Aroma Volatile Compounds Profile of Melon \((Cucumis melo\) L.) cv. Gama Melon Parfum

U H A Hasbullah\(^1\), Supriyadi\(^2\), B S Daryono\(^3\)

\(^1\)Department of Food Technology, Faculty of Engineering and Informatics, Universitas PGRI Semarang, Jl. Sidodadi Timur No. 24 Semarang 50125, Indonesia
\(^2\)Department of Food and Agricultural Product Technology, Faculty of Agricultural Technology, Gadjah Mada University, Jl. Flora No. 1 Yogyakarta 55281, Indonesia
\(^3\)Genetic Laboratory, Faculty of Biology, Gadjah Mada University, Yogyakarta, Indonesia

Abstract. Aromatic volatile compound from melon \((Cucumis melo\) L.) cv. Gama Melon Parfum (GMP) has not been identified. The purpose of this study is to identify aromatic volatile profile and measure the key pleasant aroma of GMP melon. Sample was taken from garden then store at temperature -20°C. The volatile compounds was extracted by cold maseration method, then concentrated using vigorous column. Volatile extract was analysed using GC-MS-Olfactometry. The result showed that some identified aromatic volatile compounds consisted of 3 alcohols, 3 esters, 1 ketone and 1 hydrocarbon. Interestingly, the key aroma characteristics of GMP melon was influenced by 3-penten-2-ol, hexyl acetate and 3-hydroxy 2-butanoone.

Keywords: \(Cucumis melo\) L. cv. Gama Melon Parfum; aromatic volatile; GC-MS-Olfactometry

1. Introduction

Melon consisted of a lot of cultivars that have a wide range of flavor attribute. Taste and aroma is the most important factor for consumer preferences of melon. GMP cultivar has known a powerful pleasant aroma when ripe. This cultivar is made from cross-breeding Natsumo Omoide and Miyamauri and has been developing in Indonesia.

Some aromatic volatiles from melon has been identified and dominated by acetic esters and non-acetic esters [1][2]. Characteristic impact flavor and aroma compounds (CIFACs) of melon consisted of 26 compounds i.e., ethyl 2-methylpropanoate, methyl 2-methylbutanoate, ethyl butanoate, ethyl 2-methylbutanoate, ethyl hexanoate, 3-methylbutyl acetate, 2-methylbutyl acetate, hexyl acetate, \((E)\)-3-hexenyl acetate, \((Z, Z)\) 3,6-nonadienyl acetate, benzyl acetate, eucalyptol, \((Z)\)-6-nonenol, \((Z, Z)\)-3,6-nonadienol, \((E)\)-2-hexenal, \((Z)\)-3-hexenal, \((Z)\)-6-nonenal, \((E, Z)\)-2,6-nonadienial, \((E)\)-2-nonenal, S-methyl thiobutanoate, 3-(methylthio) propanal, ethyl 2-(methylthio) acetate, ethyl 3-(methylthio) propanoate, 3-(methylthio) propyl acetate, \((Z)\)-1,5-octadien-3-one [3]. Alcohols, aldehydes, ketones, sulfur-derived compounds, lactones, and C6 compounds a re also identify from skin and pulp of melon [4].
Composition of Aromatic volatile compounds from GMP melon has not been identified yet. The goal of this work was to identify aromatic volatile profile and measure the key pleasant aroma of GMP melon.

2. Materials and Methods

2.1. Samples

The samples of the present study were Ripe melons (*Cucumis melo* L. cv. Gama Melon Parfum) harvested from Kebun Pendidikan, Penelitian dan Pengembangan Petanian (KP4) UGM Berbah, Yogyakarta. They were sent to laboratory soon. In the laboratory, the rind of the fruits was then delicately removed from flesh. Rind and flesh were then immediately frozen with liquid nitrogen and stored at -20°C until analysis.

2.2. Isolation of volatiles

Frozen samples were added with liquid nitrogen (Samator), and then homogenized. Fifty g of samples were mixed with 120 ml of dichloromethane/ pentane solvent mixture (1:2, v/v) (Ajax, Australia). Then, 5 μl 1-octanol (4.12 mg/5 μl) (Sigma) was added as an internal standard into the solution. The released volatiles were extracted using cold maceration at -20°C for 24 h. The volatile extract was decanted and initially dried over anhydrous sodium sulphate (Merck, Germany). The extract was concentrated to 5 ml using vigregous column and store in the dark glass vial at -20°C until analysis.

2.3. Gas chromatography-mass spectrometry-olfactometry (GC-MS-O) analysis

The extract of aromatic volatile compounds was analysed using GC-MS-Olfactometry (Agilent Technologies 7890A with MS 5975C insert XL EI/CI MSD with triple axis detector) equipped with sniffing port. The extract (2 µl) was injected with a splitless mode. The injection temperature was maintained at 250°C. The fused capillary column HP-INNO wax (30 m x 0.25 mm; film thickness 0.25 µm) was used for separation. The initial oven temperature was 40°C, followed by a ramp of 3°C/min up to 80°C, held for 1 min, and then at 5°C/min up to 130°C, held for 2 min, and then at 6°C/min to reach a final temperature of 240°C, which was held for 5 min. The carrier gas was helium with a flow rate of 1 ml/min. Mass spectra were obtained by electron ionization (EI) at 70 eV, and a spectrum range of 33-550 m/z was used. The detector worked at 280°C. Olfactometry detection was started at 10 min until finished. The peaks were identified using a mass spectrometer coupled to the GC by comparison of experimental spectra with those of National Institute for Standards and Technology (NIST05a) data bank. The retention time from a series of straight-chain alkanes was used under identical conditions to calculate the Retention indices (RI) for all identified compounds.

3. Result and Discussion

3.1. Results

3.1.1. Aromatic volatile compounds profile

The results showed that five volatile compounds were detected in the flash (*Table 1*). The compounds consisted of 2 alcohols, 1 ketone, 1 hydrocarbon, and 1 chloride. Identification of rind showed that there were 57 compounds detected (*Table 2*). HP INNO wax column has caused much amount of esters detected. Separation with this column was able to separate 15 esters, 6 alcohols, 6 acids, 2 aldehydes, 1 ketone, 3 sulfurs, 2 phenols, 4 terpenoids and isoprenoids, 2 chloride, 15 hydrocarbons and 1 phthalate (*Fig. 1*). Based on this result, the rind was selected to determine GMP aroma.
Table 1: Volatile compounds profile in flash of ripe GMP melon

| Compounds name          | CAS        | RI   |
|-------------------------|------------|------|
| **Alcohols**            |            |      |
| 2-hexanol               | 000626-93-7| 1242 |
| 3-pyrrolidinol          | 040499-83-0| 1302 |
| **Keton**               |            |      |
| 3-hydroxy-2-butanone    | 000513-86-0| 1218 |
| **Hydrocarbon**         |            |      |
| 3-methoxy-2-methyl-1-propene | 022418-49-1| 1111 |
| **Chlor**               |            |      |
| 1,2-dichloro-ethane     | 000107-06-2| 1018 |

Fig. 1. Relative percentage class of volatile compounds in GMP rind.

3.1.2. Pleasant aroma compounds by olfactometry

Eight aroma compounds were identified in olfactometry (Fig. 2). The compounds were 3 alcohols (3-penten-2-ol, 1-octanol and Z-4-dodecenol), 3 esters (ethyl hexanoate, hexyl acetate and hexyl hexanoate), 1 keton (3-hydroxy-2-butanon) and hydrocarbon ((Z)-3-methyl 2-undecen) (Table 3).
| Compounds name                        | CAS       | RI   | Compounds name                        | CAS       | RI   |
|---------------------------------------|-----------|------|---------------------------------------|-----------|------|
| **Esters**                            |           |      | **Sulfurs**                           |           |      |
| ethyl butanoate                       | 000105-54-4 | 1005 | ethyl (methylthio)acetate             | 004455-13-4 | 1376 |
| ethyl hexanoate                       | 000123-66-0 | 1188 | divinyl sulfide                       | 000625-51-0 | 2269 |
| hexyl acetate                         | 000142-92-7 | 1223 | ethyl (methylthio)acetate             | 004455-13-4 | 2071 |
| (Z)-3-hexen-1-ol acetate             | 003681-71-8 | 1261 |                                     |           |      |
| hexyl formate                         | 000629-33-4 | 1314 |                                     |           |      |
| octyl acetate                         | 000112-14-1 | 1412 | δ-cadinene                           | 000483-76-1 | 1710 |
| hexyl hexanoate                       | 006378-65-0 | 1557 | (+)-epi-bicyclosesquiphellandrene    | 054324-03-7 | 1966 |
| decyl acetate                         | 000112-17-4 | 1619 | d-camphene                           | 005794-03-6 | 2030 |
| (Z)-3-decen-1-ol acetate             | 081634-99-3 | 1637 |                                     |           |      |
| 3-phenyl-1-propanol acetate           | 000122-72-5 | 1848 | 2-methoxy-3-(2-propenyl)-phenol       | 001941-12-4 | 2056 |
| 2-propen-1-ol 3-phenyl- acetate       | 000103-54-8 | 2042 | 4-(2-propenyl)-phenol                | 000501-92-8 | 2217 |
| methyl hexadecanoate (methyl palmitate) | 000112-39-0 | 2139 |                                     |           |      |
| ethyl 9,12-octadecadienoate           | 007619-08-1 | 2432 | 1,2-dichloro-ethane                  | 000107-06-2 | 1027 |
| ethyl linolenate                      | 001191-41-9 | 2487 | 1-chloro-heptacosane                 | 062016-79-9 | 2173 |
| cyclobutyl hexadecyl oxalate          | 1000309-70-6 | 2531 |                                     |           |      |
| **Alcohols**                          |           |      | **Phenols**                           |           |      |
| 3-penten-2-ol                         | 001569-50-2 | 1119 | ethylhexyl-2-ethyl-2-propenyl acetate | 000695-15-2 | 1437 |
| 4-methyl-2-pentanol                   | 000108-11-2 | 1252 | (E)-3-decen-1-yne                    | 002807-10-5 | 1689 |
| 1-octanol                             | 000111-87-5 | 1514 | cyclohexene                          | 003618-12-0 | 1732 |
| benzy1 alcohol                        | 000100-51-6 | 1792 | (E)-cyclohexene,                     | 001486-75-5 | 1834 |
| 1-hexadecanol                         | 036653-82-4 | 1814 | (E,E,E)-1,4,8-dodecatriene           | 024252-85-5 | 1920 |
| 3-cyclohexene-1-ethanol               | 018240-10-3 | 1863 | 1,1′-bicyclopentyl                    | 001636-39-1 | 1949 |
| **Acids**                             |           |      | E,1,9-dodecadiene                    | 1000245-70-8 | 1956 |
| acetic acid                           | 000064-19-7 | 1380 | 10-methyl nonadecane                 | 056862-62-5 | 2106 |
| (S)-2-hydroxy-4-methyl-pentanoic acid | 013748-90-8 | 1498 | heneicosane                          | 000629-94-7 | 2112 |
| butanoic acid                         | 000107-92-6 | 1549 | heptacosane                          | 000593-49-7 | 2171 |
| hexanoic acid                         | 000142-62-1 | 1751 | tetratetracontane                    | 007908-22-8 | 2130 |
| nonheaxacontanoic acid                | 040710-32-5 | 2507 | eicosane                             | 000112-95-8 | 2315 |
| nonhexacontanoic acid                 | 040710-32-5 | 2541 | 1,5-dibromo-tetrapentacontane        | 1000156-09-4 | 2360 |
| **Aldehydes**                         |           |      | 1,5-dibromo-tetrapentacontane        | 1000156-09-4 | 2546 |
| benzaldehyde                          | 000100-52-7 | 1446 |                                     |           |      |
| (Z)-9,17-Octadecadienal               | 056554-35-9 | 2398 | didodecyl phthalate                  | 002432-90-8 | 2561 |
| **Keton**                             |           |      |                                     |           |      |
| 3-hydroxy-2-butanone                  | 000513-86-0 | 1229 |                                     |           |      |

**Table 2. Volatile compound profile in the rind of ripe GMP melon**
Fig. 2. Chromatogram of aroma compounds by GC-O.

Table 3. Aroma compounds identified from GMP melon by GC-O

| Compounds          | Concentration (ug/kg) | Odor Threshold (ppb) | % Area | OAV | Aroma Response | Odor Description Reference | Aroma Intensity |
|--------------------|-----------------------|----------------------|--------|-----|----------------|----------------------------|-----------------|
| **Alcohols**       |                       |                      |        |     |                |                            |                 |
| 3-penten-2-ol      | 421.4                 | 48                   | 2.36   | 8.78| sweet, fruity  | green vinyl<sup>b)</sup>    | medium (5)      |
| 1-octanol          | 865.62                | 110-130              | 4.85   | 6.66| green, sweet   | waxy, green, citrus, aldehydic and floral with a sweet, fatty, coconut nuance<sup>b)</sup> | rather medium (4) |
| Z-4-dodecenol      | 58.94                 | -                    | 0.79   | -   | Sour           |                            | rather medium (4) |
| **Esters**         |                       |                      |        |     |                |                            |                 |
| ethyl hexanoate    | 72.61                 | 1                    | 0.41   | 72.6| creamy, sweet  | sweet, fruity, pineapple, waxy, fatty and estery with a green banana nuance<sup>b)</sup> | weak (3)        |
| hexyl acetate      | 312.85                | 2                    | 1.75   | 156 | sweet, flowery | green, fruity, sweet, fatty, fresh, apple and pear<sup>b)</sup> | medium (5)      |
| hexyl hexanoate    | 70.96                 | 820                  | 0.40   | 0.09| fruity, green  | green, sweet, waxy, fruity with tropical and berry notes<sup>b)</sup> | rather medium (4) |
| **Ketone**         |                       |                      |        |     |                |                            |                 |
| 3-hydroxy 2-butanone | 1142.17            | 800                  | 6.40   | 1.43| acid, fruity   | sweet buttery creamy dairy milky fatty<sup>b)</sup> | medium (5)      |
| **Hydrocarbon**    |                       |                      |        |     |                |                            |                 |
| (Z) 3-methyl 2-undecene | 27.27             | -                    | 0.36   | -   | green          |                            | weak (3)        |

Note: OAV = Odor Active Value (ratio of the concentration of aroma compound and the OT of the compound)

source:  <sup>a)</sup> Leffingwell and Associates (www.leffingwell.com),  <sup>b)</sup> thegoodscentscompany.com
3.2. Discussion

3.2.1. Compounds profile by GC-MS

Esters and hydrocarbons dominated in the GMP rind at ripening, followed by alcohols and terpenoids and isoprenoids (Fig. 1). This profile showed that there were many esters and fewer alcohols and acids. It is probably due to esterification between alcohols and acids forming esters at ripening stage. Phthalate detected is possibly derived from residues of pesticides used during cultivation. Compounds that having the odor active value (OAV) more than one from acetate esters are hexyl acetate and octyl acetate, ester group nonacetate including ethyl butanoate and ethyl hexanoate, alcohols including 3-penten-2-ol and 1-octanol, ketone including 3-hydroxy 2-butanoone, sulfur including ethyl (methylthio) acetate and chlor including 1,2-dichloro-ethane (ethylene dichloride). Acetate esters and nonacetate esters had a OAV in the range 70-1500, this value was very large compared alcohols, ketone, sulfur and chlor. Esters gave potential fruity aroma contribution on GMP melon. Acetate esters dominated of all esters (Table 4). Acetate esters presented in 69.19% while nonacetate esters presented in 30.81% by total esters. The dominance of acetate esters in ripe melon has also been reported [5][1][6].

| Table 4: Percentage of acetate and nonacetate esters in ripe GMP rind |
|---------------------------------|--------|
| **Esters group**                | %      |
| **Acetate Esters**              |        |
| (Z)-3-decen-1-ol, acetate       | 25,00  |
| octyl acetate                   | 22,20  |
| decyl acetate                   | 10,00  |
| hexyl acetate                   | 7,28   |
| 3-phenyl-1-propanol, acetate    | 1,85   |
| 3-phenyl-2-propen-1-ol, acetate | 1,77   |
| (Z)-3-hexen-1-ol, acetate       | 1,08   |
| **Total**                       | 69,19  |
| **Nonacetate Esters**           |        |
| methyl hexadecanoate            | 3,19   |
| ethyl butanoate                 | 3,72   |
| ethyl hexanoate                 | 1,69   |
| ethyl linolelaidate             | 5,48   |
| ethyl linolenate                | 8,68   |
| hexyl formate                   | 5,88   |
| hexyl hexanoate                 | 1,65   |
| cyclobutyl hexadecyl oxalate    | 0,52   |
| **Total**                       | 30,81  |

Acetate esters were dominated by (Z) 3-decen-1-ol acetate (25%) then octyl acetate (22.2%) and decyl acetate (10%). While the nonacetate esters were dominated by ethyl linoleate (8.68%). Volatile esters are formed during the alcohol esterification by alcohol acyltransferase (AAT) [7]. This process uses CoA moiety or CoA-ester as acyl donors during ripening [3]. Volatile flavor esters can be formed by reaction between alcohols and short-chain fatty acids by catalytic alcohol acyl CoA-acyl transferase on phospholipid catabolism when fruits become ripe [8]. Acetate esters were formed from the esterification between acetic acid with alcohols (hexanol, octanol, decanol, 3-decen-1-ol, 3-phenyl-1- propanol, 3-phenyl-2-propene-1-ol and 3-hexen- 1-ol). Acetic acid and alcohols were formed as the result of lipid catabolism when the fruits ripened.
Nonacetate esters were formed from alcohols derived from the catabolism of lipids such as ethanol, hexanol, methanol, and cyclobutyl hexadecanol. Nonacetate esters formed were dominated by esterificated of ethanol with fatty acids of lipid catabolism result such as butanoic acid, hexanoic acid, linolelaic acid and linolenic acid. Hexanol reacted with formic acid and hexanoic acid, which were fatty acids derived from the catabolism of lipids to form esters. Methanol reacted with hexadecanoic acid to form ester. Cyclobutyl hexadecanol reacted with oxalic acid which was an organic acid that was formed from the citric acid cycle to form ester.

Detected alcohols which had OAV>1 (range value 7-9) gave green dominant aroma contribution. Alcohols are derived from aldehydes reduction catalyzed by alcohol dehydrogenase (ADH) [9][10] and also from a product of the lipids catabolism [8][11]. Ketones had OAV 1.4 which contributed to the sweet aroma. Volatile ketones can be formed from the biosynthesis intermediate product of leucine, valine and pantothenate or lipid metabolism product [11].

Sulfurs had OAV 4.8 which contributed sulfurous aroma. Volatile sulfurs can be formed from sulfur-containing amino acids such as cysteine/cystine and methionine, reducing sugar and thiamin (vitamin B1) [11]. Sulfurs are thioester formed from the conversion of L-methionine experiencing demethiolation activity to be α-ketobutyrate and CH3SH then reacts with Amyl-CoA (Acetyl-CoA) derived from fatty acids, sugars or amino acids [11]. Chlorines had OAV 77.5 that gave chloroform aroma to the extract. The compound 1,2-dichloro-ethane is possible comes from the solvent used for volatile compounds extraction.

3.2.2. Pleasant aroma key compounds by olfactometry

Detected aromatic alcohols are derived from the metabolism of fatty acids such as linoleic acid and linolenic acid and also sugar [11]. Formation of alcoholic volatile from fatty acids can occur in three different oxidation pathways: (1) α- and β-oxidation, (2) oxidation catalyzed lipoxygenase (LOX) and (3) autooxidation [12]. 1-Octanol can be formed from the conversion of octanoic acid into ketones by acyl-thiokinase, then converted by acyl-CoA reductase into octanal, then converted by alcohol-NAD oxydoreductase into 1-octanol in the presence of NADH [11].

Detected aromatic esters are from esterification of alcohol in metabolism of fatty acids, amino acids and sugars with short chain fatty acids of lipid catabolism results. Hexyl acetate and hexyl hexanoate formed from the esterification hexanol with acetic acid and hexanoic acid. Ethyl hexanoate compound is formed from the esterification reaction of ethanol with hexanoic acid. Hexyl esters are formed from the oxidation of linoleic acid and linolenic acid by lipoxygenase (LOX) catalysis to form hexanol then esterified by fatty acids. Linoleic acid undergoes oxidation by LOX catalysis form hexanal which can turn into haxanoic acid. In addition, linoleic acid also experiences β-oxidation forming hexanoic acid. Hexanoic acid is then esterified with fatty acids forming hexanoic esters [13]. Detected aromatic ketones were 3-hydroxy-2-butanoate or acetoin. Generally, ketones are intermediate products of oxidation reaction of the acid that will be converted into alcohols, Aldehydes, and esters by a series of enzyme systems in plants [11]. Detected aromatic hydrocarbons were (Z)-3-methyl-2-undecen. Hydrocarbons are supposedly formed from lipids oxidation [14].

Aroma compounds with the greatest intensity were 3-penten 2-ol, hexyl acetate and 3-hydroxy 2-butanoate. The compound 3-penten 2-ol has odor threshold 48 ppb. It was detected in sniffing with sweet and fruity aroma interpretation with an area of 2.36% and OAV 8.78 (> 1). Hexyl acetate has odor threshold 2 ppb. It was detected in sniffing with sweet-flowery aroma interpretation with an area 1.75% and OAV 156 (> 1). The compound 3-hydroxy 2-butanoate has odor threshold 800 ppb and was detected in sniffing with acid-fruity aroma interpretation with an area 6.4% and OAV 1.43 (> 1). The compound 3-penten 2-ol and hexyl acetate had odor threshold greater than ethyl hexanoate, but those had percent area of total ion chromatogram greater than ethyl hexanoate. This led to the intensity
detection of two compounds is greater than ethyl hexanoate. Meanwhile, 3-hydroxy 2-butanone has very large odor threshold (800 ppb), but it has great percent area of the total ion chromatogram. This compound has a large percent area so that although odor threshold was large, detected in sniffing should be greater intensity than the ethyl hexanoate.

The compound 3-penten-2-ol has sweet and fruity aroma response. Thegoodscentscompany described compound 3-penten-2ol aroma was green vinyl. Narain et al. [15] reported that 3-penten 2-ol has fruity, acrid, pungent odor description. Le Guen et al. [16] reported that this compound had grilled odor description. Kesen et al. [17] describe as green, grassy. These compounds were found also in yellow passion fruits [15], mussels (Mytilus edulis) [16] and olive oil [18].

Hexyl acetate has sweet and flowery aroma response. The good scents company described the aroma as green, fruity, sweet, fatty, fresh, apple, and pear. Andreu-Sevilla et al. [19] reported that hexyl acet had apple, cherry, floral, pear odor description. Cai et al. [20] reported that the odor description of hexyl acetate was apple, cherry, pear, floral. Jiang et al. [21] report it as a pleasant fruity and pear. Welke et al. [22] described as apple, cherry, pear, floral. Narain et al. [15] described as a banana, fruity, cherry, sweet fruity berry, and pear-like odor, milder amyl acetate, less natural, slightly floral and green. Jiang et al. [21] and Welke et al. [22] reported that threshold value of hexyl acetate was 670ug/l.

Hexyl acetate was also found in some types of melons, i.e., orange-flesh netted cantaloupes (Cucumis melo L. var. reticulatus Naud. Cv. Sol Real) [23][5][3], Israeli Galia melon cultivars (Cucumis melo var. reticulans , cv. C8 and cv. 5080) [24], three cultivars of muskmelon: Galia (C. melo var. reticulatus Naud.), orange-fleshed cantaloupe (C. melo var. cantalupensis Naud.) and honeydew (C. melo var. inodorus Naud.) [25], oriental sweet melons (Cucumis melo var. makuwa Makino) cv. Yumeiren [7], C. melo var. inodorus cv. Piel de Sapo Naud, C. melo ssp. Conomon Group cv. Shongwan Charmi (PI 161 375), Galia melon (C. melo var. reticulates cv. Fado F1), Charentais type (C. melo var. cantalupensis Naud, cv. V'edrantais) and near-isogenic lines (NILS) [26][27], netted muskmelons (Cucumis melo var. reticulatus cv. Earl's Together) [28], muskmelon (Cucumis melo, cv. Reticulatus Naud) cv. Mirado and Rony [29], transgenic melon (Cucumis melo var. makuwa Makino) cv. Yumeiren and Tianbao [32], five Cucurbita maxima × Cucurbita moschata hybrids (Polifemo, AS10, RSS841, P360 and ELSI) and two melon genotypes (Energia and Sting) [33], muskmelons (C. melo L., reticulatus group) cv. Navigator, Mas Rico and Thunderbird [34], as well as 15 cultivars of Charentais cantaloupe melons (Cucumis melo var. cantalupensis Naud.) [35][36].

Hexyl acetate was also found in other fruits and plants, i.e. nine strains of Fuji apple (Malus domestica Borkh.) [37], emitted fruit volatile compounds and endogenous rind apple cv. Tsugaru ripe [38], apple cv. Jonagold [39] cv. Fuji and Granny Smith [40], peach (Prunus persica L. Batsch cv. Tardibelle) [41], Olive fruits (Olea europaea L.) cv. Verdial [42], leaves of Arabidopsis thaliana [43], Chilean strawberries (F. chiloensis spp. chiloensis) [44], as well as Mountain papaya (Vasconcellea pubescens) [45].

The compound 3-hydroxy 2-butanone has aroma response acid, fruity. Thegoodscentscompany describes that aroma is sweet buttery creamy milky fatty dairy. Cai et al. [20] described the aroma compound 3-hydroxy 2-butanone or acetoin as buttery, fatty. Duarte et al. [46] described as fatty, moldy, wood. Sharma et al. [47] described as buttery/cut ash gourd type. Welke et al. [22] described as buttery, cream. Narain et al. [15] described as fruity, moldy, woody, fresh, like butter. Cai et al. [20] reported that the odor threshold acetoin was 150,000 ug/l. Duarte et al. (2010) [46] reported a threshold of 152.600 ug/l. Welke et al. [22] reported that the threshold was 150,000 ug/l. Cano-García et al. [48] reported that the threshold was 800 ng/g in the air. Leffingwell and Associates reported the threshold was 800 ppb in the water.
The compound 3-hydroxy 2-butanone was also found in Charentais cantaloupe melons (Cucumis melo var. cantalupensis Naud.) cultivars Figaro, Cézanne, Nogaro, Escrito, Anasta, Lunabel, Sirio, Person, Stromboli, Aneto, Colt, Dalton, Etna, Kousto and Tobbia [35], Queen Anne's pocket melon (Cucumis melo var. dudaim L. Naudin) [4], yellow passion fruit [15], unprocessed avocado puree and it was many presented in ripe pineapple [49], presented in large numbers and contributed to the aroma of the ash gourd fruit / winter melon (Benincasa hispida) [47], lychee juice fruits (L. chinensis Sonn. var. Nuomi Ci) [50], and gooseberries (Ribes uva crispa L.) [51].

4. Conclusion
This study has demonstrated that volatile compound profile of GMP rind consisted of alcohols (3-penten-2-ol, 1-octanol and Z4-dodecenol), esters (ethyl hexanoate, hexyl acetate and hexyl hexanoate), ketone (3-hydroxy 2-butanon) and hydrocarbon ((Z) 3-methyl 2-undecen). The pleasant key aroma of GMP was influenced by 3-penten-2-ol, hexyl acetate and 3-hydroxy 2-butanon.

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