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Essential Oil Composition of Different Plant Parts of *Syzygium aromaticum* (L.) Merr. & Perry Grown in South Andaman Island, India

AJIT ARUN WAMAN* and POOJA BOHRA

Division of Horticulture and Forestry, ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands, India.

Abstract

Dried unopened flower bud is the economic produce obtained from clove tree. Similar to clove buds, its essential oil also has manifold applications in food, flavor and pharmaceutical industries worldwide. These properties are mainly attributed to the presence of various bioactive molecules including Eugenol. In order to know the composition of essential oil present in clove leaves and pedicels as compared to commercially used clove buds, the present study was undertaken. Results revealed that different plant parts had varied essential oil composition in terms of relative percentage of various compounds. Leaf essential oil was found to be the richest source of Eugenol among the plant parts studied. This finding suggests use of clove leaves for season independent commercial scale essential oil extraction and growing perennial clove plants for dedicated leaf production purpose.

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Introduction

Clove (*Syzygium aromaticum* (L.) Merr. & Perry), an important tree spice prized for its unopened flower buds, is grown in the humid tropical regions of the world. In India, it was introduced in 1800 AD and since then its cultivation has been practiced in parts of Tamil Nadu, Karnataka, Kerala and Andaman and Nicobar Islands.[1] Besides its use for culinary purposes, clove oil is an important constituent of various pharmaceutical formulations and serves as a preservative owing to its antimicrobial properties.[2] Generally, clove buds are employed for extraction of essential oil, however, as clove buds are the major economic produce in spice trade, utilizing alternative plant parts such as clove leaves and pedicels for essential oil extraction is desirable. During present investigation, essential oil composition of bud, leaf and pedicel of clove grown in South Andaman Island was determined using GC-MS analysis.

CONTACT Ajit Arun Waman ajit.hort595@gmail.com Division of Horticulture and Forestry, ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands, India.

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Materials and Methods

Collection of Samples and Extraction of Essential Oils

The experiment was carried out during 2018. Clove samples were collected from South Andaman Island and brought to the authors' laboratory. Clove leaves, buds and pedicel samples were grinded using an electric grinder and used for extraction of essential oil. Samples were accurately weighed and volatile oils were extracted using Clevenger's apparatus. Oils were dried over anhydrous sodium sulphate and stored at 4°C until further analysis.

Determination of Essential Oil Composition Using GC-MS Analysis

Gas Chromatograph (Varian-3800) attached with Ion-Trap Mass Spectrometer (Varian-4000) was employed for determining essential oil composition of clove bud, leaf and pedicel. For analysis, VF-5MS (Factor four; Varian, USA) fused-silica capillary column was used which had dimensions of 30 m length × 0.25 mm inner diameter and 0.25 mm film thickness. Experimental conditions as described earlier[3] were used for analysis. To determine the total volatile content of the sample, all GC peak areas in each chromatogram were summed, while relative percent area was used for quantification of individual compounds. Compounds were identified by comparing the retention index (determined by using homologous series of n-alkanes (C5–C32) as standard) besides comparison of the spectra using spectral libraries (Wiley and NIST-2007).

Results and Discussion

Clove buds have traditionally been used as a spice and ingredient of numerous medicinal formulations. Presence of Eugenol in the volatile oils is known to contribute to major biological activities of the species. Results of the present study revealed presence of nineteen compounds in the essential

Table 1: Chemical composition of essential oil of bud, leaf and pedicel of clove collected from Andaman Islands

Sl. No.	Name of the Compounds	Bud oil	Leaf oil	Pedicel oil
1	Bergamol	-	-	0.042
2	2-methyl-2-bornene	-	-	0.023
3	Octanoic acid	0.908	0.464	0.430
4	Methyl salicylate	-	-	1.485
5	Octanoic acid, 2-methyl-	2.157	1.701	1.599
6	Nonanoic acid	0.840	0.665	0.595
7	Chavicol	0.154	0.079	0.058
8	β-Cubebene	-	0.051	0.037
9	2,3-dihydro-1,4-thiopyrano[5,6-b] indole	0.139	-	0.064
10	Eugenol	69.236	86.525	71.648
11	β-Caryophyllene	13.552	4.593	5.603
12	β-Ylangene	0.315	0.069	0.550
13	α-Humulene	1.802	0.683	6.811
14	Junipene	0.185	-	0.557
15	β-Cadinene	0.330	-	1.392
16	ĩ-Cadinene	0.090	0.140	0.439
17	β-Cedrene	0.126	-	0.077
18	δ-Cadinene	2.264	0.055	3.880
19	Eugenol acetate	4.516	0.795	0.767
20	β-Selinene	0.061	1.003	0.039
21	(+)-Aromadendrene	0.058	0.237	0.038
22	Neoclovene	0.060	-	0.070
23	(-)-Spathulenol	0.109	0.281	0.098
	Total	**96.902**	**97.341**	**96.302**

oil of clove buds, which accounted for 96.902% of its composition. On the other hand, 15 compounds contributing to 97.341% and 23 compounds amounting to 96.302% of total composition were detected in clove leaf and pedicel oils, respectively. It means that some compounds were present in all plant parts, while few of them were exclusive to some parts (Table 1).

Distinct differences were noticed for the oil composition among the plant parts used for distillation. Relative abundance of the compounds varied with the plant parts. Fourteen compounds were common in all the plant parts, of which Eugenol (69.236-86.525%), β-Caryophyllene (4.593-13.552%) and Octanoic acid, 2-methyl- (1.599-2.157%) were major. Six, four and seven compounds had content more than 1% in the essential oil of buds, leaves and pedicels, respectively.

Eugenol was the most dominant compound in oils of all the parts studied in the present experiment. Highest content (86.525%) of Eugenol was observed in oil of leaves, which was followed by pedicel oil (71.648%) and bud oil (69.236%). Eugenol content of clove bud oil has been reported to vary with the region e.g. 55.6% (Java), 70.0% (India), 74.7% (Manado) and 82.6% (Madagascar).[4,5] However, in all the cases, Eugenol was the dominant constituent of clove bud oil. Eugenol, a phenolic compound, chemically known as 1-allyl-4-hydroxy-3-methoxy benzene is considered as a versatile compound considering its multifaceted applications. The Food and Drug Administration of the United States of America has accredited Eugenol in GRAS category, owing to its non-cancer causing and non-mutagenic properties.[6] The compound is known to have a large number of medicinal properties including antimicrobial, antioxidant, anthelmintic, anesthetic, antidiabetic, hypocholesterolemic etc.[2,6] Though it could be chemically synthesized in the laboratories, plant sources have received attention from the researchers across the world.[7]

Interestingly, leaf oil was the richest source of Eugenol (86.55%) in the present study. Unlike buds and pedicels, leaves are produced by the plant throughout the year. Further, clove generally bears good crop once in four years[1] and hence, utilization of leaves to produce quality essential oil is much feasible. In fact, it would be desirable to grow clove plants for leaf production and pruning them regularly for commercial production of Eugenol rich essential oil. For establishing commercial orchards for such purpose, closer spacing could be adopted to accommodate more number of plants per unit area.

β-Caryophyllene was the second most abundant compound in the oils of buds (13.552%) and leaves (4.593%), while it was present to the tune of 5.603% in pedicel oil. Jirovetz *et al.*[8] analyzed the commercial clove leaf essential oil sample and also found that eugenol (76.8%) and β-caryophyllene (17.4%) were the top two dominant compounds. β-Caryophyllene is among one of the versatile compounds commonly used in pharmaceutical, food and cosmetic industries.[9] Due to its similarity in structure and properties with that of cannabinoids, it is also called as a dietary phytocannabinoid.[10] In case of pedicel oil, however, α-Humulene (α-Caryophyllene) was the second dominant compound with content of 6.811%.

Selective richness of compounds in a plant part was witnessed in the present study. For example, Eugenol acetate was present in larger quantities (4.516%) in bud oil, while it was present in meager quantities (0.767-0.795%) in other two plant parts. Similarly, δ-Cadinene and α-Humulene were present in higher quantities in bud (2.264% and 1.802%, respectively) and pedicel oils (3.880% and 6.811%, respectively), whereas their quantity was limited in leaf oil (0.055% and 0.683%, respectively). β-Selinene was present in higher quantities in leaf oil, whereas Methyl salicylate (1.485%) was exclusively found in the pedicel oil. Two other compounds namely Bergamol and 2-methyl-bornene were also exclusively present in pedicel oil, but at very low proportions (0.023-0.042%). β-Cubebene was the only compound that was absent in bud oil but present in other two oils, though at low proportions. Accumulation/ synthesis of compounds in a species are specific to the part as varied concentrations have been reported in other species as well. For example, Eugenol content in leaves of cinnamon (76.74%) was much higher than that in bark (4.15%), fruits (0.45%) and roots (0.21%).[11]

A number of other compounds such as Octanoic acid, Nonanoic acid, Chavicol, 2,3-dihydro-1,4-

thiopyrano[5,6-b] indole, β-Ylangene, Junipene, ĩ-Cadinene, β-Cedrene, (+)-Aromadendrene, Neoclovene and (-)-Spathulenol were present in the essential oils as minor compounds.

Conclusion

It can be concluded that different plant parts of clove differed in their essential oil composition and clove leaves could be employed for commercial scale essential oil extraction. This will ensure regular supply of raw material for industries requiring Eugenol rich oil.

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Conflict of Interest

The authors do not have any conflict of interest.

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