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AROMA VOLATILE COMPOUNDS OF MANGO CULTIVARS NEELUM AND BANGANAPALLI

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ABSTRACT : A laboratory study was undertaken to determine the volatile profile of mango fruits using hexane extract and GC-MS technique. The number of aroma components identified from Neelum and Banganapalli were 24 and 31, respectively. Neelum had estersas propenal constituent and alkanes, ketones, alcohols, lactone and acid as associates. In Banganapalli, alkanes were the dominant constituent followed by esters, alcohols, ethers, fatty acid, amino acid triterpene and sulfur. The presence of mineral components such assulfur and nitrogen were found to constitute for the aroma of mango fruits.

Key words : Mango, Aroma, Volatile components and GC-MS.

INTRODUCTION

Mango is highly preferable by mankind mainly due to its attractive flavor. Flavor results from compounds that are divided into two broad classes: Those responsible for taste and thosefor odors, the latter often designated as aroma substances. Aroma substancesare volatile compounds which are perceived by the odor receptor sites of the smell organ, *i. e.* the olfactory tissue of the nasal cavity. The volatile compounds responsible for fruit aroma and flavor are produced through metabolic pathways during harvesting, ripening and post-harvest storage (Quijano*et al,* 2007). The aroma profiling of mango is complex as most of them are oxygenated volatile compounds which include terpene hydrocarbons, esters, furanones, lactones, ketones, alcohols, aldehydes, acids and other groups (Zhang *et al,* 2006). More than 300 volatile compounds were separated from different mango cultivars including approximately 162 terpenes and terpinoids, 128 esters, 86 aromatics, 61 ketones and lactones, 37 aldehydes, 34 alcohols, 21 acids, 21 alkanes and cycloalkanes 13 norisoprenoids and 15 miscellaneous compounds (Pino*et al.,* 2005). The type andamount volatiles of mango depend on cultivars (Andrade *et al,* 2000), maturity of the fruit (Lalel*et al,* 2003), a part of the fruit (Lalel*et al,* 2003), area of production (Singh*et al,* 2004), processing method and solvent used (Zhang *et al,* 2006; Laohaprasit*et al*, 2011).

The main objective of this work is to profile the volatile components of ripe fruit of mango cultivars Neelum and Banganapalli that are predominantly grown in Tamil Nadu (Indian Horticultural database, 2013). From the reported literature, Neelum and Bangalora are considered medium flavor cultivars and Banganapalli and Alphonso are high flavor cultivars (Ibrahim *et al,* 2010). One medium flavor cultivar (Neelum) and one high flavor cultivar (Banganapalli) were chosen for this study.

MATERIALS AND METHODS

Mango fruits of cvs. Neelum and Banganapalli were harvested from Krishnagiri region of TamilNadu for studying the volatile components responsible for its aroma. The fruits were then stored at ambient condition (Temperature: 27±3°C, RH: 60±5%) to study the volatile componentsemitted during fruit ripening.

Sample preparation and solvent extraction

Fiveripe fruit samples of cultivars Neelum and Banganapalli were randomly selected from the lot of 20 fruits. The fruits were washed thoroughly in running tap water for removal of sap, wiped off and cut into small pieces. Fifty grams of cut fruits were weighed and wrapped with filter paper and put into solvent extraction unit, then added with 200 ml of Hexane solvent for volatile component extraction as per the suggested procedure (Helena *et al,*2000) and the extraction was done for 4 hrs as suggested byLaohaprasit*et al*(2011). The temperature maintained during the solvent extraction process was 40 °C - 50 °C. The solvent layer was separated from aqueous layer by placing the flask in rotator water bathat 45°C till it condensed upto 20 ml. The combined extracts were dried over anhydrous Na_2SO_4 for complete removal of water particles

Table 1 : Aroma compounds of Mango fruit cv. Neelum.

S.No.	RT	Compound Name	Probability	Area (%)
1.	2.33	Nonane	82.63	2.16
2.	2.82	Octane, 3,5-dimethyl-	55.86	1.97
3.	3.43	Methane, isocynate	16.44	4.61
4.	4.02	Benzene, 1-ethyl-3-methyl-	28.87	6.50
5.	4.73	Benzene, 1-methyl-4-(1-methylethyl)-	37.91	1.93
6.	5.51	1-Propanone, 1-phenyl-	52.60	1.26
7.	7.12	Octane, 3,5-dimethyl-	33.80	1.16
8.	25.70	Diethyl Phthalate	92.69	0.18
9.	26.02	Hexadecane	17.00	0.55
10.	29.10	Oleyl Alcohol	30.67	3.45
11.	29.83	Cyclopropanecarboxylic acid, 3-(2,2-dichlorovinyl)-2,2-dimethyl-, (3-phenoxyphenyl)methyl ester, (1R-cis)-	44.85	7.52
12.	31.32	Tridecane	28.55	0.59
13.	31.69	Dibenzyl ketone	38.24	0.96
14.	32.93	2(3H)-Furanone, 5-hexyldihydro-	24.54	1.30
15.	33.21	Octadecane, 1-isocyanato-	12.31	0.38
16.	34.97	1,2-Benzenedicarboxylic acid, bis(2-methylpropyl) ester	43.81	0.78
17.	36.19	3-Hexanone, 2,2-dimethyl-	21.65	0.78
18.	37.92	1,2-Benzenedicarboxylic acid, monobutyl ester	25.39	1.14
19.	39.26	Eicosane	36.83	0.70
20.	41.73	n-Tridecan-1-ol	15.80	1.17
21.	42.24	Heptadecane	21.96	0.45
22.	45.07	Pentadecane, 2-methyl-	30.23	0.19
23.	45.42	n-Tridecan-1-ol	22.76	2.32
24.	47.80	Pentadecane, 2-methyl-	12.22	0.41
25.	49.92	Unknown	15.99	22.71
26.	50.41	Unknown	16.92	26.01
27.	52.12	Unknown	29.88	8.82

(Yunchalad*et al,* 1997), and then extracted volatiles were analysed through GC-MS.

GC-MS Analysis of volatile compounds

The extracts were analyzed through GC/MS (Thermo Scientific Trace GC Ultra DSQ II) equipped with column (30mm × 0.25mm × 0.25µm) under the following conditions: carrier gas as Helium with flow rate at 1ml per minute and 1µl sample injection with pre injection of solvent by AI/AS 3000 Method; split-less mode injection with 30 sec of sampling time; the column temperature maintained initially at 50°C at the increasing rate of 10°C/min, followed by increasing up to 200 °C and kept at the same temperature for 2 minutes hold with surge pressure 3kPa and 220 base temperature at right SSL method and 250 base temperature at right ECD method with the Aux 1 MS transfer line at 250 °C; the electron impact energy was 70eV, Juletline temperature was set at 200°C and the source temperature was set at 200 °C. Electron impact (EI) mass scan (m/z) was recorded in the 45-450 aMU range.

The total chromatogram was obtained for each sample. The base peak of each spectrum was compared with the base peak of the chemical components in the NIST Ver.2005 MS data library through on-line and comparing the spectrum obtained through GC/MS. The volatile metabolites emanated during mango fruit ripeningwere identified.

RESULTS AND DISCUSSION

Aroma components of Mango fruit cv. Neelum

The volatile components identified by the comparison of their mass spectra with retention time (RT) (Table 1; Fig. 1). The GC/MS analysis of volatile components emitted by the ripe mango fruit cv. Neelum was detected at the retention time from 2.00 to 53.02. There were 24 volatile compounds including 3 unknown. Among the 23

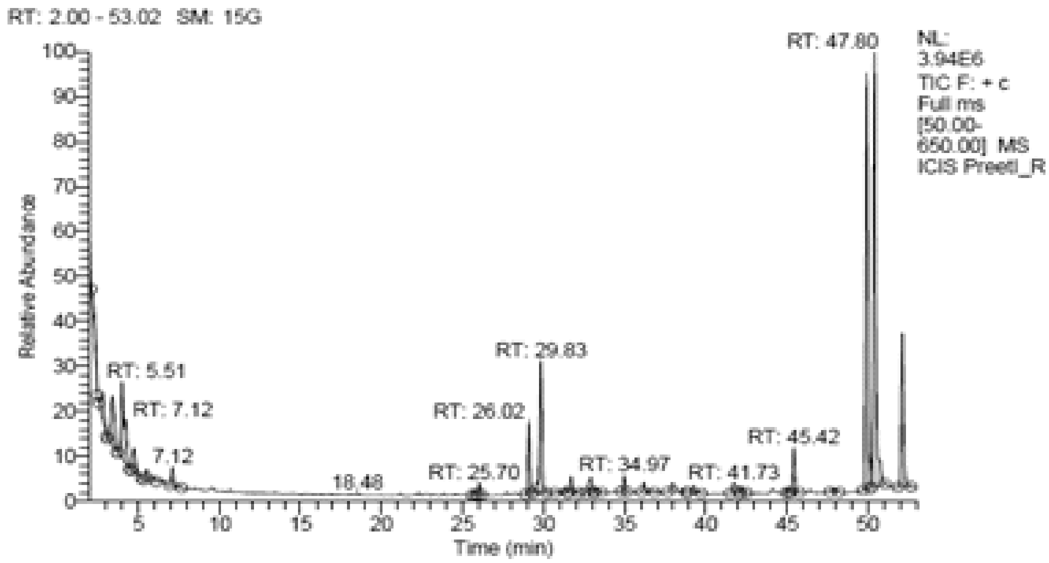

Fig. 1 : Aroma compounds of Mango fruit cv. Neelum.

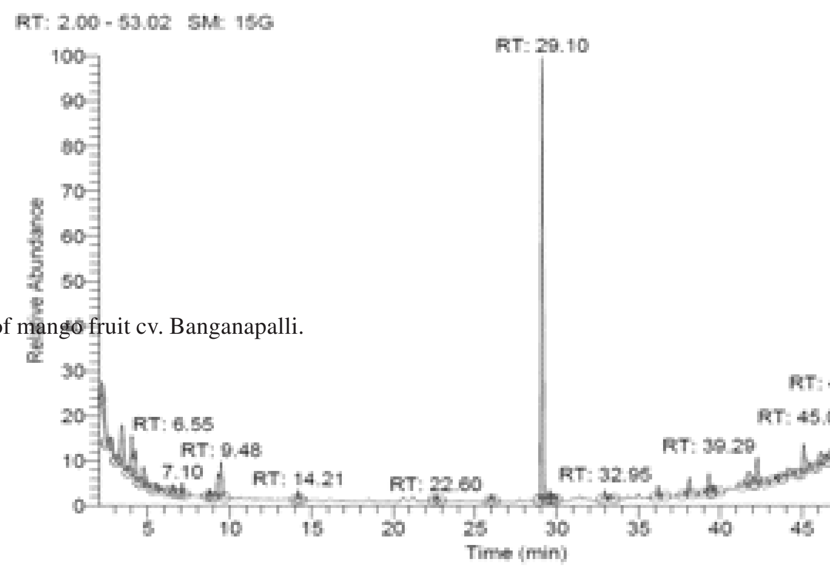

Fig. 2 : Aroma compounds of mango fruit cv. Banganapalli.

identified components, 8 were ester compounds (Octane, 3,5-dimethyl-, Benzene, 1-ethyl-3-methyl-, Benzene, 1-methyl-4-(1-methylethyl)-, Cyclopropanecarboxylicmacid, 3-(2,2-dichlorovinyl)-2,2-dimethyl-(3-phenoxyphenyl)methyl ester, (1R-cis)-, 1,2-Benzenedicarboxylic acid, bis(2-methylpropyl) ester, 3-Hexanone, 2,2-dimethyl, 1,2-Benzenedicarboxylic acid, monobutyl ester and Pentadecane, 2-methyl-), 6 were alkanes (Nonane, Hexadecane, Tridecane, Octadecane, 1-isocyanato-, Eicosane and Heptadecane), 3 ketones (Methane, isocyanate-, 1-Propanone, 1-phenyl- and Dibenzyl ketone), 2 alcohols (Oleyl Alcohol and n-Tridecan-1-ol)1 acid (Diethyl Phthalate *syn.* Benzene carboxylic acid) and 3 unknown components.

detected at the retention time from 2.00 to 53.02. The total number of components identified from ripe fruit of Banganapalli cultivar was 31. Among the 31 identified components, 10 were alkanes (Nonane, Undecane, Tridecane, Heptadecane, 1-Nonadecene, Pentadecane, Decane, Hexadecane, Heneicosane and Eicosane), 5 ester compounds (Cyclohexane, nitro-, Benzene, 1,2,3-trimethyl-, Pyrrole, Benzene, 1-ethyl-3-methyl-, and 1,3-Cyclopentanedione, 2-methyl-), 5 alcohols (Cyclohexane,

Table 2 : Aroma compounds of Mango fruit cv. Banganapalli.

S.No.	RT	Compound Name	Probability	Area (%)
1.	2.33	Nonane	72.90	2.77
2.	2.76	Cyclohexane, propyl-	53.41	1.25
3.	3.41	Cyclohexane, nitro-	45.31	4.30
4.	4.00	Benzene, 1,2,3-trimethyl-	41.58	3.80
5.	4.73	Pyrrole	19.21	1.70
6.	5.51	Benzene, 1-ethyl-3-methyl-	11.91	0.73
7.	6.55	Hexaethylene glycol dimethyl ether	37.57	0.43
8.	7.10	Undecane	47.70	0.61
9.	8.77	1,3-Cyclopentanedione, 2-methyl-	24.54	0.38
10.	9.48	11-Hexadecen-1-ol, (Z)-	26.92	3.24
11.	14.21	cis-9-Tetradecen-1-ol	24.10	0.48
12.	22.60	Unknown	98.54	0.30
13.	26.02	Tridecane	53.47	0.30
14.	29.10	Oleyl Alcohol	41.26	22.44
15.	29.57	Heptadecane	26.90	0.52
16.	29.79	1-Nonadecene	15.94	0.26
17.	32.95	Pentadecane	28.51	0.82
18.	36.19	Decane	15.23	0.74
19.	38.10	SULFUR, MOL. (S8)	98.90	1.17
20.	39.29	Hexadecane	25.82	1.30
21.	39.61	Unknown	18.39	0.54
22.	41.73	Threonine	23.31	1.94
23.	42.24	Heneicosane	44.79	2.06
24.	43.38	Ricinoleic acid	17.12	0.58
25.	44.11	Unknown	8.89	1.24
26.	45.09	Eicosane	16.76	2.49
27.	46.11	Ricinoleic acid	14.90	1.76
28.	47.03	Squalane	11.59	2.15
29.	47.82	Eicosane	13.99	3.33
30.	48.82	Androst-4-en-3-one, 17-(acetyloxy)-, (17á)-	11.74	2.60
31.	49.72	2-Propyl-1-pentanol	11.29	8.96
32.	50.55	2,5-Cyclohexadiene-1,4-dione, 2,6-bis(1,1-dimethylethyl)-	20.40	13.89
33.	51.37	Unknown	26.27	7.89
34.	52.41	Heptadecane	10.66	3.03

propyl-, 11-Hexadecen-1-ol, (Z)-, cis-9-Tetradecen-1-oland 2-Propyl-1-pentanol), 3 were ethers (Hexaethylene glycol dimethyl ether, Androst-4-en-3-one, 17-(acetyloxy)-, (17á)- and 2,5-Cyclohexadiene-1,4-dione, 2,6-bis(1,1-dimethylethyl)-), 1 wasfattyacid (Ricinoleic acid), 1 amino acid (Threonine), 1 was triterpene (Squalane), Sulfur and 4 were unknown.

Previous analysis of fresh ripe mango fruits of different mango cultivars revealed range of volatile components. Pino *et al* (2005) identified and quantified nearly 375 volatile components from 20 Cuban cultivars. The components identified from cv. Neelum in this study showed similarity for 12 components ofDelicioso, Haden, Super-Haden, Manga amarilla, Macho, Manga blanca, Ordonez, Obispo, Corazon, Delicia, Filipino, Huevo de toro, San Diego, Manzano, Smith, Florida, Minin, La Paz, Keitt, and Kent. Remaining 9 were reported first time in ripe fruits of medium flavor mango cv. Neelum. They components areOctane, 3,5-dimethyl-, Methane, isobutyl-, 1-Propanone, 1-phenyl-, Diethyl Phthalate, Oleyl Alcohol, Cyclopropanecarboxylic acid, 3-(2,2-dichlorovinyl)-2,2-dimethyl-,(3-phenoxyphenyl)methyl ester, (1R-cis)-, 1,2-Benzenedicarboxylic acid, bis(2-methylpropyl) ester, 1,2-Benzenedicarboxylic acid, monobutyl ester and Eicosane. Considering mango cultivar Banganapalli into account, 14 components were showing similarity of Pino's result. The components Pyrrole, Benzene, 1-ethyl-3-methyl-, Hexaethylene glycol dimethyl ether, Oleyl Alcohol, Sulfur, Threonine, Heneicosane, Ricinoleic acid, Eicosane, Squalane, Androst-4-en-3-one, 17-(acetyloxy)-, (17á)-, 2-Propyl-1-pentanol and 2,5-Cyclohexadiene-1,4-dione, 2,6-bis(1,1-dimethylethyl)-.

Terpenes are the most abundant volatile component in fruit of almost all the mango cultivars and esters are the second highest group followed by ketones and lactones (Singh, 2011). Triterpene identified in this study was Squalanewhich may responsible for a high flavor of cv. Banganapalli such compound is absent in medium flavor cultivar Neelum. Esters were found to be wider contributors of volatile components in cv. Neelum. Esters of Octane, 3,5-dimethyl-, Cyclopropanecarboxylic acid, 3-(2,2-dichlorovinyl)-2,2-dimethyl-,(3-phenoxyphenyl)methyl ester, (1R-cis)-, 1,2-Benzenedicarboxylic acid, bis(2-methylpropyl) and 1,2-Benzenedicarboxylic acid, monobutyl were also reported in mango fruit cv. Neelum. Likewise,Pyrrole[heterocyclic aromatic ester compound and biosynthetic precursor of caroteneoids (Walsh *et al,* 2006)] and 1,2-Benzenedicarboxylic acid, monobutyl ester were also identified in mango cv. Banganapalli. The esters identified may be straight chain, saturated or unsaturated which are generally metabolized from fatty acids through â-oxidation. Generally, the precursor of esters has been found to be high during ripening of mango (Lalel*et al,* 2003). A fatty acid called ricinoleic acid was also identified from cv. Banganapalli. There are two main biogenetic pathways can be considered for alcohols, amino acid metabolism and lipid peroxidation pathway, leads to the formation unsaturated alcohols (Pino*et al,* 2005). The only alcohol newly identified in both the cultivars was Oleyl Alcohol and the amino acid Threonine was found in cv. Banganapalli. in this study the alkanes,Eicosane was identified and reported in mango fruits of both the cultivars. But this alkane was previous reported by Boussaada*et al.* (2008) isolated from *Rhaponticumacaule* – an aromatic plant, for its antimicrobial activity. In mango fruits of 20 Cuban cultivars, the mineral component sulfur was also identified, Pino *et al*(2005) reported that these mineral component may be responsible for the 'S' and 'N' group components such asMethane, isocyanate- and Cyclohexane, nitro-respectively which was also reported in this study.The components listed in Table1 and 2, specific for two Indian mango cultivars *i.e*. Neelum and Bangalora may individually or collectively responsible for their characteristic aroma.

CONCLUSION

Overall, the results have showed that aroma compounds are very unique to mango cultivars and could be used as identification keys or to develop e-nose for varietal discrimination.

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