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# Influence of the cultivation system in the aroma of the volatile compounds and total antioxidant activity of passion fruit

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# ABSTRACT

The aim of this study was to investigate the influence of the cultivation system on the volatile composition of the passion fruit and to determine the odoriferous contribution of the compounds for the aroma of the organic and conventional fruit, besides to assess the total antioxidant activity. The volatile compounds were isolated from dynamic headspace, separated by high-resolution gas chromatography and the odoriferous contribution to the passion fruit aroma was evaluated using the OSME technique. Total antioxidant activity was determined using the ABTS radical reaction. The organic and conventional passion fruit showed similar volatile profile, although some differences occurred. Ethyl 2-propenoate, 2methyl-1-propanol, diethyl carbonate and ethyl hexanoate were threefold higher in the organic fruit while butyl acetate, hexanal, cis-3-hexenyl acetate and trans-3-hexenyl butanoate were threefold higher in the conventional fruit. Hexanoate and acetate esters, and saturated alcohols described as fruity, sweet, citrus and passion-fruit aroma showed the highest odorific intensity in the organic fruit. Furthermore, trans and cis-3-hexenyl acetate and alpha-copaene, alpha-terpineol, D-limonene, trans-beta-ocimene and delta-cadinene had higher contribution to the organic passion fruit aroma. On the other hand, unsaturated alcohols, beta-myrcene and beta-linalool described as grass, sulfur-like and passion-fruit aroma were higher in the conventional fruit. The organic passion fruit showed higher levels of total phenolic compounds and total antioxidant activity than the conventional fruit, suggesting that the cultivation system influenced the production of antioxidant bioactive compounds.

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# 1. Introduction

Organic foods have been gaining popularity among health and environment conscious consumers who prefer foods of high nutritional and sensory quality without chemical residues used in production agriculture (IFOAM, 2010). The world market of organic foods has an annual turnover of around US\$ 30 billion. The Brazilian market represents about US\$ 250 million, but this is growing at 25% a year, particularly passion fruit, mango, guava, papaya, banana, grape, strawberry and citrus fruit. Most Brazilian organic foods are exported to Europe, the United States, Canada and Japan. Seventy percent of the organic producers in the country are small producers and most of the certified organic growers are concentrated in the southeast and southern regions, especially in the state of São Paulo (IBD, 2010). Brazil is the largest producer and consumer of passion fruit in the world. The economically most important form of passion fruit (*Passiflora edulis* Sims f. *flavicarpa* Deg.) is responsible for 95% of the cultivation area, grown by organic or conventional systems. Passion fruit is consumed as in natura fruit and used to produce industrialized juice and other fruit products (Meletti & Maia, 1999), being very appreciated mainly because of the exotic, flowery and fruity aroma.

Many studies have reported that organic products have superior nutritional and sensory quality than conventional products (Amaro & Monteiro, 2001; Asami, Hong, Barrett, & Mitchell, 2003; Carbonaro & Mattera, 2001; Dani et al., 2007; Santos & Monteiro, 2004). It can be attributed to the favored synthesis of bioactive compounds from the secondary metabolism in response to the stressful conditions inherent to the organic cultivation system, such as the lack of use of pesticides and fertilizers, among others. This may lead to important changes in the physicochemical characteristics and in the composition of the volatile compounds, such as terpenes and esters, important for the characteristic aroma of fruit (Briskin, 2000; Engelberth, 2006).

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The influence of the variety, post-harvest period and processing on the passion fruit volatile profile has been reported (Narain, Almeida, Galvão, Madruga, & Brito, 2004; Pino, 1997; Shibamoto & Tang, 1990; Winterhalter, 1991). The importance of the volatile compounds derived from the terpenes, from the breakdown of carotenoids and from the sulfur compounds for the characteristic aroma of passion fruit has also been reported (Engel & Tressl, 1991; Werkhoff, Güntert, Krammer, Sommer, & Kaulen, 1998).

Even though a wide range of studies have been published on the volatile compounds of yellow passion fruit, few have made use of the CG-O technique (gas chromatography-olfactometry) to identify which odoriferous compounds are important for the aroma. The olfactometric technique OSME allows the odoriferous importance of each volatile compound to be determined by associating chromatographic peaks to the odor intensity responses of a selected and trained panel of judges, so that the impact of each volatile compound on the overall aroma of the fruit can be assessed (Le Guen, Prost, & Demaimay, 2000; McDaniel, Miranda-Lopez, Watson, Micheals, & Libbey, 1990; Van Ruth & O'Connor, 2001). The passion fruit produced by conventional system has been analyzed by CG-O-AEDA (Jordán, Goodner, & Shaw, 2002) and CG-O-OSME (Jales et al., 2005) techniques. However, no research has been published using these methods to relate the passion fruit volatile composition to the cultivation system.

The aim of this study was to investigate the influence of the cultivation system on the volatile composition of the passion fruit and to determine the odoriferous contribution of the compounds for the aroma of the organic and conventional fruit, besides to assess the total antioxidant activity.

## 2. Material and methods

## 2.1. Material

Organic and conventional yellow Afruvec passion fruit (*P. edulis* Sims f. *flavicarpa* Deg.) were obtained from producers in the Southwest region of the State of São Paulo, Brazil, during the 2006 harvest. The organic fruits, certified at the Biodynamic Institute (IBD), São Paulo, Brazil, were cultivated in Paulistânia, SP ( $22^{\circ}34'42''$  S and  $49^{\circ}24'10''$  W, 645 m altitud) and the conventional fruits in Bauru, SP ( $22^{\circ}19'18''$  S and  $49^{\circ}04'13''$  W, 526 m altitud). Organic and conventional passion fruit (40 kg) from the same stage of development was harvested and immediately taken to the laboratory (Amaro & Monteiro, 2001; De Marchi, Monteiro, Benato, & Silva, 2000). The fruits were screened, inspected and washed. The pulp was separated from the seeds and peel, which were discarded. The clean pulp was packed directly in hermetically sealed 250 mL glass flasks and stored in a freezer at -18 °C until the analysis.

## 2.2. Reagents

All reagents used were of GC-analytical grade, and were supplied by Merck (Darmstadt, Germany) or J. T. Baker (Philipsburg, USA). The volatile standards used were from Sigma—Aldrich (St. Louis, USA) or Fluka (Steinheim, Germany).

#### 2.3. Total antioxidant activity and physicochemical analysis

The total antioxidant activity of the organic and conventional passion fruit pulp was analyzed using the ABTS radical reaction (Rufino et al., 2010), and total phenolic compounds by the Folin–Ciocalteu reaction (Asami et al., 2003; Macoris, Janzantti, & Monteiro, 2008). Soluble solids (°Brix), pH, titratable acidity, ascorbic acid and total and reducing sugar were determined according to AOAC (1998). Three replicate analyses were carried out

for the pulp of each cultivation system. The ratio (rate of soluble solids and titratable acidity) was calculated.

### 2.4. Isolation of the volatile compounds

The volatile compounds were isolated by dynamic headspace (Franco & Rodriguez-Amaya, 1983). Three hundred grams of passion fruit pulp were placed in a 1000 mL flask with NaCl (30 g/ 100 g), used to avoid the enzymatic degradation of the volatile compounds. The volatile compounds from the headspace of the passion fruit pulp were sucked by vacuum (79.99 mm Hg) at room temperature (25 °C) into a porous polymer trap (15 cm  $\times$  0.3 cm of 100 mg of a 150–180 µm Porapak Q, Waters Associates, Milford, USA) for 2 h and then eluted with 300 µL of dichloromethane (Macoris, Janzantti, Garruti, & Monteiro, 2011). Three replicates of the organic and conventional yellow passion fruit pulps were analyzed by GC–FID.

### 2.5. Gas chromatographic analysis

The volatile compounds of the passion fruit pulp were analyzed using a Shimadzu 2010 (Kyoto, Japan) high-resolution gas chromatograph (GC) equipped with a DB-Wax column (30 m length, 0.25 mm i.d., 0.25  $\mu$ m film thickness) from J & W Scientific, (Folsom, USA), maintained at 40 °C for 10 min and then programmed to rise to 200 °C at 3 °C/min, where it was held for 10 min. The splitless mode injector (2  $\mu$ L) was maintained at 200 °C and the flame ionization detector (FID) at 250 °C. Hydrogen was the carrier gas at a flow rate of 1.3 mL/min.

# 2.6. Gas Chromatography–Mass Spectrometry (GC–MS)

The volatile compounds of the passion fruit pulp were identified by GC–MS analysis. A Shimadzu 2010 GC equipped with a Shimadzu 2010 Mass Detector (Kyoto, Japan) was used to obtain the mass spectra. The column and temperature programs were the same as those used for the chromatographic analysis. The DB-Wax column (30 m length, 0.25 mm i.d., 0.25  $\mu$ m film thickness) was maintained at 40 °C for 10 min and then programmed to rise to 200 °C at 5 °C/min, where it was held for 10 min. Helium was the carrier gas at a flow rate of 1.3 mL/min. The injector and detector temperatures were 230 °C and 240 °C, respectively. Mass spectra were obtained by electron impact at 70 eV, in the scanning mode, *m/z* range from 35 to 350.

The volatile compounds were identified from the mass spectra and literature data (NIST vers. 1.7). Retention indices were determined using a homologous series of normal *n*-alkanes,  $C_{10}-C_{26}$ . The identities were confirmed by comparison of the relative retention indices and odor of the compounds with those of authentic standards and/or from literature sources (Acree & Arn, 2004; Jales et al., 2005; Jordán et al., 2002; Macoris et al., 2011).

## 2.7. Gas Chromtography–Olfactometry (GC–O)

The odoriferous contribution of the volatile compounds of the pulp of organic and conventional passion fruit was analyzed by OSME (Da Silva, Lundhal, & McDaniel, 1994). Each volatile compound in the headspace was separated on a capillary column and assessed by selected and trained judges, the data being colleted and analyzed by SCDTI, a time-intensity data acquisition system developed jointly by the School of Food Engineering and School of Electrical Engineering and Institute of Computing of the State University of Campinas-UNICAMP, Brazil (Da Silva, 1999).

GC was used for the separation of the volatile compounds, under the same conditions as those employed to analyze the volatile profile of the pulp. For the olfactometric analysis, the equipment was modified, so that the GC column was disconnected from the FID and connected to a flow splitter installed in the chromatograph oven, which directed the emerging volatile compounds via an inactive column (without stationary phase) to the nose of the judge. The splitter also introduced a carrier gas, to make up the volume of the column and ensure the compounds were delivered quickly from the system. The ODO II system from SGE (Texas, USA) was used to lead the outlet gas stream to the nose of the judge and to warm the tube surrounding the inactive column. This system includes a device to introduce moistened air into the outlet stream, to minimize the discomfort caused by drying of the nasal mucosa during the olfactometric tests.

The intensity of the aroma perceived by the judge for each volatile compound was recorded on a hybrid 10-point scale, anchored at 0, 5 and 10 points, representing "none", "moderate" and "extreme or strong", respectively. The judge was prompted to use the scale displayed on a computer screen, while each compound was being eluted from the GC column, to record the intensity and describe the odor. Each session lasted 30 min and each judge took two sessions to complete each replicate test.

The olfactometric analysis was carried out in triplicate by five selected and trained female judges, aged between 22 and 35 years. The chosen judges showed good discrimination ( $p \le 0.005$ ) and repeatability (p > 0.05) when analyzing the intensity of characteristic aroma of the passion fruit (Macoris et al., 2011).

The aroma intensity data colleted by the SCDTI program from each judge were united to generate an individual aromagram, which represented the average of three replicates. Therefore, only the data referring to aromas recorded by the judge in at least 50% of the replicates were used to construct the aromagram.

At the end of the session, the individual average aromagrams were combined into a consensus aromagram by the panel of judges. Only those data associated with aromatic compounds recorded by at least two of the five judges were included. As before, the consensus intensity of each aroma was obtained by summing the intensities described by the judges who detected that aroma and dividing by their number. The qualitative description of each aroma was elaborated from the descriptions produced by all the judges.

To ensure that the chromatographic data and compound identities were correctly related to the olfactometric data, the retention indices of each aroma described in the consensus aromagram were calculated. Furthermore, the judges' description of the aroma of each compound was checked against their published descriptions (Acree & Arn, 2004; Jales et al., 2005; Jordán et al., 2002; Sampaio, Garruti, Franco, Janzantti, & Da Silva, 2011).

## 2.8. Statistical analysis

Physicochemical data were subjected to analysis of variance (one-way ANOVA) and Tukey's test, employing the Statistical Analytical System, SAS<sup>®</sup> 6.12. The olfactometric data were processed with Microsoft Excel.

## 3. Results and discussion

#### 3.1. Physicochemical characteristics of the passion fruit pulp

The results for total antioxidant activity, total phenolic compounds and physicochemical characteristics of the pulp of organic and conventional passion fruit are shown in Table 1. The organic fruit pulp showed higher titratable acidity ( $p \le 0.05$ ), reducing sugars (p > 0.05), total sugars (p > 0.05), ascorbic acid ( $p \le 0.05$ ), total phenolic compounds ( $p \le 0.05$ ) and total antioxidant activity. The conventional passion fruit pulp showed higher

values for soluble solids ( $p \le 0.05$ ), pH (p > 0.05) and ratio ( $p \le 0.05$ ). The higher levels of total phenolic compounds and total antioxidant activity in the organic pulp suggest that the cultivation system influenced the production of antioxidant bioactive compounds (Carbonaro & Mattera, 2001; Dani et al., 2007).

The Brazilian legislation establishes values of 2.5 g of citric acid/ 100 mL; glucose content lower than 18.0 g/100 mL, 11 °Brix and pH values between 2.7 and 3.8; as standards for identity and quality of passion fruit pulp (BRASIL, 2000). All the physicochemical parameters (Table 1) conformed to the requirements of the Brazilian legislation, indicating that the pulps were suitable to be industrialized and consumed, and to be employed in the present assessment of the profile and odoriferous importance of the headspace volatile compounds.

### 3.2. Profile of volatiles of the passion fruit pulp

Eighty-four compounds were detected in the headspace of the passion fruit pulp, sixty-four of which were identified by mass spectra, retention indices and odor descriptions in comparison with those of volatile standards, comprising 96% of the chromatogram area (Table 2 and Fig. 1). The identified volatile compounds consisted of esters (31 compounds), alcohols (11), terpenes (10), aldehydes (5), ketones (5), an aromatic hydrocarbon (1) and a sulfur compound (1).

The esters, well-known as major contributors to the characteristic fruity and sweet aromas of a wide variety of fruits, have also formed the largest group of volatile compounds in other studies on passion fruit, while the alcohols, which are important for the flowery, green and herby aromas, are the second largest group (Shibamoto & Tang, 1990; Winterhalter, 1991). The hexanal, octanal and benzaldehyde are worth mentioning for their particular contribution to the green and citrus aromas of various fruits (Werkhoff et al., 1998). Volatile compounds from the breakdown of non-volatile precursors, such as the terpenes beta-linalool, alphaterpineol, beta-myrcene, alpha-copaene, D-limonene, *trans*-betaocimene, *cis*-beta-ocimene and alpha-cubebene (Table 2), among others, are also considered to be important to the green aroma of the passion fruit (Pino, 1997).

The only sulfur compound identified in this study was dimethyl disulfide (Table 2). Others have been detected in minimum amounts in passion fruit, by means of an electron-capture detector, a specific detector for sulfur, nitrogen and halogen compounds, including 3-mercaptohexanol and 3-mercaptohexyl butanoate (Engel & Tressl, 1991).

In both the organic and conventional passion fruit, the most abundant headspace volatile compounds were ethyl butanoate, vinyl benzene and hexanol. They showed minor differences between the relative area percentage of the chromatographic peaks of the organic and conventional passion fruit (Table 2). Ethyl

1			
		-	

Table

Physicochemical parameters of the organic and conventional passion fruit pulps.

Parameters	Organic	Conventional
Titratable acidity (g citric acid/100 mL)	4.32 <sup>a</sup>	3.81 <sup>b</sup>
Soluble solids (°Brix)	13.43 <sup>b</sup>	14.71 <sup>a</sup>
рН	3.36 <sup>a</sup>	3.53 <sup>a</sup>
Ratio	3.19 <sup>b</sup>	3.85 <sup>a</sup>
Reducing sugars (g glucose/100 mL)	4.78 <sup>a</sup>	4.71 <sup>a</sup>
Total sugars (g glucose/100 mL)	5.26 <sup>a</sup>	5.23 <sup>a</sup>
Ascorbic acid (mg/100 mL)	5.62 <sup>a</sup>	3.63 <sup>b</sup>
Total phenolic compounds (mg galic acid/100 mL)	528.93 <sup>a</sup>	415.66 <sup>b</sup>
Total antioxidant activity (µmol Trolox/100 mL)	112.21	53.44

Means with the same letter in the same line did not significantly differ in the Tukey test ( $p \le 0.05$ ). Ratio = soluble solids/titratable acidity.

butanoate has also been reported as the majoritary volatile compound in passion fruit (Winterhalter, 1991). Although the organic and conventional fruit volatile profiles were similar, there were significant differences in the percentage area of certain compounds. It is worth mentioning that the organic pulp showed a threefold peak area for ethyl 2-propenoate, 2-methyl-1-propanol, diethyl carbonate and ethyl hexanoate, whereas butyl acetate, hexanal, *cis*-3-hexenyl acetate and *trans*-3-hexenyl butanoate had a threefold peak area greater for the conventional fruit pulp (Table 2).

## 3.3. CG-O-OSME of the passion fruit pulp

The consensus aromagrams for organic and conventional passion fruit pulps are shown in Fig. 2. The sensory panel detected 58 odor compounds in both fruit pulps. The volatile compounds that brought odoriferous contributions to the aroma of the fruit showed intensities ranging from 0.49 (unidentified compound - IR 2247 -described as having a rubber and toasty aroma) and 0.36 (benzaldehyde, described citrus and sweet) up to 9.12 (ethyl hexanoate, described as sweety and fruity) and 9.38 (ethyl butanoate, described as a sweet and strawberry), for the organic and conventional fruit, respectively (Table 3). On the aromagram, the volatile compounds whose intensity lays in the upper half of the hybrid scale (>5.0 points), between "moderate" and "extreme or strong", were considered to be of great importance to the passion fruit aroma. Those of intensity between 3.0 and 4.9 were described as making a moderate odoriferous contribution, while those between 0.1 and 2.9 were of low contribution.

The volatile compounds that were most important to the passion fruit aroma were the same in both the conventional and the organic fruit, in spite of some differences in intensity. Thus, the esters propyl acetate ("passion fruit", sour and flowery), diethyl carbonate (synthetic, plastic and metallic) and ethyl hexanoate (sweet and fruity) had stronger intensity in the organic pulp aroma. The esters methyl butanoate ("passion fruit", sweet, strawberry and fruity), ethyl butanoate (sweet and strawberry) and ethyl octanoate (grass and earthy), as well as the alcohol *cis*-3-hexen-1-ol ("passion fruit", sulfur-like and grass), were more intense in the conventional passion fruit (Table 3).

The volatile compound *cis*-3-hexenyl acetate, alpha-copaene, *cis*-3-hexenyl hexanoate and alpha-terpineol, all described as "passion fruit" aroma, were of low intensity yet still present in the headspace of both organic and conventional fruits, but with higher intensity in the organic fruit. On the other hand, the compounds 2-pentanone and the unidentified peak 2 (IR <1000), described as "passion fruit", were only perceived in the conventional fruit pulp, at low intensity (Table 3).

Hexanal (sweet, citrus and green), 1-butanol (sharp, flowery and sweet), D-limonene (eucalypt, lemon grass and citrus), *trans*-betaocimene (herb, peel and sweet) and butyl hexanoate (flowery and green) showed moderate intensity aroma in the organic, but low strength in the conventional fruit. The opposite was found for ethyl *cis*-3-hexenoate (leaf, grass, plastic and burnt) and hexyl propanoate (green banana and strawberry). The terpenes beta-myrcene (sweet and citrus) and beta-linalool (lemon, citrus and sour) contributed with moderate intensity to the aroma of passion fruit of both cultivation systems, but they were more intense in the conventional fruit.

*Trans*-3-hexenyl acetate (fruity and citrus), amyl hexanoate (stink and stink bug), hexyl hexanoate (solvent, stink and sulfurlike), benzyl acetate (citrus, flowery and green) and deltacadinene (citrus and flowery) contributed weakly to the aroma of the pulp from both organic and conventional passion fruit, albeit with higher intensity in the organic fruit. Octanal (sweet, fruity,

Table 2	
Volatile compounds identified in the organic and conventional passion fru	it pulps

	compound	s heritinen in the organie und eo	intentional p	ubbion n'un puipbi
Peak	RI <sup>d</sup>	Compound	Organic <sup>e</sup>	Conventional <sup>e</sup>
7	<1000	Propyl acetate <sup>a</sup>	0.10	0.16
8	<1000	3-methylbutanal <sup>b</sup>	0.48	0.73
9	<1000	Methyl butanoate <sup>a</sup>	0.25	0.14
10	<1000	Ethyl 2-propenoate <sup>c</sup>	0.82	nd-0.05
11	<1000	2-hexanone <sup>b</sup>	nd-0.05	nd
12	1006	Methyl 2-methylbutanoate	tr-0.05	nd-tr
13	1009	2-methylpropyl acetate <sup>4</sup>	0.33	0.40
14	1013	Methyl 3-methylbutanoate	0.43	0.72
16	1033	Ethyl butanoate"	56.69	56.31
17	1042	2-methyl-3-buten-2-ol	0.87	1.28
18	1045	Ethyl 2-methylbutanoate	0.44	0.49
19	1069	Dimethyl disulfide <sup>5</sup>	0.07	0.19
20	1072	Butyl acetate"	0.36	1.34
21	1077	Hexanal <sup>-</sup>	nd	0.26
22	1090	2-methyl-1-propanor	0.53	0.07
25	1120	2 mothylbultyl acotato <sup>b</sup>	2.09	0.19
25	1129	5-methylburtyl acetate	0.57	0.77
20	1142	3-bentanone <sup>b</sup>	0.05	0.12
27	1150	1-butanol <sup>b</sup>	0.10	0.10
20	1161	Alpha_phellandrene <sup>b</sup>	nd_0.05	0.02
30	1167	Beta-myrcene <sup>a</sup>	1 47	1 10
31	1178	2-heptanone <sup>b</sup>	0.10	0.22
32	1182	Hentanal <sup>b</sup>	0.09	tr-0.06
33	1183	D-limonene <sup>a</sup>	0.05	0.27
34	1188	Isoamyl alcohol <sup>b</sup>	0.19	tr
35	1190	Butyl butanoate <sup>a</sup>	0.79	0.79
38	1216	Trans-beta-ocimene <sup>b</sup>	0.65	0.49
39	1217	Ethyl hexanoate <sup>a</sup>	2.23	0.50
40	1239	Vinyl benzene <sup>b</sup>	15.60	13.04
41	1253	Cis-beta-ocimene <sup>b</sup>	1.66	2.28
44	1265	Pentanol <sup>b</sup>	0.14	nd-0.10
45	1276	Hexyl acetate <sup>a</sup>	1.17	2.75
46	1282	Octanal <sup>a</sup>	0.08	tr
47	1303	Ethyl <i>trans</i> -3-hexenoate <sup>b</sup>	0.28	0.48
49	1308	Ethyl <i>cis</i> -3-hexenoate <sup>b</sup>	0.05	0.09
50	1311	Trans-3-hexenyl acetate <sup>b</sup>	0.09	0.22
51	1319	Cis-3-hexenyl acetate <sup>b</sup>	0.46	2.19
52	1333	6-methyl-5-hepten-2-one <sup>b</sup>	0.16	tr-0.12
53	1339	Hexyl propanoate <sup>b</sup>	0.06	0.17
54	1345	Ethyl <i>trans</i> -2-hexenoate	nd-tr	tr-0.08
55	1347	3-nonanone <sup>D</sup>	0.06	nd-0.12
56	1366	Hexanol <sup>4</sup>	2.87	2.93
57	13/4	Irans-3-hexen-1-ola	0.17	0.21
58	1392	Cis-3-hexen-1-ol <sup>a</sup>	0.34	0.79
60	1416	Butyl hexanoate <sup>b</sup>	0.11	0.23
61	1419	Hexyl Dutanoate	1.10	2.12
64	1439	Alpha subshapa <sup>b</sup>	0.11 tr 0.04	0.08
64 65	1458	Alpha-cubebelle	0.12	0.50
66	1405	Cis 3 hexepulbutanoate <sup>b</sup>	0.12	nd_tr
67	1470	Alpha-consene <sup>b</sup>	tr-0.04	$tr_0 07$
68	1515	Benzaldehyde <sup>b</sup>	nd	0.23
69	1546	Amyl beyanoate	tr-0.04	0.25
70	1559	Beta-linalool <sup>a</sup>	0.58	0.28
71	1570	Octanol <sup>a</sup>	0.06	tr-0.09
73	1614	Hexyl hexanoate <sup>b</sup>	0.54	0.69
74	1661	Cis-3-hexenylhexanoate <sup>b</sup>	0.07	0.21
75	1703	Alpha-terpineol <sup>a</sup>	0.13	tr
76	1709	Benzyl acetate <sup>c</sup>	nd-0.05	nd-0.05
77	1729	Delta-cadinene <sup>b</sup>	nd-tr	tr-0.11
80	1883	Benzyl alcohol <sup>b</sup>	0.07	0.16
82	1978	Dodecanol	0.15	0.19
83	2186	Methyl hexadecanoate <sup>c</sup>	tr-0.04	tr

nd: peak not detected by GC-FID.

tr: trace = peak area < 0.04% in chromatogram.

<sup>a</sup> volatile compound identified by mass spectra, retention indices, odor descriptions and volatile standards.

<sup>b</sup> volatile compound identified by mass spectra, retention indices and odor descriptions.

<sup>c</sup> volatile compound identified by mass spectra and retention indices.

<sup>d</sup> IR: retention index of peak in DB-Wax column.

 $^{\rm e}\,$  % area: mean of triplicate GC–FID results for volatile compound peak.





lemon and sharp) also gave a small odoriferous contribution to both pulps, but it was slightly greater for the conventional passion fruit. Dimethyl disulfide ("passion fruit", sweet, overripe fruit) gave a small contribution to the odor of both organic and conventional fruits (Table 3).

Ethyl butanoate produced the largest area on the chromatogram, as well as one of the highest odoriferous intensities; hexanol (citrus, eucalypt and herbal) showed an aroma of moderate intensity in both organic and conventional fruits, and vinyl benzene (caramel and rubber) contributed weakly only to the organic fruit aroma. Some important aromas perceived by the judges were not noticed in the chromatograph at the retention time determined by the FID (Figs. 1 and 2). These peaks on the aromagram are identified by letters (Table 3 and Fig. 2). Although undetected by FID, some of these compounds gave an important contribution to both the organic and conventional fruit aroma. These include those that formed peaks I (quince jelly, candy and flowery), L (candy floss and caramel) and O (solvent and plastic).



Fig. 2. Consensus aromagram of the organic (a) and conventional (b) Passion fruit pulps.

In other studies using the OSME technique to analyze the odoriferous contributions of the volatile compounds of fruits and beverage (Garruti, Franco, Da Silva, Janzantti, & Alves, 2006; Jales et al., 2005), the judges also reported aroma compounds in regions of the chromatogram in which the FID did not detect any volatile compounds, indicating that the human nose is more sensitive than the FID. The importance of individual volatile compounds in the aroma of passion fruit juice produced in Florida, USA, was analyzed by the olfactometric technique AEDA, using only two judges (Jordán et al., 2002). The compounds found to contribute most to the aroma were 2-methylbutyl hexanoate and 1,3-dimethylbenzene, described as having a nutty and oily, and medicine aroma. These compounds were not detected in our study, perhaps reflecting the different origins of the fruits and the

technique. In a study of conventional passion fruit grown in Fortaleza, CE, in the extreme northeast of Brazil, methyl butanoate, ethyl butanoate, beta-myrcene and ethyl hexanoate were found to be the main contributors to the sweet and fruity aroma, and betalinalool to the flowery aroma, by means of the OSME technique (Jales et al., 2005). These authors also reported the high intensity of the aroma of diethyl carbonate and 2-pentanone (plastic and glue) and of gamma-terpinolene (metallic).

The differences between the aromas of organic and conventional passion fruit may be attributed largely to the presence of hexanoate and acetate esters and saturated alcohols, which exhibited higher intensities in the organic fruit. Unsaturated alcohols showed higher intensities for the conventional fruit. Besides the above differences, the interaction of plant tissues with abiotic

Table 3
Odor active compounds in organic and conventional passion fruit detected by GC-O-OSME

Image         Image         Image         Image           2         <1000         ni         Particle         Pariticle         Pa	Peak	IR <sup>a</sup>	Compound	Description of aroma	Organic	Conventional
1          Sour         -         0.49           2         <1000         ni         Passion fruit, sour, flowery         6.72         5.16           7         <1000         Progriance         Passion fruit, sour, flowery         6.72         5.16           9         <1000         Mettyl blaunaate         Passion fruit, sweet, strawherry, fruity         5.16         5.33           10         1008         Isobutyl actate         Sweet, strawherry, fruity         5.16         5.33           11         1007         ni         Sharp, ped, woody         1.1         -         1.85           11         1007         ni         Sweet, strawherry, fruity         5.16         5.33           1109         1009         Diarthyl diallide         Sweet, strawherry, fruity         3.22         1.89           21         1007         Hexano         Sweet, strawherry, fruity         3.22         1.89           23         1089         Diarthyl diallide         Sweet, strawherry, fruity         3.22         1.83           24         118         J-bitanol         Sharp, flowery, sweet         3.03         1.28           23         1183         D-lineachyl diawhery         Sweet, strawhery, sweet <t< th=""><th></th><th></th><th></th><th></th><th>I max<sup>b</sup></th><th>I max<sup>b</sup></th></t<>					I max <sup>b</sup>	I max <sup>b</sup>
2<1000niPassion fruit, geel-0.51A<1000	1	<1000	ni	Sour	_	0.49
7         <1000	2	<1000	ni	Passion fruit, peel	-	0.51
A         <1000	7	<1000	Propyl acetate	Passion fruit, sour, flowery	6.72	5.16
9         <1000	Α	<1000	2-pentanone	Passion fruit, sulfurous-like, peel	-	1.39
B         108         Isobury acctate         Shara, per, woody         -         1.83           15         1021         ni         Shara, per, woody         1.0         -           16         1033         Elity buanaate         Sweet, strawberry         8.23         9.38           19         10089         Dimethyl isolifde         Sweet, strawberry         8.22         1.83           21         1077         Hexanal         Sweet, straw, geren         3.22         1.83           23         1099         Diely i carbonate         Sweet, burnt, dry         -         0.82           23         1198         1 varanol         Sweet, burnt, dry         -         0.82           24         1198         1 varanol         Sweet, burnt, dry         0.79         -           23         1183         Delemptre         Elity formanats, straws, straws         0.74         -           24         1183         Delemptre         Sweet, fruity, lemps, straws         0.74         -           24         1238         Ving benzon         Caranet, nubber, flowery         3.12         0.53           350         1308         Elyty (ra-3-becen, lactate         Fuity, strins         1.30         C5 <td>9</td> <td>&lt;1000</td> <td>Methyl butanoate</td> <td>Passion fruit, sweet, strawberry, fruity</td> <td>5.16</td> <td>5.93</td>	9	<1000	Methyl butanoate	Passion fruit, sweet, strawberry, fruity	5.16	5.93
15101niSharp, pel, wody1.10-161033Ethyl bianoleSweet, pasion fruit, overripe fruit0.870.87191069Dinethyl disulfideSweet, pasion fruit, overripe fruit0.870.871211077HexanalSweet, pasion fruit, overripe fruit0.870.871231089Diethyl carbonateSymtheir, plastic, metallic6.930.24241169nSweet, fruit, plastic, metallic6.930.24241169nSweet, fruit, plastic, metallic0.371.83361167Retx-myrcneSweet, fruit, plastic, metallic0.70-371168PrimoneneHendypi, lemon gras, cirtus3.121.27381216Trans-beta-ocimeneHefb, peel, sweet3.470.53401239Viny benzeneSweet, fruity, lemon, sharp1.942.64411282OctanalSweet, fruity, lemon, sharp1.942.644291308Ethyl for-3-hexenolteFruity, lemon, sharp1.942.644301311Trans-3-hexenolteFruity, brunt, undergrowth1.77531313Hexyl propanateGras, pasion fruit, flowery2.191.301.37541346Ethyl trans-2-hexenoleGras, sarthy.163.443.4755Hexyl propanateGras, sarthy.16.1736561339Hexyl propanate <td>В</td> <td>1008</td> <td>Isobutyl acetate</td> <td>Sweetish, stink</td> <td>-</td> <td>1.86</td>	В	1008	Isobutyl acetate	Sweetish, stink	-	1.86
16         103         Ethyl hutanate         Sweet, strawberry         8.23         0.38           19         1066         Dimethyl Gishfle         Sweet, citrus, green         3.22         1.89           21         1077         Hexaal         Sweet, citrus, green         3.22         1.89           23         1090         Diethyl carbonate         Synthetic, plastic, metallic         -         0.72           23         1108         n         Sweet, citrus, green         3.33         1.28           24         1138         1-butanol         Sharp, flowery, sweet         3.18         3.93         1.28           30         1136         Delimonene         Eacalypt, lennong grass, citrus         3.17         -         -         -           318         1316         Delimonene         Eacalypt, lennon, grass, citrus         3.47         -         -           319         1216         Prome Seta-ocimene         Hein, lenno, sharp         3.47         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         - <td< td=""><td>15</td><td>1021</td><td>ni</td><td>Sharp, peel, woody</td><td>1.10</td><td>-</td></td<>	15	1021	ni	Sharp, peel, woody	1.10	-
19         1069         Dinethyl disulfide         Sweet, passion fruit, overripe fruit         0.87         0.87           21         1077         Hexanal         Sweet, citrus, green         3.22         1.89           23         1098         ni         Rubber, burnt, dry         -         0.72           24         1099         Diethyl carbonate         Sweet, burnt         -         0.82           24         1158         I-butanol         Sweet, citrus         3.03         1.32         1.21         1.27           30         1167         Beta-myrcence         Sweet, citrus         3.03         1.21         1.27           36         1188         D-limonene         Euclaypic Henong arsa, citrus         3.12         1.27           37         1216         Trans-beta-colinene         Heto, buet, flowery         9.47         0.53           38         1216         Trans-beta-colinene         Heto, buet, sweet, fruity         9.10         -         -           40         1239         Virgi becanote         Edity dissi, abecanote         Edity dissi, abecanote         1.00         -           51         1308         Ethyl dissi, abecanote         Edity dissi, abecanote         1.00         -         -<	16	1033	Ethyl butanoate	Sweet, strawberry	8.23	9.38
21         1077         Hexaal         Sweet, citus, green         3.22         1.89           23         1099         Dictiyl carbonate         Synthetic, plastic, metallic         6.33         6.24           24         1158         I-butanol         Sweet, burnt         -         0.82           28         1158         I-butanol         Sharp, flowery, sweet         3.03         1.28           30         1167         Beta-myrcene         Sweet, citus         3.18         3.93         1.23         1.27           36         1196         ni         Rubber, flowery         0.79         -         -           38         1216         Trans-beta-citinene         Herb, peel, sweet         3.47         0.53           40         1239         Vinyl benzene         Caramel, rubber         1.10         -           41         1282         Octaal         Sweet, fruity, lenon, sharp         1.33         0.75           51         1311         Trans-Shexenote         Caramel, rubber         1.33         0.75           53         1339         Hexyl propanote         Citus, sansion fruit, flowery         2.19         1.30           54         1345         Etyl arans-2-hexenote         Citu	19	1069	Dimethyl disulfide	Sweet, passion fruit, overripe fruit	0.87	0.87
C       1098       ni       Rubber, burnt, dry $-$ 0.72         23       1099       Diethyl carbonate       Synthetic, plastic, metalic, metalic       6.93       0.12         24       1109       ni       Sweet, burnt $-$ 0.82         24       1109       ni       Sweet, burnt $-$ 0.82         30       1167       Beta-myrcene       Sweet, druss       3.12       1.21         33       1183       D-limonene       Euclypt, lemon grass, druss       3.12       1.27         36       1196       ni       Rubber, flowery       0.79 $-$ 38       1216       Trans-beta-crimene       Herb, peel, sweet       3.47       0.53         39       1217       Brhy hexanoate       Sweet, fruity, lemon, sharp       1.10 $-$ 46       1280       Ottahal       Sweet, fruity, lemon, sharp       1.54       0.75         51       1311       Trans-b-hexenyla cetale       Grig sas, plastic, burnt       2.51       0.35         53       1339       Greed proyregate       Greed proyregate       1.10       0.45         54       1365       Hehy furma-2-hexenyle       Treespasion fruit, flowery, g	21	1077	Hexanal	Sweet, citrus, green	3.22	1.89
23         1099         Diethyl carbonate         Synthetic, plastic, metallic         6.93         6.24           24         1158         1-botanol         Sharp, flowery, sweet         3.03         1.28           30         1167         Beta-myrcene         Sweet, cirus         3.18         3.12         1.27           33         1183         D-limonene         Eucalypt, lemon grass, cirus         3.12         1.27           36         1196         ni         Rubber, flowery         0.79         -           38         1216         Truns-beta-ocimene         Herb, ped, sweet         3.47         0.53           40         1239         Viny benzene         Caramel, rubber         1.10         -           45         1282         Octanal         Sweet, fruity, lemon, sharp         1.94         2.64           49         1308         Bihyl cfs-3-hexenoate         Cirus, passion fruit, flowery         2.19         1.30         0.75           51         1319         Crs-3-hexenyl acetate         Cirus, passion fruit, flowery         2.10         4.95           54         1345         Ethyl crass-acetate         Cirus, savith         -         0.93           53         1339         Hexelyl propao	С	1098	ni	Rubber, burnt, dry	-	0.72
24       1109       ni       Sweet, burnt       -       0.82         28       1158       1-butanol       Shap, flowery, sweet, and provent, sweet, flowery       0.73       -         33       1183       D-limonene       Euclypt, lemon grass, cirturs       3.12       1.27         36       1196       ni       Rubber, flowery       0.79       -         34       1216       Trans-beta-ocimene       Herb, peel, sweet, flowery       0.79       -         37       1217       Ethy loxanoate       Sweet, flowery       0.79       -       -         46       1220       Otcahal       Sweet, flowery       0.79       1.00       -         47       1339       Ethyl (ora-3-bexenolacetate       Fruity, cirus       1.33       0.75         51       1319       Gras-bexenolacetate       Grass, plastin, tinky, passin fruit, grass, plastin, tinky, passin       3.64       3.17         54       1345       Ethyl oranoate       Grass, plastin, tinky, plastin, flawery       -       0.93         55       1366       Hexonlo       Grass, plastin, flawery       1.11       0.41         57       1374	23	1099	Diethyl carbonate	Synthetic, plastic, metallic	6.93	6.24
28     1158     1-butanol     Sharp, flowery, sweet     3.03     1.28       30     1167     Beta-myrcene     Sweet, firus     3.12     1.27       33     1183     D-linonene     Eucalypt, lemon gras, cirus     3.12     1.27       36     1196     ni     Rubber, flowery     0.79     -       38     1216     Trans-beta-ocimene     Herb, peel, sweet     3.47     0.53       39     1217     Ethyl hexanoate     Sweet, furity, lemon, sharp     1.94     2.64       40     1239     Winyl benzene     Caramel, rubber     1.30     0.75       50     1311     Trans-bacenyl actate     Citrus, spasion fruit, flowery     2.19     1.30       51     1319     Cis-3-bexenyl actate     Citrus, scalath, herbal     3.64     3.17       53     1339     Hexyl prognaoate     Cirus, scalath, herbal     3.64     3.17       54     1345     Ethyl actanate     Fuily, citrus     actanath, herbal     3.64     3.17       57     1374     Trans-bacen-1-ol     Sattrus, scalath, herbal     3.64     3.17       58     1392     Cis-abexen-1-ol     Sattrus, scalath, herbal     4.62     2.01       67     1479     Alpha-copaene     Citrus, furity, passio	24	1109	ni	Sweet, burnt	-	0.82
301167Heta-myrceneSweet, cirus3.183.93331183D-limoneneEuclypt, lemon grass, cirus3.121.27361196niRubber, flowery0.79381216Trans-beta-cirueneHeth, peel, sweet, fuily9.128.85391217Ethyl hexanoateSweet, fuily, lemon, sharp9.128.85401239Vinyl beracenCaranel, rubber1.00-411232OctanalSweet, fuily, lemon, sharp1.942.64491308Ethyl (ris-3-hexenyl acetateFruity, cirus, fuison fuil, flowery2.191.30501311Trans-a-hexenyl acetateGreen banna, strawberry2.804.95511339Hexyl propanoateGreen banna, strawberry2.804.95541366HexanolCirus, casion fruit, flowery2.804.95551366HexanolCirus, basion fruit, grass5.126.96601416Burly hexanoateHowery, green4.165.1461Hutyl bacanoateGrass, carthy4.165.14621515BenzaldehydeGirus, fuiry, passion fruit, sweet-0.36711518Ethyl anoateSaion fruit, sweet-0.36621546Anyl hexanoateSweet, fuiry, honey, flowery1.020.77731519BenzaldehydeGirus, fuiry, fuiry, fuiry, fuiry-0.3674168	28	1158	1-butanol	Sharp, flowery, sweet	3.03	1.28
33     1183     D-limonene     Eucalypt, lemon grass, cirusus     3.12     1.27       36     1196     ni     Rubber, flowery     0.79     -       38     1216     Trans-beta-ocimene     Herb, peel, sweet     3.47     0.53       39     1217     Ethyl hexanoate     Sweet, fruity, lowens, sharp     1.10     -       40     1239     Vinyl benzene     Caramet, nubber     1.00     -       416     1282     Octaal     Sweet, fruity, lowens, sharp     1.94     2.64       429     1308     Ethyl cis-3-nexenoate     Leaf, grass, plastic, burnt     2.55     3.93       51     1319     Cis-3-nexenyl actate     Citrus, sussion fruit, flowery     2.19     1.30       53     1339     Hexyl propanoate     Green banaa, strawberry     2.00     4.95       54     1345     Ethyl droms-2-nexenoate     Fruity, cirus     scaling, flowery     2.12     0.31       57     1374     Toms-shexen-1-ol     Toasty, stink     -     0.93       58     1392     Cira-shexen-1-ol     Stift-rike, scaling, herbal     1.11     0.41       69     1515     Benzaldehyde     Cirus, sweet     0.78     -       61     1525     Hexyl protanoate     Sweet, foatly	30	1167	Beta-myrcene	Sweet, citrus	3.18	3.93
36     1196     ni     Rubber, flowery     0.79     -       38     1216     Trans-beta-ocimene     Herh, peet, sweet, fuity     9.12     8.85       39     1217     Ethyl hexanate     Sweet, fruity, lemon, sharp     1.10     -       46     1229     Vinyl benzene     Caramet, rubber, lemon, sharp     1.94     2.64       49     1308     Ethyl or, 3-hexenote     Leaf, grass, plastic, burnt     2.55     3.93       50     1311     Trans-5-hexenyl acetate     Fruity, sortin, undergrowth     1.77     -       51     1319     CRs-5-hexenyl acetate     Gruey, pasion fruit, flowery     2.80     4.95       54     1345     Ethyl propanote     Green banana, strawberry     2.80     4.95       54     1345     Ethyl propanote     Green banana, strawberry     2.80     4.95       55     1366     Hexanol     Citrus, euclipt, herbal     3.64     3.17       57     1374     Trans-5-hexen-1-0     Toasty, stink     -     0.36       60     1416     Butyl hexanote     Grass, eartyl     4.16     5.14       61     1439     Ethyl octanote     Grass, eartyl     0.78     -       62     1515     Berzadehyde     Citrus, sweet, fauity, honey, flower	33	1183	D-limonene	Eucalypt, lemon grass, citrus	3.12	1.27
38     1216     Trans-beta-ocimene     Herb, peel, sweet, fuity     3.47     0.53       39     1217     Ethyl hexanoate     Sweet, fuity     9.12     8.85       40     1239     Vinyl benzene     Garanel, rubber     1.10     -       46     1282     Octanal     Sweet, fuity, lenon, sharp     1.94     2.64       49     1308     Ethyl dr3-hexenotacte     Leaf, grass, plastic, burnt     2.55     3.93       50     1311     Trans-becenval acteate     Citrus, passion fruit, flowery     2.19     1.30       53     1339     Hexyl propanoate     Green bahana, strawberry     2.80     4.95       54     1345     Ethyl trans-2-hexenoate     Fuity, burnt, undergrowth     1.77     -       56     1366     Hexanol     Citrus, eucalipt, herbal     3.64     3.17       57     1374     Trans-bexen-1-ol     Suffur-like, passion fruit, grass     5.12     6.96       60     1416     Butyl hexanoate     Grees, sarthy     4.16     5.14       61     1479     Alpha-copaene     Citrus, fuity, passion fruit, grass     5.12     6.96       62     1515     Benzaldehyde     Citrus, fuity, passion fruit, suffur-like, passion fruit, suffur-like, passion fruit, grass     5.12     6.96	36	1196	ni	Rubber, flowery	0.79	-
391217Ethyl hexanateSweet, furity9.128.85401239Vinyl berazneCaramel, rubber1.10-461282OctanalSweet, furity, lemon, sharp1.942.64491308Ethyl (r.shexenoateLef, grass, plasic, burnt2.553.93501311Trans-3-hexenyl acetateFruity, citrus1.330.75511319Gra-3-hexenyl acetateGrus, passion fruit, flowery2.191.30531339Hexyl propanoteGreen banana, strawberry2.804.95541345Ethyl trans-2-hexenolateFruity, burnt, undergrowth1.77-561366HexanolGrus, passion fruit, grass5.126.96601416Butyl hexanateFlowery, green4.422.01611439Alpha-copaeneGrus, serity fruity, burnt, undergrowth-0.36621515BernzideHydeGrus, serity0.78-631518Ethyl otcanateFlowery, green4.422.01641515BernzideHydeGrus, strik, bug0.78-701539Hexyl pertanoateSweet, taxty0.78-71154Alpha-copaeneGrus, strik, suffur-fike0.960.36731514Hexyl pertanoateSweet, taxty, honey, flowery0.780.36741661Gra-3-hexenylhexanateSweet, furity, honey, flowery0.790.58 <td< td=""><td>38</td><td>1216</td><td>Trans-beta-ocimene</td><td>Herb, peel, sweet</td><td>3.47</td><td>0.53</td></td<>	38	1216	Trans-beta-ocimene	Herb, peel, sweet	3.47	0.53
40       1.239       Vinyl benzene       Caramel, rubber       1.04 $-$ 46       1282       Octanal       Sweet, ruity, lemon, sharp       1.94       2.64         49       1308       Ethyl icis – 3-hexenoate       Leaf, grass, plastic, burnt       2.55       3.93         50       1311       Torns - 3-hexenyl acetate       Fruity, cirrus       1.31       0.75         51       1339       Hexyl propanoate       Green banan, strawberry       2.80       495         54       1345       Ethyl trans – 2-hexenoate       Fruity, burnt, undergrowth       1.77       -         56       1366       Hexanol       Cirus, eucalipt, herbal       3.64       3.17         57       1374       Trans - 3-hexen - 1-ol       Suffur-like, passion fruit, grass       5.12       6.96         60       1416       Burgh hexanoate       Flowery, green       4.42       2.01         67       1479       Alpha-copaene       Cirus, sweet       -       0.36         68       1515       Benzaldehyde       Cirus, sweet       -       0.36         69       1546       Anyl hexanoate       Sweet, carth, undergrowth, sharp       0.78       -         73       1614	39	1217	Ethyl hexanoate	Sweet, fruity	9.12	8.85
46     1282     Octanal     Sweet, fruity, lemon, sharp     1.94     2.64       49     1308     Ethyl (icr -3 -hexenotae     Leaf, grass, plastic, burnt     2.55     3.33       50     1311     Trons-3-hexenyl acetate     Fruity, citrus     1.33     0.75       51     1319     Cis-3-hexenyl acetate     Citrus, soaison fruit, flowery     2.19     1.30       53     1339     Hexyl propanoate     Green banan, strawherry     2.80     4.95       54     1345     Ethyl trans-2-hexenoate     Fruity, burnt, undergrowth     1.77     -       56     1366     Hexanol     Citrus, eucaligh, herbal     3.64     3.17       57     1374     Trans-3-hexen-1-01     Suffur-like, passion fruit, grass     5.12     6.96       60     1416     Buryl hexanoate     Flowery, green     4.16     5.14       67     1479     Alpha-copaene     Citrus, fruity, passion fruit, sweet     -     0.36       70     1518     Ethyl 3-hydroxybutanoate     Sweet, toasty     0.78     -       68     1515     Beradehyde     Citrus, sourg, sourg, sourg, sourg     0.88     0.59       71     152     Hexyl pentanoate     Sweet, truity, honey, honey, sourg     0.88     0.59       72     15	40	1239	Vinyl benzene	Caramel, rubber	1.10	-
49         1308         Ethyl (as-3-hexen) acetate         Laf, grass, plastic, burnt         2.55         3.33           50         1311         Turas-3-hexen) acetate         Fruity, citrus         1.33         0.75           51         1319         Gs-3-hexen) acetate         Gitrus, passion fruit, flowery         2.80         4.95           54         1345         Ethyl trans-2-hexenoate         Fruity, burnt, undergrowth         1.77         -           56         1366         Hexanol         Citrus, eucalipt, herbal         3.64         3.17           57         1374         Turas-3-hexen-1-ol         Toasty, stink         -         0.93           58         1392         Cfs-3-hexen-1-ol         Suffur-like, passion fruit, grass         5.12         6.96           60         1416         Butyl bexanoate         Flowery, green         4.46         5.14           67         1479         Alpha-copaene         Citrus, struity, passion fruit, strust         -         0.36           70         1518         Ethyl 3-hydroxybutanoate         Weet, toasty         0.78         -           71         153         Benzaldehyde         Citrus, strust, strukt	46	1282	Octanal	Sweet, fruity, lemon, sharp	1.94	2.64
50         1311         Trans-3-hexenyl acetate         Futiy, citrus         1.33         0.75           51         1319         Gr3-hexenyl acetate         Citrus, assion fruit, flowery         2.80         4.95           53         1336         Ethyl propanoate         Green banan, strawberry         2.80         4.95           54         1345         Ethyl rans-2-hexenoate         Fruity, burnt, undergrowth         1.77         -           56         1366         Hexanol         Citrus, eucalipt, herbal         3.64         3.17           57         1374         Trans-3-hexen-1-01         Suffur-like, passion fruit, grass         5.12         6.96           60         1416         Butyl hexanoate         Flowery, green         4.16         5.14           67         1479         Alpha-copaene         Citrus, fruity, passion fruit, sweet         -         0.36           68         1515         Benaldehyde         Citrus, sweet, fruity, hongy         0.88         0.59           70         1559         Beta-linalod         Lemon, citrus, sour         4.80         4.92           71         1614         Hexyl hexanoate         Solvent, stink, suffur-like         0.96         0.36           73         1614	49	1308	Ethyl cis-3-hexenoate	Leaf, grass, plastic, burnt	2.55	3.93
51     1319     Cis-3-hexenpl acetate     Citrus, passion fruit, flowery     2.19     1.30       53     1339     Hexyl propanote     Citrus, passion fruit, flowery     2.80     4.95       54     1345     Ethyl trans-2-hexenoate     Fruity, burnt, undergrowth     1.77     -       56     1366     Hexanol     Citrus, eucalipt, herbal     3.64     3.17       57     1374     Trans-3-hexen-1-01     Toasty, stink     -     0.93       60     1416     Butyl hexanoate     Flowery, green     4.42     2.01       63     1439     Ethyl octanoate     Citrus, sweet     -     0.36       64     1515     Benzaldehyde     Citrus, sweet     -     0.92       67     1579     Alpha-copaene     Citrus, sour     4.80     4.92       70     1518     Ethyl 3-hydroxybutaoate     Sweet, toasty     0.78     -       71     164     Amyl hexanoate     Solvent, stink, stink bug     0.88     0.59       73     1614     Hexyl hexanoate     Solvent, stink, stink fug     0.92     0.79       74     1661     Cis-3-hexenylhexanoate     Solvent, stink, stink fug     0.36     0.36       75     1703     Alpha-terpineol     Passion fruit, fuity, sharp	50	1311	Trans-3-hexenyl acetate	Fruity, citrus	1.33	0.75
53     1339     Hexyl propanoate     Green banan, strawberry     2.80     4.95       54     1345     Ethyl trans-2-hexenoate     Fruity, burnt, undergrowth     1.77     -       56     1366     Hexanol     Citrus, eucalipt, herbal     3.64     3.17       57     1374     Trans-3-hexen-1-ol     Suffur-like, passion fruit, grass     5.12     6.96       60     1416     Butyl hexanoate     Flowery, green     4.42     2.01       63     1439     Bthyl octanoate     Grass, earthy     4.16     5.14       64     1479     Alpha-copaene     Citrus, fruity, passion fruit, sweet     1.11     0.41       68     1515     Benzaldehyde     Citrus, sweet, toasty     0.78     -       69     1546     Amyl hexanoate     Stek, sink bug     0.88     0.59       70     1559     Beta-linalool     Lemon, citrus, sour     4.80     4.92       73     1614     Hexyl hexanoate     Solvent, stink, sulfur-like     0.96     0.36       75     1703     Alpha-reprineol     Solvent, stink, sulfur-like     0.96     0.36       74     1661     Cis-3-hexen-lone     Solvent, stink, sulfur-like     0.96     0.36       75     1703     Alpha-reprineol     Passion	51	1319	Cis-3-hexenyl acetate	Citrus, passion fruit, flowery	2.19	1.30
54       1345       Ethyl trans-2-hexenoate       Fruity, burrt, undergrowth       1.77 $-$ 56       1366       Hexanol       Citry, eucalpt, herbal       3.64       3.17         57       1374       Trans-3-hexen-1-ol       Toasty, stink       -       0.93         58       1392       Cis-3-hexen-1-ol       Sulfur-like, passion fruit, grass       5.12       6.96         60       1416       Butyl hexanoate       Flowery, green       4.42       2.01         63       1439       Ethyl of transate       Grass, earthy       4.16       5.14         67       1479       Alpha-copaene       Citrus, fruity, passion fruit, sweet       -       0.36         7       1515       Benzaldehyde       Citrus, sweet, toasty       0.78       -       9.92         69       1546       Amyl hexanoate       Solvent, stink, stink bug       0.88       0.59         70       1559       Betz-linalol       Emon, citrus, souer       0.92       0.36         73       1614       Hexyl hexanoate       Solvent, stink, stink bug       0.96       0.36         71       169       Actophenone       Sweet, fruity, honey, flowery       1.02       0.79         74	53	1339	Hexyl propanoate	Green banana, strawberry	2.80	4.95
56         1366         Hexanol         Citrus, euclipt, herbal         3.64         3.17           57         1374         Trans-3-hexen-1-ol         Totaky, stink         -         0.93           58         1392         Cis-3-hexen-1-ol         Sulfur-like, passion fruit, grass         5.12         6.96           60         1416         Butyl hexanoate         Flowery, green         4.42         2.01           63         1439         Bthyl octanoate         Grass, earthy         4.16         5.14           63         1515         Benzaldehyde         Citrus, sweet         -         0.36           68         1515         Benzaldehyde         Citrus, sweet         -         0.36           69         1546         Anyl hexanoate         Sulex, tanky, sulfur-like         0.88         0.59           70         1559         Beta-linalol         Lemon, citrus, sour         4.80         4.92           73         1614         Hexyl hexanoate         Solvent, stink, sulfur-like         0.96         0.36           74         1661         Cis-3-hexenylhexanoate         Solvent, stink, sulfur-like         9.92         0.77         0.58           75         1703         Alpha-terpineol         Citrus	54	1345	Ethyl trans-2-hexenoate	Fruity, burnt, undergrowth	1.77	-
57 $1374$ $Trans-3$ -hexen-1-ol $Toaxty, stink$ $ 0.93$ $58$ $1392$ $Cis-3$ -hexen-1-olSulfur-like, passion fruit, grass $5.12$ $6.96$ $60$ $1416$ Buty hexanoateFlowery, green $4.42$ $2.01$ $63$ $1439$ Ethyl octanoate $Grass, earthy$ $4.16$ $5.14$ $67$ $1479$ Alpha-copaeneCitrus, fruity, passion fruit, sweet $ 0.36$ $0$ $1518$ Ethyl $3$ -hydroxybutanoateSweet, toasty $0.78$ $ E$ $1525$ Hexyl pentanoatePeach, earth, undergrowth $ 0.92$ $70$ $1556$ Beta-linalolLemon, citrus, sour $4.80$ $4.92$ $73$ $1614$ Hexyl hexanoateSolvent, stink, sulfur-like $0.96$ $0.36$ $F$ $1679$ AcetophenoneSweet, fruity, horey, flowery $1.02$ $0.79$ $74$ $1661$ $Cis-3$ -hexenylhexanoateSaison fruit, furity, sharp $ 0.61$ $75$ $1703$ Alpha-terpineolPassion fruit, furity, sharp $ 0.61$ $75$ $1703$ Alpha-terpineolPassion fruit, furity, sharp $ 0.61$ $76$ $1799$ Benzyl acetaleCitrus, flowery $0.33$ $0.64$ $71$ $1729$ Delta-cadineneCitrus, flowery $0.57$ $ 75$ $1703$ Alpha-terpineolSweet, fairly, flowery $0.57$ $ 74$ $1680$ ni $0.61$ $  -$	56	1366	Hexanol	Citrus, eucalipt, herbal	3.64	3.17
581392Cis-3-hexen-1-olSulfur-like, passion fruit, grass5.126.96601416Butyl hexanoateFlowery, green4.422.01631439Ethyl octanoateGrass, earthy4.165.14671479Alpha-copaeneCitrus, fuity, passion fruit, sweet1.110.41681515BenzaldehydeCitrus, sweet-0.36D1518Ethyl 3-hydroxybutanoateSweet, toasty0.78-E1525Hexyl pentanoatePeach, earth, undergrowth-0.92691546Anyl hexanoateSolvent, stink, sufur-like0.860.59701559Beta-inaloolLemon, citrus, sour4.804.92731614Hexyl hexanoateSolvent, stink, sufur-like0.960.36F1679AcetophenoneSweet, fruity, honey, flowery1.020.79741661Cis-3-hexenylhexanoatePassion fruit, grues, sour1.020.79751703Alpha-terpineolPassion fruit, fuity, sharp1.010.44761709Benzyl actateCitrus, flowery, green2.471.60771729Delta-cadineneCitrus, flowery0.930.64H178niCitrus, sowet, flowery, green2.555.37801883Benzyl alcoholSweet, flowery0.57-81179Delta-cadineneSweet, flowery0.57-8217	57	1374	Trans-3-hexen-1-ol	Toasty, stink	-	0.93
601416Butyl hexanoateFlowery, green4.422.01631439Ethyl octanoateGrass, earthy4.165.14671479Alpha-copaeneCitrus, fruity, passion fruit, sweet1.110.41681515BenzaldehydeCitrus, sweet-0.36D1518Ethyl 3-hydroxybutanoateSweet, toasty0.78-E1525Hexyl pentanoateStink, stink bug0.880.59701559Beta-linaloolLemon, citrus, sour4.804.92731614Hexyl hexanoateSolvent, stink, sulfur-like0.960.36F1679AcetophenoneSweet, fruity, honey, flowery1.020.79741661Cis-3-hexenylhexanoatePassion fruit, undergrowth, sharp0.770.58G1680Germacrene DCitrus, flowery, green2.471.60771729Delta-cadineneCitrus, flowery, green2.471.60771729Delta-cadineneCitrus, flowery, green0.930.61781857niCitrus, sweet, passion fruit leaf0.770.53781857niCitrus, sweet, passion fruit leaf0.770.51821978DodecanolSweet, flowery0.95-91853Benzyl alcoholSweet, flowery, sweet0.95-19196niCitrus, sweet, passion fruit leaf0.62-74196ni	58	1392	Cis-3-hexen-1-ol	Sulfur-like, passion fruit, grass	5.12	6.96
631439Ethyl octanoateGrass, earthy4.165.14671479Alpha-copaeneCitrus, fruity, passion fruit, sweet1.110.41681515BenzaldehydeCitrus, sweet-0.36D1518Ethyl 3-hydroxybutanoateSweet, toasty0.78-E1520Hexyl pentanoatePeach, earth, undergrowth-0.92691546Amyl hexanoateStink, stink bug0.880.59701559Beta-linaloolLemon, citrus, sour4.804.92731614Hexyl hexanoateSolvent, stink, suffur-like0.960.36741661Citra-3-hexenylhexanoatePassion fruit, undergrowth, sharp0.770.58751703Alpha-terpineolCitrus, pepermint, sweet, sharp-0.61761709Benzyl acetateCitrus, flowery, green2.471.60771729Delta-cadineneCitrus, flowery, green2.470.38141780niQuince jelly, candy, flowery5.355.37781857niCitrus, sweet, flowery0.57-811916niSweet, flowery, sweet0.95-151938Benzyl alcoholSweet, flowery0.95-771729Delta-cadineneSweet, flowery0.57-811916niCitrus, sweet, passion fruit leaf0.770.51821978Dodecanol	60	1416	Butyl hexanoate	Flowery, green	4.42	2.01
67 $1479$ Alpha-copaeneCitrus, fruity, passion fruit, sweet $1.11$ $0.41$ $68$ 1515BenzaldehydeCitrus, sweet $ 0.36$ D1518Ethyl 3-hydroxybutanoateSweet, toasty $0.78$ $-$ E1525Hexyl pentanoateSweet, coasty $0.78$ $ 69$ 1546Amyl hexanoateStink, stink bug $0.88$ $0.59$ $70$ 1559Beta-linaloolLemon, citrus, sour $4.80$ $4.92$ $73$ 1614Hexyl hexanoateSweet, fuity, honey, flowery $1.02$ $0.79$ $74$ 1661Cis-3-hexenylhexanoatePassion fruit, undergrowth, sharp $0.77$ $0.58$ G1680Germacrene DCitrus, peppermint, sweet, sharp $ 0.61$ $75$ 1703Alpha-terpineolPassion fruit, fuity, sharp $1.11$ $0.44$ $76$ 1709Benzyl acetateCitrus, flowery, green $2.47$ $1.60$ $77$ 1729Delta-cadineneCitrus, flowery, green $2.47$ $0.53$ $78$ 1857niCitrus, flowery, fruity, afary $ 0.38$ $81$ 1916niGitrus, sweet, flowery $0.95$ $ 82$ 1978DodecanolSweet, flowery $0.95$ $ 84$ 2047niCandy floss, caramel $0.95$ $ 83$ 2186Methyl hexadecanoateSharp, solvent $ 0.66$ $84$ 2247niGitrus, saty	63	1439	Ethyl octanoate	Grass, earthy	4.16	5.14
68         1515         Benzaldehyde         Citrus, sweet         -         0.36           D         1518         Ethyl 3-hydroxybutanoate         Sweet, toasty         0.78         -           69         1546         Amyl hexanoate         Peach, earth, undergrowth         -         0.92           69         1546         Amyl hexanoate         Stink, stink bug         0.88         0.59           73         1614         Hexyl pertanoate         Solvent, stink, sulfur-like         0.96         0.36           73         1614         Hexyl hexanoate         Solvent, stink, sulfur-like         0.96         0.36           74         1661         Cfs-3-hexenylhexanoate         Passion fruit, undergrowth, sharp         0.77         0.58           75         1703         Alpha-terpineol         Passion fruit, fruity, sharp         1.11         0.44           76         1709         Benzyl acetate         Citrus, flowery         0.93         0.64           77         1729         Delta-cadinene         Citrus, flowery         5.35         5.37           78         1857         ni         Citrus, sweet, flowery, string         0.77         0.51           81         1916         ni         Flowery, string<	67	1479	Alpha-copaene	Citrus, fruity, passion fruit, sweet	1.11	0.41
D         1518         Ethyl 3-hydroxybutanoate         Sweet, toasty $0.78$ $-$ E         1525         Hexyl pentanoate         Peach, earth, undergrowth $ 0.92$ 69         1546         Amyl hexanoate         Stink, stink bug $0.88$ $0.59$ 70         1559         Beta-linalool         Lemon, citrus, sour $4.80$ $4.92$ 73         1614         Hexyl hexanoate         Solvent, stink, sulfur-like $0.96$ $0.36$ 74         1661         Cis-3-hexenylhexanoate         Passion fruit, undergrowth, sharp $ 0.61$ 75         1703         Alpha-terpineol         Passion fruit, fruity, sharp $1.11$ $0.44$ 76         1709         Benzyl acetate         Citrus, flowery, green $2.47$ $1.60$ 77         1729         Delta-cadinene         Citrus, flowery $9.93$ $0.64$ 78         1857         ni         Citrus, sweet, passion fruit leaf $0.77$ $0.51$ 80         183         Benzyl alcohol         Sweet, flowery $0.57$ $-$ 11         1946	68	1515	Benzaldehyde	Citrus, sweet	_	0.36
E         1525         Hexyl pentanoate         Peach, earth, undergrowth         -         0.92           69         1546         Amyl hexanoate         Stink, stink bug         0.88         0.59           70         1559         Beta-linalool         Lemon, citrus, sour         4.80         4.92           73         1614         Hexyl hexanoate         Solvent, stink, sulfur-like         0.96         0.36           74         1661         Cis-3-hexenylhexanoate         Passion fruit, undergrowth, sharp         0.77         0.58           G         1680         Germacrene D         Citrus, peppermint, sweet, sharp         -         0.61           75         1703         Alpha-terpineol         Passion fruit, furity, sharp         1.11         0.44           76         1709         Benzyl acetate         Citrus, flowery, green         2.47         1.60           77         1729         Delta-cadinene         Citrus, flowery         5.35         5.37           78         1857         ni         Citrus, sweet, flowery         0.57         -           80         1883         Benzyl alcohol         Sweet, flowery         0.57         -           81         1916         ni         Sharp, leaf, fruity,	D	1518	Ethyl 3-hydroxybutanoate	Sweet, toasty	0.78	_
691546Amyl hexanoateStink, stink bug0.880.59701559Beta-linaloolLemon, citrus, sour4.804.92731614Hexyl hexanoateSolvent, stink, sulfur-like0.960.36F1679AcetophenoneSweet, fruity, honey, flowery1.020.79741661Cis-3-hexenylhexanoatePassion fruit, undergrowth, sharp0.770.58G1680Germacrene DCitrus, peppermint, sweet, sharp-0.61751703Alpha-terpineolPassion fruit, fruity, sharp1.110.44761709Benzyl acetateCitrus, flowery, green2.471.60771729Delta-cadineneCitrus, flowery0.930.64181844niQuince jelly, candy, flowery5.355.37781857niCitrus, sweet, passion fruit leaf0.770.51801883Benzyl alcoholSweet, flowery0.95-811916niFlowery, sweet0.95-821978DodecanolSweet, sharp0.62-142043niCitrus, caramel, solvent-0.66142043niCardy floss, caramel8.578.89151980niSlovent1.32-162047niSolvent1.32-171249niSolvent1.32-1832186Methyl hex	E	1525	Hexyl pentanoate	Peach, earth, undergrowth	-	0.92
70         1559         Beta-Innalool         Lemon, citrus, sour         4.80         4.92           73         1614         Hexyl hexanoate         Solvent, stink, sulfur-like         0.96         0.36           74         1661         Cis-3-hexenylhexanoate         Passion fruit, undergrowth, sharp         1.02         0.79           74         1661         Cis-3-hexenylhexanoate         Passion fruit, undergrowth, sharp         -         0.61           6         1680         Germacrene D         Citrus, peppermint, sweet, sharp         -         0.61           75         1703         Alpha-terpineol         Passion fruit, flowery, green         2.47         1.60           77         1729         Delta-cadinene         Citrus, flowery, green         2.47         1.60           78         1844         ni         Quince jelly, candy, flowery         5.35         5.37           78         1857         ni         Citrus, sweet, passion fruit leaf         0.77         0.51           80         1883         Benzyl alcohol         Sweet, flowery         0.57         -           81         1916         ni         Sweet, flowery         0.57         -           82         1978         Dodecanol <td< td=""><td>69</td><td>1546</td><td>Amyl hexanoate</td><td>Stink, stink bug</td><td>0.88</td><td>0.59</td></td<>	69	1546	Amyl hexanoate	Stink, stink bug	0.88	0.59
73         1614         Hexyl nexanote         Solvent, stink, suffur-like         0.96         0.36           F         1679         Acetophenone         Sweet, fruity, honey, flowery         1.02         0.79           74         1661         Cis-3-hexenylhexanoate         Passion fruit, undergrowth, sharp         0.77         0.58           G         1680         Germacrene D         Citrus, peppermint, sweet, sharp         -         0.61           75         1703         Alpha-terpineol         Passion fruit, fruity, sharp         1.11         0.44           76         1709         Benzyl acetate         Citrus, flowery, green         2.47         1.60           77         1729         Delta-cadinene         Citrus, flowery         0.93         0.64           H         1780         ni         Quince jelly, candy, flowery         5.35         5.37           1         1844         ni         Quince jelly, candy, flowery         0.57         -           80         1857         ni         Citrus, sweet, flowery, sweet         0.95         -           81         1916         ni         Sharp, leaf, fruity, stink         0.62         -           K         2003         ni         Candy floss, carame	70	1559	Beta-linalool	Lemon, citrus, sour	4.80	4.92
F       16/9       Acctophenone       Sweet, truity, honey, howery       1.02       0.79         74       1661       Cits-3-hexenylhexanoate       Passion fruit, undergrowth, sharp       0.77       0.58         G       1680       Germacrene D       Citrus, peppermint, sweet, sharp       -       0.61         75       1703       Alpha-terpineol       Passion fruit, fruity, sharp       1.11       0.44         76       1709       Benzyl acetate       Citrus, flowery, green       2.47       1.60         77       1729       Delta-cadinene       Citrus, flowery, fruity       -       0.38         1       1844       ni       Quince jelly, candy, flowery       5.35       5.37         78       1857       ni       Citrus, sweet, passion fruit leaf       0.77       0.51         80       1883       Benzyl alcohol       Sweet, flowery       0.95       -         81       1916       ni       Flowery, sweet       0.95       -         82       1978       Dodecanol       Sweet, sharp       0.95       -         J       1980       ni       Candy floss, caramel       2.10       -         K       2003       ni       Candy floss, caramel	/3	1614	Hexyl hexanoate	Solvent, stink, sulfur-like	0.96	0.36
741661CL*-3-nexenyinexanoatePassion truit, undergrowth, sharp0.770.58G1680Germacrene DCitrus, peppermint, sweet, sharp-0.61751703Alpha-terpineolPassion truit, fruity, sharp1.110.44761709Benzyl acetateCitrus, flowery, green2.471.60771729Delta-cadineneCitrus, flowery, green0.930.64H1780niFlowery, fruity-0.38I1844niQuince jelly, candy, flowery5.355.37781857niCitrus, sweet, passion fruit leaf0.770.51801883Benzyl alcoholSweet, flowery0.95-811916niFlowery, sweet0.95-821978DodecanolSweet, sharp0.95-J1980niCandy floss, caramel8.578.89M2047niCandy floss, caramel8.578.89M2149niSolvent1.32-832186Methyl hexadecanoateSharp, solvent0.64-02190niSolvent, plastic7.605.10842247niSolvent, plastic7.605.10	F	1679	Acetophenone	Sweet, fruity, honey, flowery	1.02	0.79
G       1680       Germattene D       Cltrus, peppermint, sweet, sharp       -       0.61         75       1703       Alpha-terpineol       Passion fruit, fruity, sharp       1.11       0.44         76       1709       Benzyl acctate       Citrus, flowery, green       2.47       1.60         77       1729       Delta-cadinene       Citrus, flowery, green       0.93       0.64         H       1780       ni       Flowery, fruity       -       0.38         I       1844       ni       Quince jelly, candy, flowery       5.35       5.37         78       1857       ni       Citrus, sweet, passion fruit leaf       0.77       -         80       1883       Benzyl alcohol       Sweet, flowery       0.57       -         81       1916       ni       Flowery, sweet       0.95       -         82       1978       Dodecanol       Sweet, sharp       0.62       -         J       1980       ni       Cardy floss, caramel       8.57       8.89         M       2043       ni       Candy floss, caramel       8.57       8.89         M       2047       ni       Candy floss, caramel       2.10       -	74	1661	Cis-3-nexenyinexanoate	Passion fruit, undergrowth, sharp	0.77	0.58
751703Alpha-terpineolPassion mult, multy, sharp1.110.44761709Benzyl acetateCitrus, flowery, green2.471.60771729Delta-cadineneCitrus, flowery0.930.64H1780niFlowery, fruity-0.38I1844niQuince jelly, candy, flowery5.355.37781857niCitrus, sweet, passion fruit leaf0.770.51801883Benzyl alcoholSweet, flowery0.57-811916niFlowery, sweet0.95-821978DodecanolSweet, sharp0.95-J1980niSharp, leaf, fruity, stink0.62-K2003niCandy floss, caramel, solvent-0.66L2043niCandy floss, caramel8.578.89M2047niSolvent1.32-832186Methyl hexadecanoateSharp, solvent0.64-02190niSolvent, plastic7.605.10842247niRubber, toasty0.490.39	G	1680	Germacrene D	Citrus, peppermint, sweet, snarp	-	0.61
76         1709         Benzyl acetate         Cliftus, nowery, green         2.47         1.60           77         1729         Delta-cadinene         Citrus, flowery, fruity         0.93         0.64           H         1780         ni         Citrus, flowery, fruity         -         0.38           I         1844         ni         Quince jelly, candy, flowery         5.35         5.37           78         1857         ni         Citrus, sweet, passion fruit leaf         0.77         0.51           80         1883         Benzyl alcohol         Sweet, flowery, sweet         0.95         -           81         1916         ni         Sweet, sharp         0.95         -           J         1980         ni         Sharp, leaf, fruity, stink         0.62         -           K         2003         ni         Candy floss, caramel, solvent         -         0.666           L         2043         ni         Candy floss, caramel         8.57         8.89           M         2047         ni         Candy floss, caramel         1.32         -           N         2149         ni         Solvent         1.32         -           83         2186	75	1703	Alpha-terpineoi	Passion fruit, fruity, snarp	1.11	0.44
<i>H</i> 1729Defa-califiereCitrus, inverty0.930.64H1780niFlowery, fruity-0.38I1844niQuince jelly, candy, flowery5.355.37781857niCitrus, sweet, passion fruit leaf0.770.51801883Benzyl alcoholSweet, flowery0.57-811916niFlowery, sweet0.95-821978DodecanolSweet, sharp0.95-J1980niSharp, leaf, fruity, stink0.62-K2003niCitrus, caramel, solvent-0.66L2043niCandy floss, caramel8.578.89M2047niSolvent1.32-832186Methyl hexadecanoateSharp, solvent0.64-02190niSolvent, plastic7.605.10842247niRubber, toasty0.490.39	76	1709	Belizyi acetate	Citrus, flowery, green	2.47	1.60
I       1780       in       Prowery, futty       -       0.58         I       1844       ni       Quince jelly, candy, flowery       5.35       5.37         78       1857       ni       Citrus, sweet, passion fruit leaf       0.77       0.51         80       1883       Benzyl alcohol       Sweet, flowery       0.57       -         81       1916       ni       Flowery, sweet       0.95       -         82       1978       Dodecanol       Sweet, sharp       0.95       -         J       1980       ni       Sharp, leaf, fruity, stink       0.62       -         J       1980       ni       Citrus, caramel, solvent       0.62       -         L       2043       ni       Candy floss, caramel       8.57       8.89         M       2047       ni       Candy floss, caramel       1.32       -         N       2149       ni       Solvent       1.32       -         83       2186       Methyl hexadecanoate       Sharp, solvent       0.64       -         0       2190       ni       Solvent, plastic       7.60       5.10         84       2247       ni       Rubber, toas	// U	1729	Delta-Caulifelle	Element, fruitu	0.95	0.04
1144inGuinte jen, cality, nowery5.535.57781857niCitrus, sweet, passion fruit leaf0.770.51801883Benzyl alcoholSweet, flowery0.57-811916niFlowery, sweet0.95-821978DodecanolSweet, sharp0.95-J1980niSharp, leaf, fruity, stink0.62-K2003niCitrus, caramel, solvent-0.66L2043niCandy floss, caramel8.578.89M2047niSolvent1.32-832186Methyl hexadecanoateSharp, solvent0.64-02190niSolvent, plastic7.605.10842247niRubber, toasty0.490.39	п	1760		Quince jelly candy flowery	- 5 25	0.56
751837InCitrus, sweet, passion nutriear0.770.51801883Benzyl alcoholSweet, flowery0.57-811916niFlowery, sweet0.95-821978DodecanolSweet, sharp0.95-J1980niSharp, leaf, fruity, stink0.62-K2003niCitrus, caramel, solvent-0.66L2043niCandy floss, caramel8.578.89M2047niCandy floss, caramel2.10-N2149niSolvent1.32-832186Methyl hexadecanoateSharp, solvent0.64-02190niSolvent, plastic7.605.10842247niRubber, toasty0.490.39	1 79	1044	lii pi	Citrus sweet passion fruit loaf	0.55	0.51
ability alcoholSweet, hovery0.57-811916niFlowery, sweet0.95-821978DodecanolSweet, sharp0.95-J1980niSharp, leaf, fruity, stink0.62-K2003niCitrus, caramel, solvent-0.66L2043niCandy floss, caramel8.578.89M2047niSolvent1.32-N2149niSolvent1.32-832186Methyl hexadecanoateSharp, solvent0.64-02190niSolvent, plastic7.605.10842247niRubber, toasty0.490.39	20	1007	III Ponzul alcohol	Sweet flowery	0.77	0.51
811910InHowely, sweet0.93-821978DodecanolSweet, sharp0.95-J1980niSharp, leaf, fruity, stink0.62K2003niCitrus, caramel, solvent-0.66L2043niCandy floss, caramel8.578.89M2047niCandy floss, caramel2.10-N2149niSolvent1.32-832186Methyl hexadecanoateSharp, solvent0.64-02190niSolvent, plastic7.605.10842247niRubber, toasty0.490.39	80 91	1005	belizyi alcolloi	Flowery	0.57	-
J1980niSweet, snap0.53-J1980niSharp, leaf, fruity, stink0.62K2003niCitrus, caramel, solvent-0.66L2043niCandy floss, caramel8.578.89M2047niCandy floss, caramel2.10-N2149niSolvent1.32-832186Methyl hexadecanoateSharp, solvent0.64-02190niSolvent, plastic7.605.10842247niRubber, toasty0.490.39	81 82	1910	Dedecapel	Sweet sharp	0.95	-
K2003niCitrus, caramel, solvent-0.62L2043niCitrus, caramel, solvent-8.578.89M2047niCandy floss, caramel2.10-N2149niSolvent1.32-832186Methyl hexadecanoateSharp, solvent0.64-02190niSolvent, plastic7.605.10842247niRubber, toasty0.490.39	52 I	1970	ni	Sharn leaf fruity stink	0.55	—
L2043niCardy flos, cramel8.578.89M2047niCardy flos, cramel2.10-N2149niSolvent1.32-832186Methyl hexadecanoateSharp, solvent0.64-02190niSolvent, plastic7.605.10842247niRubber, toasty0.490.39	к Г	2003	ni	Citrus caramel solvent	-	0.66
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N2149niCarly hos, caraner210-N2149niSolvent1.32-832186Methyl hexadecanoateSharp, solvent0.64-02190niSolvent, plastic7.605.10842247niRubber, toasty0.490.39	M	2045	ni	Candy floss, caramel	210	-
R32186Methyl hexadecanoateSharp, solvent0.64-02190niSolvent, plastic7.605.10842247niRubber, toasty0.490.39	N	2149	ni	Solvent	1 32	_
O         2190         ni         Solvent, plastic         7.60         5.10           84         2247         ni         Rubber, toasty         0.49         0.39	83	2145	Methyl hexadecanoate	Sharp solvent	0.64	_
84 2247 nj Ruber, toasty 0.49 0.39	0	2100	ni	Solvent plastic	7.60	5 10
	84	2247	ni	Rubber, toasty	0.49	0.39

A-O letters: compound not detect by GC-FID.

ni: compound not identified by GC-MS.

<sup>a</sup> IR: retention index of peak in DB-Wax column.

<sup>b</sup> Imax: maximum intensity of peak in GC–O–OSME, 0-(no odor) to 9 (strong/extreme odor).

and biotic factors, is responsible for physiological changes, particularly the defensive mechanisms induced by pathogens. This leads to the synthesis of protective secondary metabolites, such as terpenes and esters (Gobbo-Neto & Lopes, 2007). In this study, *trans* and *cis*-3-hexenyl acetate and alpha-copaene, alpha-terpineol, Dlimonene, *trans*-beta-ocimene and delta-cadinene showed higher aroma intensity for the organic passion fruit, while beta-myrcene and beta-linalool were slightly higher in the conventional fruit (Table 3). All these compounds provide significant contributions to the characteristic aroma of passion fruit and some, such as the hexenyl acetates, have been described as metabolites that are able to protect the plant (Briskin, 2000; Engelberth, 2006).

Some volatiles not identified, but whose presence was revealed by low peaks on the aromagram of just one of the fruits, may also play a part in the characteristic differences in flavor between the organic and conventional passion fruit (Table 3).

## 4. Conclusions

The passion fruit volatile composition was not markedly influenced by the cultivation system. The organic and conventional passion fruit showed similar volatile profile, although some differences occurred. Ethyl 2-propenoate, 2-methyl-1-propanol, diethyl carbonate and ethyl hexanoate were threefold higher in the organic fruit while butyl acetate, hexanal, *cis*-3-hexenyl acetate and *trans*-3-hexenyl butanoate were threefold higher in the conventional fruit.

Gas chromatography-mass spectrometry and GC—O allowed the identification of the odoriferous compounds that contributed to the aroma of the passion fruit from both cultivation systems. The hexanoate and acetate esters, and saturated alcohols described as fruity, sweet, citrus and passion-fruit aroma showed the highest odorific intensity in the organic fruit. Furthermore, the *trans* and *cis*-3-hexenyl acetate and the alpha-copaene, alpha-terpineol, D-limonene, *trans*-beta-ocimene and delta-cadinene had higher contribution to the organic passion fruit aroma. On the other hand, the unsaturated alcohols described as grass, sulfur-like and passion-fruit aroma were higher in the conventional fruit. The beta-myrcene and beta-linalool were slightly higher in the conventional passion fruit.

The organic passion fruit showed higher levels of total phenolic compounds and total antioxidant activity than the conventional fruit, suggesting that the cultivation system influenced the production of antioxidant bioactive compounds.

The correlation between instrumental and sensory data enabled the identification of the volatile compounds of greatest importance to the overall aroma of both the organic and conventional passion fruit, and also indicated the differences between the fruits. However, additional research will be needed, especially in order to identify the compounds that provided considerable contributions to the aroma, but which were not detected by the flame-ionization detector.

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