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Chemical composition of essential oil of nutmeg (*Myristica fragrans* Houtt.) accessions

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Abstract

Sixty-five nutmeg (*Myristica fragrans*) germplasm accessions from Indian Institute of Spices Research, Experimental Farm, Peruvannamuzhi (Kerala), were evaluated for chemical composition of essential oil of nutmeg and mace and variability was observed among the accessions. The major constituents of significance in the essential oil were sabinene, safrole, myristicin and elemicin. Among the accessions, A9/71 and A9/95 had high sabinene and low hallucinogens namely, myristicin, elemicin and safrole, in both nutmeg and mace oils.

Key words: essential oil, *Myristica fragrans*, nutmeg.

Nutmeg (*Myristica fragrans* Houtt.) contributes two separate spice products namely, nutmeg, which is the kernel of the seed, and mace, the dried aril that surrounds the seed within the fruit. Dried nutmeg and mace are used as spices and also for extracting oil and oleoresins. Nutmeg also contains fat or butter that has applications in pharmaceutical preparations. Sabinene, myristicin, safrole and elemicin constitute 80% of both these oils. The West Indian oils (oils from nutmeg cultivated in Grenada) have considerable amounts of α-pinene, β-pinene and sabinene (40%-50%) and are low in safrole and myristicin, whereas East Indian oils (oils from nutmeg cultivated in Indonesia and other regions in South East Asia) have higher amounts of myristicin (Purseglove *et al.* 1981). Gas chromatographic analysis of nutmeg and mace oils by Gopalakrishnan (1992) showed that α-pinene, β-pinene and sabinene together constituted 77.38% and 60.76% in nutmeg and mace oil, respectively. He also noted that the concentration of myristicin and elemicin are very high in Indian oils (oils from nutmeg cultivated in India). Mallavarapu & Ramesh (1998) reported that nutmeg oil contained 76.8% monoterpenes, 12.1% oxygenated monoterpenes and 9.8% phenyl propanoid ether; they also reported that mace oil consisted of 51.2% monoterpenes, 30.3% oxygenated monoterpenes and 18.8% phenyl propanoid ether. Their study indicated that Indian oils to be intermediate in quality between East Indian and West Indian oils.

Hallstrom & Thuvander (1997) have given the toxicological evaluation of myristicin.

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Myristicin or methoxy safrole, the principal aromatic constituent of nutmeg, is also found in several members of Umbelliferae. In human beings, 6-7 mg kg^{-1} of body weight is enough to cause psychopharmacological effects. Ingestion of 5 g nutmeg corresponding to 1-2 mg myristicin kg^{-1} body weight has been shown to cause intoxication. Woolf (1999) also reported the specific toxicity of nutmeg essential oils. Nutmeg, mace and their oils are generally used with sweet foods like cakes, cookies, doughnuts, fruit pies, egg nog and puddings to give them a delicate smooth flavour. The oil is used in canned soups and stews and has an important application in neutralising the unpleasant smell of cooked cabbage (Lewis 1984). The present study was undertaken to evaluate nutmeg germplasm for chemical composition and to short-list accessions suitable for the food industry.

Fully matured nutmeg and mace samples were collected from Indian Institute of Spices Research, Experimental Farm, Peruvannamuzhi (Kerala), and dried under shade. The essential oil from both nutmeg and mace was extracted by hydrodistillation (AOAC 1975). The samples were analysed using Perkin Elmer Autosystem Gas Chromatograph equipped with PE Nelson 1022 GC Plus Integrator and FID detector. The column (SE-30) temperature was programmed as 70-220°C @ 5° C min^{-1}. The flow rate of nitrogen was 30 ml min^{-1}. The detector and injector temperature were 300°C and 200°C, respectively. Compounds in the oil were identified by comparing the retention time (R_t.) with that of authentic standards.

The essential oils of both nutmeg and mace used in the present study consisted of α-pinene, sabinene, α-phellandrene, α-terpinene, p-cymene, 1,8-cineole, limonene, β-phellandrene, γ-terpinene, linalool, safrole, myristicin and elemicin. Lewis (1984) and Lawrence (2000) reported the presence of these constituents in nutmeg and mace oils. Myristicin, elemicin and safrole are hallucinogenic compounds in nutmeg oil (Purseglove *et al.* 1981) whereas, sabinene imparts sweetness to the products (Zachariah 1995; Verghese 2001). Ehlers *et al.* (1998) observed differences in composition of East Indian, West Indian and Papuan nutmeg oils.

The composition of essential oils in 65 accessions is presented in Table 1. The essential oil content ranged from 3.9% (A9/116) to 16.5% (A9/18) (v/w) in nutmeg and 6% (A9/107) to 26.1% (A9/18) in mace. Accessions A9/18, A9/49 and A11/49 were rich in both nutmeg and mace oils.

Myristicin content ranged from 1.1% (A9/20) to 45.6% (A11/21) in nutmeg oil and 0.21% (A9/13) to 36.6% (A4/117) in mace oil; the elemicin content ranged from 1.0% (A4/22) to 29.7% (A11/26) in nutmeg oil and 1.0% (A9/1) to 30.2 % (A4/12) in mace oil. Safrole content ranged from 0.1% (A9/11) to 22.1% (A9/13) in essential oil and 0.2% (A9/11) to 21.8% (A9/13) in mace oil. It is noteworthy that A9/13 had the highest safrole content in both the spices. Lawrence (2000) indicated high variability in the composition of nutmeg and mace oil constituents. It is interesting to observe that A9/18, which had the highest oil content (16.5%) among the accessions, also possessed high myristicin in nutmeg and mace oils (15.1% & 27.4% respectively). Many of the high myristicin accessions possessed relatively low level of sabinene that contributes to a pleasant flavour. A one-way ANOVA was performed by considering A9/71 and A9/95 in one group and the other accessions in another group (Table 2). The test indicated that these two accessions had significantly low myristicin and high sabinene contents among the accessions.

Some of the accessions, with low myristicin had comparatively high elemicin and vice versa (in both nutmeg and mace). This is supported by the study that myristicin and elemicin are synthesized separately in the plant (Khosla & Bhasin 2000). The study contradicts some of the previous observations of Gopalakrishnan (1992) and Mallavarapu & Ramesh (1998) wherein they reported that Indian nutmeg possess high myristicin (15.00% and elemicin (15.76%). This study clearly es-

Table 1. Essential oil content and its constituents in nutmeg and mace of various accessions

Accession	Nutmeg					Mace				
	Oil (%)	Myristicin (%)	Elemicin (%)	Safrole (%)	Sabinene (%)	Oil (%)	Myristicin (%)	Elemicin (%)	Safrole (%)	Sabinene (%)
A4/5	10.7	10.7	19.8	2.7	19.5	10.7	9.3	4.4	0.2	32.4
A4/11	9.9	3.3	0.5	0.4	39.4	17.4	33.2	4.8	4.7	14.7
A4/12	8.2	11.2	27.2	4.8	11.1	11.3	19.9	30.2	3.3	5.9
A4/17	8.8	21.9	18.8	5.4	16.8	12.5	25.4	21.0	5.0	13.3
A4/22	4.2	0.3	1.0	0.4	38.2	8.7	2.6	0.8	0.6	32.3
A4/116	10.4	20.7	1.7	3.6	23.5	12.0	21.9	4.0	4.0	17.3
A4/117	11.5	29.9	16.0	7.2	11.8	12.5	36.6	16.8	6.0	7.5
A9/1	7.0	5.5	4.8	2.5	6.3	12.3	2.3	1.0	0.3	35.1
A9/3	8.3	39.3	4.7	9.1	11.1	13.3	4.1	2.3	6.4	31.5
A9/4	7.1	12.5	13.7	0.1	35.9	7.1	22.0	20.8	0.7	19.7
A9/11	8.5	3.2	2.9	0.1	31.0	8.8	2.0	4.0	0.2	31.9
A9/13	10.1	0.3	6.0	22.1	29.3	15.2	0.2	5.2	21.8	27.9
A9/18	16.5	15.1	4.6	0.1	35.6	26.1	27.4	1.2	0.2	21.8
A9/20	5.9	0.9	3.1	1.2	41.7	10.0	3.6	11.4	0.3	37.0
A9/28	8.7	2.1	8.2	0.1	44.8	12.0	4.1	26.1	1.3	28.4
A9/30	5.5	1.5	15.5	0.1	32.6	11.2	0.8	12.4	11.1	29.4
A9/37	7.7	3.3	1.5	2.4	27.9	11.1	3.8	1.7	2.4	29.0
A9/41	9.4	7.4	10.3	2.1	27.2	12.4	18.8	19.2	3.2	19.9
A9/44	8.5	1.9	2.5	0.1	50.2	13.9	2.3	0.5	0.2	32.3
A9/49	13.9	23.2	3.4	6.1	13.3	21.0	7.7	1.1	4.3	28.7
A9/53	7.5	21.1	4.6	2.1	26.7	15.4	5.7	3.9	0.3	36.4
A9/57	9.7	35.4	2.6	4.8	15.3	14.9	16.5	1.1	1.9	31.2
A9/63	6.8	1.9	10.0	0.2	34.5	14.9	0.8	4.2	5.2	32.0
A9/66	6.9	0.3	11.8	0.0	34.0	10.0	5.4	1.3	0.7	40.2
A9/71	5.0	1.9	0.8	0.1	45.0	16.2	1.1	1.0	3.2	41.9
A9/74	6.4	4.0	0.6	0.1	34.2	12.1	1.6	0.4	0.3	37.4
A9/79	5.7	12.7	1.7	1.6	35.5	7.7	20.5	1.8	2.6	27.7
A9/85	8.0	17.8	30.9	1.7	14.8	8.6	4.9	1.2	2.1	30.7
A9/86	8.7	6.3	11.8	0.0	37.1	15.8	4.6	20.4	2.0	18.1
A9/95	8.0	3.3	1.6	0.1	45.9	14.7	2.1	1.5	0.3	36.2
A9/98	9.9	7.5	28.5	3.4	16.3	13.3	4.3	17.2	2.2	23.1
A9/102	7.5	1.5	1.1	0.3	39.6	7.6	10.7	2.3	0.7	24.7
A9/107	6.0	2.2	0.4	0.1	33.0	6.0	12.9	0.7	0.2	33.8
A9/109	7.1	3.9	2.3	0.1	45.4	11.9	4.1	6.2	0.3	33.6
A9/116	3.9	4.3	1.1	0.2	34.5	12.6	5.1	1.3	0.3	33.7
A9/150	9.5	0.6	5.2	0.1	33.9	10.3	0.8	3.9	0.2	33.5
A9/4/1	11.1	21.0	19.4	5.1	25.3	9.9	25.2	20.0	4.3	14.2
A9/4/3	11.0	29.6	27.9	4.4	9.4	10.8	27.6	23.0	3.8	11.8
A9/4/8	8.3	22.3	26.9	4.2	12.9	11.1	26.4	27.7	3.8	11.8
A9/4/10	7.4	12.4	12.1	0.1	38.3	11.5	21.4	17.3	0.2	21.9
A9/4/11	8.0	14.6	16.3	2.0	6.7	8.5	30.7	29.9	3.8	6.4
A9/4/12	8.1	23.9	19.0	5.7	13.9	9.4	17.1	20.3	1.9	18.9
A9/4/13	9.1	22.3	23.0	5.4	13.2	9.9	21.7	16.2	2.2	20.3
A9/4/15	10.9	21.4	22.0	4.7	15.3	14.5	22.5	16.5	0.2	21.4
A9/4/16	8.2	19.0	15.5	0.1	24.0	13.5	19.1	16.6	0.2	21.0
A11/5	7.5	3.0	7.6	0.2	37.8	9.5	4.5	12.6	0.3	31.1
A11/6	7.2	5.4	8.4	1.2	28.3	11.0	4.0	8.9	0.4	25.5
A11/8	6.2	3.8	7.0	0.2	39.0	8.0	5.6	10.7	0.3	36.1

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Table 1. (Continued from previous page)

Accession	Nutmeg					Mace				
	Oil (%)	Myristicin (%)	Elemicin (%)	Safrole (%)	Sabinene (%)	Oil (%)	Myristicin (%)	Elemicin (%)	Safrole (%)	Sabinene (%)
A11/10	6.4	4.8	10.2	0.2	36.2	7.3	11.5	24.6	1.7	30.0
A11/12	10.6	14.1	20.1	2.6	20.7	13.1	5.9	15.0	0.2	29.9
A11/15	13.8	6.9	16.9	11.6	19.2	10.2	10.3	26.7	15.2	10.6
A11/21	11.1	45.6	3.8	2.6	14.7	11.9	13.3	18.6	1.4	19.7
A11/25	10.9	2.3	15.1	20.2	11.8	15.5	0.7	2.2	13.1	21.8
A11/26	11.9	16.6	29.7	2.6	9.5	16.0	12.8	25.8	2.1	11.8
A11/29	8.5	2.0	6.1	0.2	34.2	12.1	1.7	4.1	0.3	33.2
A11/36	7.7	39.1	5.3	2.9	12.3	9.8	24.9	2.9	2.0	18.1
A11/38	10.7	17.9	28.3	3.5	13.8	17.5	18.2	10.5	2.7	20.2
A11/41	9.6	7.7	18.5	2.8	16.7	15.0	7.4	27.6	1.9	15.6
A11/45	8.7	26.7	2.5	3.1	22.0	12.5	28.0	1.7	2.6	21.4
A11/46	12.3	33.7	15.7	4.7	8.5	14.6	16.7	15.2	5.6	19.4
A11/48	11.0	8.4	26.7	2.4	18.3	12.9	5.8	26.1	1.5	25.5
A11/49	13.5	32.6	3.8	3.3	14.4	18.3	26.4	1.5	2.6	24.9
A11/50	11.3	23.4	1.5	4.0	15.3	14.5	15.2	0.9	2.2	22.6
A11/54	10.0	15.2	3.3	1.1	22.0	15.1	19.2	1.7	1.1	15.2
A11/70	7.0	11.3	4.6	3.1	20.7	10.4	13.9	2.7	1.2	21.4

tablishes that nutmeg and mace with very high and very low myristicin levels are available in some of the accessions in India.

The major applications of nutmeg and mace oils are in the food industry. Among the accessions evaluated, 12 accessions in the A9 series (A9/4, A9/18, A9/20, A9/28, A9/44, A9/71, A9/95, A9/109, A9/4/10, A9/79, A9/86, A9/102), 3 accessions in the A11 series (A11/5, A11/8, A11/10) and 2 accessions in the A4 series (A4/11, A4/22) possessed high sabinene content (above 35%) in nutmeg oil, with the highest content (50.2%) in A9/44. Seven accessions had high sabinene (above 35%) in mace oil (A9/1, A9/20, A9/53, A9/66, A9/71, A9/74, and A9/95) with the highest content in A9/71 (41.9%).

Table 2. One-way ANOVA with A9/71 and A9/95 taken as a group and the remaining accessions as another group

	Parameter	Group*	Mean	Standard deviation	Standard error	P-value	Remarks
Nutmeg	Myristicin	Group 1	13.2370	11.3692	0.8270	0.0233	Significant
		Group 2	2.6000	0.7797	0.3183		
	Elemicin	Group 1	11.0307	9.1176	0.6632	0.0089	Highly significant
		Group 2	1.1667	0.4131	0.1687		
	Safrole	Group 1	2.9999	4.0729	0.2963	0.0835	Not significant
		Group 2	0.1000	0.0000	0.0000		
	Sabinene	Group 1	24.8212	11.4050	0.8296	0.0000	Highly significant
		Group 2	45.7500	0.3937	0.1607		
Mace	Myristicin	Group 1	12.7577	9.8665	0.7177	0.0063	Highly significant
		Group 2	1.6000	0.5933	0.2422		
	Elemicin	Group 1	10.8302	9.6139	0.6993	0.0160	Significant
		Group 2	1.2667	0.2875	0.1174		
	Safrole	Group 1	2.7608	3.8111	0.2772	0.5187	Not significant
		Group 2	1.7500	1.5897	0.6490		
	Sabinene	Group 1	24.3386	8.4479	0.6145	0.0000	Highly significant
		Group 2	39.0833	3.1613	1.2906		

* Group 2=A9/71 and A9/95; Group 1=rest of accessions

The study thus indicated that there is high variability in the nutmeg germplasm with regard to essential oil content and its constituents. Based on the low levels of myristicin, elemicin and safrole coupled with high sabinene content in the essential oil, accessions A9/71 and A9/95 can be considered for future exploitation for food and pharmaceutical applications.

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References

AOAC 1975 Official Methods of Analysis of the Association of Official Analytical Chemists. 12th Edn. Association of Official Analytical Chemists, Washington, D C.

Ehlers D, Kirchhoff J, Gerard D & Quirin K W 1998 HPLC analysis of nutmeg and mace oils produced by supercritical CO_2 extraction-comparison with steam distilled oils-comparison of East Indian, West Indian and Papuan oils. Int. J. Food Sci. Technol. 33 : 215-223.

Gopalakrishnan M 1992 Chemical composition of nutmeg and mace. J. Spices Aromatic Crops. 1 : 49-54.

Hallstrom H & Thuvander A 1997 Toxicological evaluation of myristicin. Natural Toxins 5 : 186-192.

Khosla M K & Mala Bhasin 2000 Biosynthetic correlation of major essential oil components in *Ocimum carnosum* L K Otto. Indian Perfumer 44 : 55-59.

Lawrence B M 2000 Progress in essential oils. Perfumer Flavorist 25 : 66-68.

Lewis Y S 1984 Spices and Herbs for the Food Industry. Food Trade Press Ltd., England.

Mallavarapu G R & Ramesh S 1998 Composition of essential oils of nutmeg and mace. J. Med. Aromatic Plant Sci. 20 : 746-748.

Purseglove J W, Brown E G, Green C L & Robbins S R J 1981 Spices. Vol. I. Longman, London.

Verghese J 2001 Nutmeg and Mace-IV, Essential oils of *Myristica fragrans* Houtt. Spice India. 14 (10) : 7-11.

Woolf A 1999 Essential oil poisoning. J. Toxicol. Clinical Toxicol. 37 : 721-727.

Zachariah T J 1995 Essential oil and its major constituents in selected black pepper accessions. Plant Physiol. Biochem. 22 : 151-153.