Influence of thermal processing on the volatile constituents of muskmelon puree

D. Priyanka · S. Sindhoora · P. Vijayanand ·
S. G. Kulkarni · S. Nagarajan

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Abstract Muskmelon (*Cucumis melo L*) is an important tropical fruit cultivated widely in different parts of India. Fresh muskmelon has a delicate but characteristic flavor rendering the fruit with highly acceptable flavor. Processing and preservation of muskmelon puree requires thermal processing, which affects the volatile constituents. It is imperative to understand the flavor changes during thermal processing which would affect the quality of the processed and packed muskmelon puree. Muskmelon puree was subjected to different methods of thermal processing viz., heating, canning and packing in retort pouches and the volatile constituents were analyzed. Gas chromatography–mass spectrometry (GC-MS) indicated the presence of more than 49 volatile components in the muskmelon puree samples. Major volatile components identified using GC-MS analysis showed the presence of esters (27.29 %), aldehydes (18.57 %), Heterocyclic compounds (16.63 %), aliphatic alcohols (11.72 %), phenolic compounds (6.03 %) and sesquiterpenes (0.25 %) in the fresh samples. Aldehydes decreased and ester content increased in thermally processed muskmelon puree packed in cans and retort pouches. Aliphatic alcohols, Heterocyclic compounds and phenolic compounds decreased in puree processed in tin containers and retort pouches.

Keywords Muskmelon puree · Thermal processing · Volatiles · Flavor compounds · Canned puree · Retort pouches · Canning

D. Priyanka · S. Sindhoora · P. Vijayanand (✉) · S. G. Kulkarni
Fruit and Vegetable Technology, CSIR-Central Food Technological
Research Institute, Mysore 570 020, Karnataka, India
e-mail: pasupuletiv@yahoo.com

S. Nagarajan
Plantation products, Spices and Flavor Technology, CSIR-Central
Food Technological Research Institute, Mysore 570 020,
Karnataka, India

Introduction

Muskmelon (*Cucumis melo L*) is a tropical fruit with a mild characteristic flavor relished for its fleshy endocarp. It belongs to the family Cucurbitaceae and is primarily consumed as a fresh fruit. Muskmelon is a member of melon species and is one of the popular fruits in the tropical countries. It is cultivated in temperate regions of the world due to its good adaptation to soil and climate. Fruits are consumed in the summer period and are popular because the puree of the fruit is very refreshing and sweet with a pleasant aroma. Muskmelons are of medium size, greenish colour having thick peel with a reticulate surface, the fruits are rich in vitamins A, B, C and minerals viz., calcium, phosphorous and iron. Muskmelon cultivars differ in their total soluble solids content, which ranged from 5.7 to 10.7°brix (Dull et al. 1989).

Volatile composition and sensory evaluation in eight varieties of netted muskmelon (*Cucumis melo L* variety reticulatus Naud) showed that ethyl esters were responsible for good quality aroma of muskmelon puree. Volatile fraction of fresh muskmelon contained about 100 compounds. C₉ compounds and other esters may be responsible for the fruity like odour and melon like flavor (Senisi et al. 2002). Japanese muskmelon (Miyabi variety) aroma volatiles analysed by porapak Q column method (PQM) and aroma extract dilution analysis (AEDA) method showed the presence of about 46 compounds. Different types of esters are principally attributed to the aroma of the fruits. Volatile compounds identified by olfactory-GC showed odour attributes viz., fruity note, green grassy or cucumber and sweet note (Hayata et al. 2003).

Shelf life of melon cultivars was also found to affect the aroma profile of cultivars. Twenty-eight volatiles comprising 11 esters, 8 sulfur compounds, 6 alcohols, and 3 carbonyl compounds were isolated and identified from 15 Charentais melon cultivars showed that long shelf cultivars exhibited lower volatiles than in the wild or mid shelf life melons

(Aubert and Bourger 2004). Volatile compounds in the skin and pulp of queen anne's pocket melon showed the presence of 60 volatiles comprising 20 esters, 15 alcohols, 7 lactones, 7 aldehydes and ketones, 6 sulfur compounds and 5 C₆ compounds. Concentration of volatiles was found to be more in skin than that of pulp. Components responsible for the typical aroma of the pocket melon were eugenol, thioesters, esters and lactones (Aubert and Pitrat 2006). Esters and aldehydes were the flavor impact compounds reported in cantaloupe which increased with increasing harvest maturity (Beaulieu and Grimm 2001).

Thermal processing protocols of fruit purees require heating to a temperature in the range of 80–95 °C, filling in cans or retort pouches and processing in retort. Heat treatment is known to affect the volatile compounds of the puree which in turn results in changes of the flavor of the packaged product. The influence of heat processing on the volatiles of muskmelon puree subjected to different thermal processing conditions was not reported earlier and therefore needs to be investigated. The loss of volatiles under different treatments can be used to determine the processing conditions which can be applied without significantly affecting the flavor of the puree. Processing conditions could be designed to obtain a product with good flavor and sensory quality. The main objective of the present investigation is to study the effect of thermal treatment on the volatile constituents of muskmelon puree.

Materials and methods

Chemicals Analytical grade reagents obtained from Merck specialities private limited (Mumbai-400 025, India) included pentane, diethyl ether, ethanol, citric acid and sodium sulfate.

Materials Muskmelon fruits of mature ripe quality were procured from the local fruit market at Mysore, Karnataka, India. The fruits were washed thoroughly under tap water, peeled and cut into pieces and passed through a stainless steel fruit pulp extractor fitted with a stainless sieve with a pore diameter of 0.8 mm. Muskmelon puree was packed in low density polyethylene pouches of 125 µm thickness and stored in a deep freezer at –20 °C. The frozen puree was thawed at room temperature and used for the experimental studies.

Volatiles extraction Volatile compounds were extracted using Likens and Nickerson apparatus. Muskmelon puree was thawed under ambient temperature; and 300 g of puree was taken into an extraction flask. The solvent flask containing analytical grade pentane: diethyl ether (1:1) mixture of 20 ml was attached. A small amount (0.2 ml) of distilled ethanol was added to the solvent flask. The extraction was carried out by a controlled heating process where in the temperature slowly

raised to above 100 °C in 90 min and for another 30 min at that temperature. The total extraction carried out for 2 h using a chilled condenser maintained at 5 °C. The solvent fraction was chilled and further concentrated to 0.3 ml using a vigreux column at 40 °C. The concentrated extract was used for GC-MS analysis.

Gas chromatography–mass spectrometric (GC-MS) analysis Volatile compounds were analyzed using GC (Perkin Elmer instruments) coupled with mass spectrometer (turbo mass). The sample was injected into a fused silica column SPB-1 (30 m×0.32 mm film thickness 0.25 µm), coated with polydimethyl siloxane. Helium was used as a carrier gas at a flow rate of 1 ml/min. Column temperature was programmed from 50 to 250 °C at 2 °C/min. Injection temperature was maintained at 150 °C and the detector temperature was maintained at 260 °C. A split ratio of 1:50 and ionization voltage of 70 eV were maintained. Retention indices for all the compounds were determined according to the Kovats method using mixture of hydrocarbons (C₇–C₂₉) as standards (Jennings and Shibamoto 1982). Identification of the compounds was done by comparison of Kovats indices and by matching their fragmentation pattern in mass spectra with those of NIST library and published mass spectra (Davies 1990; Adams 1989).

Thermal treatment of muskmelon puree Muskmelon puree 1,000 g was heated to 90 °C in a thermostatically controlled water bath for 5 min and immediately cooled to 25 °C using cold water bath. The heated puree was used for volatile compounds extraction as described earlier.

Canning of muskmelon puree Wholesome, ripe muskmelon fruits were procured from the fruit market at Mysore, India. The fruits were washed, peeled and passed through a fruit mill to obtain crushed pulp. The crushed puree was passed through a stainless steel pulper extractor fitted with a stainless sieve to separate the puree and seeds. The puree was analyzed for total soluble solids, acidity and pH. Citric acid was added to adjust the pH of the muskmelon puree to 4.1. The puree was heated to 90 °C in a stainless steel steam jacketed kettle, filled hot into sterilized plain tin containers of 850 g net weight and sealed using a can seamer. Sealed cans were processed in boiling water bath at 95 °C for 10 min followed by cooling in running tap water to 25 °C. The cooled cans were wiped clean and stored at room temperature.

Muskmelon puree processed in retort pouches The muskmelon puree adjusted to pH 4.1, was heated to 90 °C, filled into retort pouches of 300 g net weight and sealed using impulse heat sealing machine. The sealed pouches were held at 90 °C for 10 min and cooled in tap water.

Results and discussion

Volatile compounds of fresh muskmelon puree as well as the heated, puree packed in cans and puree packed in retort pouches were extracted. The effects on the volatile compounds of muskmelon puree before and after thermal processing were analyzed. The Likens Nickerson method has been chosen for the extraction of volatiles, since it is a suitable method for the extraction of highly volatile components particularly when the fruit samples contain the constituents such as aldehydes, esters etc., Ethanol (0.2 ml) was added in the solvent medium for trapping the extracted organic volatiles and prevent the loss during the simultaneous distillation and extraction (SDE) process. GC-MS chromatograms of muskmelon puree are depicted in Figs. 1, 2, 3, and 4. Volatiles from the fruit of fresh muskmelon as well as processed were analyzed by GCMS and the compounds identified are shown in Table 1. Thermally processed samples viz., heated puree,

puree packed in cans and in retort pouches were compared with that of fresh muskmelon puree. Overall, more than 49 volatile components were identified in the puree samples and the data is presented in Table 1. Important components from the volatile extract indicated the presence of esters (27.29 %), aldehydes (18.57 %), Heterocyclic compounds (16.63 %), aliphatic alcohols (11.72 %), phenolic compounds (6.03 %) and sesquiterpenes (0.25 %) in the fresh samples. Aldehydes decreased significantly in all thermally treated muskmelon purees, where as ester content increased. Aliphatic alcohols and heterocyclic compounds decreased in canned and retort pouch processed puree. Phenolic compounds also decreased in thermally processed puree (Table 2). Earlier reports showed aqueous essence and fresh fruit of *Cucumis melo* cv. Athena, contained 53 compounds and fresh fruit contained 38 compounds. Esters, aldehydes, alcohols and one sulphur component were found to be the principal contributors to the aroma

Fig. 1 Flavour profile of fresh muskmelon puree (TIC of GCMS)

Fig. 2 Flavour profile of heated muskmelon puree (TIC of GCMS)

Fig. 3 Flavour profile of canned muskmelon puree (TIC of GCMS)

Fig. 4 Flavour profile of muskmelon puree processed in retort pouches (TIC of GCMS)

Table 1 Volatile constituents of fresh and processed muskmelon puree

S. no	Compound	Retention time	Fresh	Heated	Retort pouch	Canned	Kovats index
1	Acetic acid 2-methyl, propyl ester	3.23	1.89	1.67	ND	ND	–
2	Hexanaldehyde	3.55	0.61	1.03	0.09	ND	–
3	Butanoic acid ethyl ester	3.65	2.85	3.11	ND	ND	–
4	Octane	3.89	2.85	2.44	0.06	0.11	–
5	2-butane thiol 2-methyl	4.12	5.88	0.45	0.32	0.73	809
6	Unidentified	4.44	0.20	ND	ND	ND	824
7	Unidentified	4.57	0.19	ND	ND	ND	829
8	Butanoic acid 2-methyl ethyl ester	4.71	1.15	8.72	ND	ND	835
9	<i>Cis</i> -3-hexenol (leaf alcohol)	4.83	0.89	8.55	ND	ND	840
10	1-hexanol	5.12	2.42	2.96	0.18	0.36	852
11	2-methyl butyl acetate	5.44	1.82	11.95	ND	0.30	863
12	Propanol, 3-(methyl thio)	5.61	0.26	0.18	ND	0.23	869
13	Propanoic acid, 2-methyl-1-methyl ethyl ester	6.77	1.04	0.90	ND	0.12	906
14	Butanoic acid 3-hydroxy ethyl ester	6.99	1.60	2.28	0.15	0.39	913
15	Unidentified	7.67	0.18	ND	ND	ND	932
16	4-hepten-1-ol	8.47	0.35	10.87	ND	0.17	952
17	Ethyl methyl thio acetate	8.72	1.38	ND	ND	1.29	958
18	3-methoxy butyric acid	9.55	0.22	2.25	ND	ND	976
19	2-pentyl furan	9.70	0.46	0.30	ND	ND	979
20	<i>n</i> -octanal	9.86	0.18	ND	ND	ND	983
21	Hexanoic acid ethyl ester	9.95	0.44	ND	0.08	ND	985
22	Decahydro naphthalenol	10.04	0.26	ND	ND	0.13	987
23	Unidentified	10.38	1.18	0.30	ND	0.15	993
24	Acetic acid hexyl ester	10.61	0.90	0.24	ND	ND	998
25	Benzene (1,2 propenyloxy)methyl	11.10	8.24	ND	1.47	3.19	1008
26	Benzylalcohol	11.42	0.34	0.62	ND	ND	1015
27	Unidentified	11.54	0.38	4.93	0.09	0.22	1018
28	2,3, butanediol diacetate	13.33	0.22	0.23	ND	ND	1053
29	6-nonenal	14.89	5.92	3.00	0.09	0.30	1080
30	Nonanal	15.16	2.50	0.81	ND	0.15	1084
31	1-phenyle pentane 2-one	15.35	1.01	0.76	0.26	0.38	1087
32	Unidentified	17.54	0.38	ND	ND	0.11	1125
33	2,6,nonadienal	17.66	4.79	2.16	0.06	0.73	1127
34	4-methyl-2-oxovaleric acid	17.92	0.56	0.28	0.10	0.17	1132
35	<i>Trans</i> -2-nonenal	18.22	1.36	0.48	ND	0.25	1137
36	Oxirane-5-hexenyl	18.44	0.78	0.22	0.09	0.28	1141
37	<i>Cis</i> -6-nonenal	19.45	3.21	0.73	ND	0.18	1157
38	Nonanol	19.68	3.16	1.03	0.12	0.47	1161
39	Benzene propanol	22.28	1.71	0.29	0.47	0.85	1200
40	5-decenol	22.78	2.27	0.80	0.36	0.15	1209
41	Unidentified	26.71	0.65	0.35	ND	ND	1273
42	Nonanoic acid	26.86	0.71	ND	0.44	ND	1275
43	Unidentified	27.06	0.45	ND	ND	0.21	1278
44	Unidentified	27.39	0.37	ND	1.21	0.24	1283
45	<i>Cis</i> -6-nonenol	27.86	0.58	ND	0.08	0.61	1289
46	Nonyl acetate	28.31	0.27	ND	ND	1.71	1296
47	<i>Trans</i> caryphyllene	34.77	0.25	ND	0.07	0.17	1401
48	Ethyl laurate	45.16	0.53	ND	0.13	0.17	1581
49	2-ethyl hexyl, 2-ethyl hexanoate	45.86	0.70	ND	0.22	0.31	1593

Table 1 (continued)

S. no	Compound	Retention time	Fresh	Heated	Retort pouch	Canned	Kovats index
50	9-hexadecenoic acid methyl ester	60.91	0.37	ND	0.47	0.85	1885
51	Heptadecanoic acid	62.21	0.25	ND	0.17	0.18	1912
52	9-hexadecenoic acid	63.03	1.27	ND	12.40	3.39	1930
53	Ethyle,9-hexadecenoate	64.23	4.45	ND	3.86	12.06	1955
54	Hexadecanoic acid	64.42	5.63	ND	ND	0.46	1959
55	Unidentified	64.61	0.20	ND	ND	ND	1964
56	Unidentified	64.66	0.96	ND	ND	ND	1965
57	Hexadecanoic acid ethyl ester	65.48	0.89	0.25	25.29	38.71	1982
58	Unidentified	69.55	0.18	ND	0.28	ND	2071
59	9,12,15-octadecatrienoic acid methyl ester (Z,Z,Z)	69.71	0.87	ND	1.60	2.28	2108
60	Linoleic acid ethyl ester	72.58	0.82	ND	16.55	9.35	–
61	9,12,15-octa decatrienoic acid ethyl ester	72.74	5.10	0.68	5.00	4.69	–
62	Unidentified	73.27	0.46	ND	1.07	0.75	–

ND not detected

of muskmelon puree (Jordan et al. 2001). Principal aroma contributing compounds observed in *Cucumis melo* fruit were methyl acetate, ethyl acetate, 2-ethyl acetate, methyl 3-propanoate, ethyl 3-propanoate and 3-propyl acetate (Wyllie and Leach 1992).

Aroma analysis of two muskmelon varieties (calypso and pamiir) at three different stages of maturity viz., unripe, ripe and over ripe showed correlations between sensory descriptor and aroma compounds mainly with total esters (0.66–0.69), formates (0.70) and acetates (0.64 & 0.72). Esters were the principal flavor compounds detected which increased 10–15 folds from unripe to ripe and over ripe stages. Ripening also increased soluble solids content from about 10°brix in unripe samples to about 15° brix (Senisi et al. 2005). Quantitative distribution of volatile compounds in the peel and puree of Queen Anne's pocket melon (*Cucumis melo* var. *dudaim* Naudin) indicated presence of volatile compounds comprising of esters (20), alcohols (15), lactones (7), aldehydes (7) ketones (7) and organic sulfur compounds (6). Distribution of

volatiles in melon peel was significantly higher than puree. Eugenol, thioesters and lactones were mainly attributed to the aroma of the pocket melon (Aubert and Pitrat 2006). Sulfur compounds are reported to play an important role in the overall aroma profile of orange fleshed *Cucumis melo* L. var. *Cantaloupensis* (Homatidou et al. 1992). Thermally processed muskmelon puree in cans and retort pouches showed increase in the esters content to 29.35 %, the esters were found in the range of 77 % and 53.35 % respectively. High ester content in packaged puree as compared to fresh and heated samples could be due to the sealed packaging system of can which protected the esters. Aldehydes content (18.57 %) of fresh puree reduced to 8.21 % in heated puree and further reduced in the canned (1.75 %) and retort (0.24 %) processed samples. Reduction of aldehydes could be due to the possible conversion of aldehydes to other oxidized compounds. Presence of aliphatic alcohols in the processed samples could also be attributed to thermal processing and the changes associated with it. Similar trend was observed with the heterocyclic, sesquiterpenes, phenolic compounds and carboxylic compounds. Aroma compounds such as sulfur and six-carbon chain containing esters were reported in cantaloupe melons; it appears that aroma compounds are specific to cultivars. Compounds with straight nine-carbon chain were reported in honey dew melons, whereas methyl esters were found in galia melons (Javier Obando-Ulloa et al. 2009).

Conclusion

Muskmelon puree showed the presence of more than 49 volatile constituents including esters, aldehydes, aliphatic alcohols, phenolic compounds and sesquiterpenes. Esters and aldehydes could be responsible for the characteristic fruity

Table 2 Composition of major volatile compounds in muskmelon puree with different treatments

Compound	Fresh	Heated	Retort pouch	Canned
Aldehydes	18.57	8.21	0.24	1.61
Esters	27.29	29.35	53.35	77
Aliphatic alcohols	11.72	25.12	1.21	2.61
Heterocyclic	16.63	1.91	2.14	4.81
Sesquiterpenes	0.25	ND	0.07	0.17
Phenolic	6.03	2.15	1.92	2.48
Carboxylic	8.64	2.53	13.11	4.2
Alicyclic alcohol	0.26	ND	ND	0.13

ND not detected

flavor of muskmelon puree. The overall volatile constituents of the muskmelon puree were affected due to the thermal processing. Volatile components profiles of puree changed with the packaging material viz., cans and retort pouches. Thermal processing retained the desirable aroma constituents to some extent such as aldehydes (8.21 %), esters (29.35 %) and aliphatic alcohols (25.12 %) in the muskmelon puree. The proportion of esters increased as compared to the aldehydes and aliphatic alcohols in puree processed in cans and retort pouches. It is evident from the study that retention of important volatiles was affected by the processing conditions and packaging material used. The investigation showed that suitable thermal processing protocols can be adopted for minimizing the loss of potential volatile constituents of muskmelon puree.

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