may in this way be acetylated for the development of vetiveryl acetate, which with its marginally more grounded velvety, fruity, green-woody subtleties is indispensable in the base notes of "haute couture" fragrances [71]. An eleven-step chemical synthesis, with a novel asymmetric organocatalytic Mukaiyama–Michael addition revealed that (+)-2-epi-ziza-6(13)en-3-one is the active smelling principle of vetiver oil. The trademark semi-pheromone-like vetiver odor was obtained by synthetic blend of 2-epi-ziza-6(13)en-3-one utilizing a remarkable imidophosphoimidate (IDPi)-catalyzed Mukaiyama–Michael expansion of a silyl ketene acetal to cyclopent-2-en-1-one.

1.6 Conclusion

The industry of flavor and fragrance is highly priced with huge and rapid changes in the technological aspects related to breeding, conservation, and analytical techniques. These sensory aspects are either synthetic or natural. The important natural flavors, including cardamom, cinnamon, cocoa, fenugreek, marigold, nutmeg, vanilla, paprika, and rosemary, are discussed briefly. In addition, davana oil, olibanum carterii, lavender, and vetiver are also described. However, more comprehensive studies need to be conducted to understand the potential of these products and improve their quality and cost in terms of flavor and fragrances. This would definitely boost the savory industries in terms of economic aspects to become the most sought-after ones among pharmaceutics and nutraceutics.

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Declaration of Interest

The authors profess no declaration of interest in this present chapter.

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