Physico-chemical Characteristics of Papaya (*Carica papaya* L.) Seed Oil of the Hong Kong/Sekaki Variety

Noorzianna Abdul Manaf Yanti¹, Jalaldeen Mohammed Nazrim Marikkar², Bangun Prajanto Nusantoro³, Kamariah Long⁴ and Hasanah Mohd Ghazali¹*.

¹ Department of Food Science, Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400 Serdang, Selangor DE, Malaysia.
² Department of Biochemistry, Faculty of Biotechnology and Biomolecular Sciences, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.
³ Department of Food and Agricultural Product Technology, Faculty of Agricultural Technology, Gadjah Mada University, Yogyakarta 55281, Indonesia.
⁴ Malaysian Agricultural Research and Development Institute, P.O. Box 12301, 50774 Kuala Lumpur, Malaysia.

Abstract: A study was carried out to determine the physicochemical characteristics of the oil derived from papaya seeds of the Hong Kong/Sekaki variety. Proximate analysis showed that seeds of the Hong Kong/Sekaki variety contained considerable amount of oil (27.0%). The iodine value, saponification value, unsaponifiable matter and free fatty acid contents of freshly extracted papaya seed oil were 76.9 g I₂/100g oil, 193.5 mg KOH/g oil, 1.52% and 0.91%, respectively. The oil had a Lovibond color index of 15.2Y + 5.2B. Papaya seed oil contained ten detectable fatty acids, of which 78.33% were unsaturated. Oleic (73.5%) acid was the dominant fatty acid followed by palmitic acid (15.8%). Based on the high performance liquid chromatography (HPLC) analysis, seven species of triacylglycerols (TAGs) were detected. The predominant TAGs of papaya seed oil were OOO (40.4%), POO (29.1%) and SOO (9.9%) where O, P, and S denote oleic, palmitic and stearic acids, respectively. Thermal analysis by differential scanning calorimetry (DSC) showed that papaya seed oil had its major melting and crystallization transitions at 12.4°C and -48.2°C, respectively. Analysis of the sample by Z-nose (electronic nose) instrument showed that the sample had a high level of volatile compounds.

Key words: *Carica papaya* L., proximate analysis, fatty acids, triacylglycerols, melting and cooling points, volatile compounds.

1 Introduction

Papaya (*Carica papaya* L.), belonging to the family Caricaceae, exists in almost all tropical and subtropical regions of the world¹⁻³. Being a tree-like herbaceous plant, papaya bears fruits throughout the year. Different forms, sizes color of the flesh of papaya are existed depending on the variety. The flesh of the papaya fruit may vary from yellow to orange or reddish. Each fruit may contain a large number of seeds which are usually attached in rows to the interior of the fruit.

The seeds of papaya are edible and found to have some spicy flavor which makes it a substitute for black pepper⁴⁻⁶. For instance, they are commercially used as an ingredient in Hawaii salad dressings⁷. The spicy-pungent flavor of the seeds is attributed to the presence of benzyl isothiocyanate⁸⁻¹². The biologically active isothiocyanate has been found to act as cancer chemopreventive agents. Lohiya et al.¹³ reported that the papaya seeds were used as a potential post-testicular anti-fertility drug. Papaya latex and seeds also have proven antihelminthic and anti-microbial activities¹⁴. For instance, it was found to be efficient in treating human intestinal parasites without side effects¹⁵.

There has been a considerable interest with regard to the oil potential of papaya seeds⁸,¹⁶⁻¹⁸. According to past studies, the oil content of papaya seed was found to be in a range of 13.9–30.7%⁸,¹⁶⁻¹⁰. Papaya seed oil is yellow (ranging from pale to dark yellow) in color and is almost odorless and flavorless²⁰; hence it can easily find new uses. Similarly, the residue left after the extraction of the seed oil is an industrially useful material. Alobo²¹ indicated that the defatted-seed flour of papaya may have some potential applications in food formulations since it was found to
show foaming and emulsifying properties. It could be mainly due to the high protein content of the papaya seed flour (32.4%) \(^{23}\). According to another investigation, the protein content of the defatted papaya seed was as high as 44.4% \(^{22}\). Hence, the extraction of oil from the waste-seeds of papaya and utilization of its defatted flour could improve the profitability of the papaya industries \(^{21}\).

Malaysia, being a country with long-established papaya cultivation, could reap the potential benefits from papaya. Papaya of the Hong Kong/Sekaki variety is the second most popularly cultivated variety in Malaysia after Eksotika. It is a cross-pollinated variety and a prolific bearer yielding a high yield of fruits per tree alike to explore possible uses of the oil. In our previous study, we determined the physical-chemical characteristics of this oil into methyl esters (FAME) and analyzed on a gas chromatograph (Shimadzu GC-14A, Shimadzu Corporation, Kyoto, Japan) fitted with an FID detector. A polar capillary column BPX70 (0.32 mm internal diameter, 30 m length and 0.25 μm film thickness; SGE International Pty, Ltd., Victoria, Australia) was used at a column pressure of 10 psi. The initial temperature of column was 90°C and increased to 110°C, held for 1 min. Then, it was increased at the rate of 8°C/min to 220°C for 1 min. The temperature of the injector and detector was maintained at 240°C \(^{26}\). Individual peaks of fatty acid methyl esters were identified by comparing their retention times with those of standards.

2.2 Proximate analysis
The moisture, crude protein (micro-Kjeldahl), crude fiber and oil contents of papaya seeds were determined using the methods described by Pearson \(^{25}\). The ash content was determined using the method of Pomeranz and Meloan \(^{26}\) and total carbohydrate was calculated by difference. All determinations were done in duplicate.

2.3 Oil extraction
Oil was extracted from the ground papaya seeds by circulating petroleum ether (40-60°C) for 8 h in a 5 L Soxhlet extractor \(^{27}\). The oil was recovered using a rotary evaporator (Model N-1, Eyela, Tokyo Rakakikal Co., Ltd., Tokyo, Japan). The extracted fat was placed in an oven at 60°C for 1 h and transferred into a blue-capped reagent bottle and stored at \(\sim\) 20°C until needed for analysis. Prior to analysis, the oil was removed from cold storage, left standing at room temperature for 1 h and then warmed at 60°C until completely melted.

2.4 Determination of iodine and saponification values, unsaponifiable matter and free fatty acid contents
The iodine and saponification values, saponifiable matter and free fatty acid contents of the oil sample were determined according to the standard analytical methods of AOAC \(^{27}\).

2.5 GC analysis of fatty acid methyl ester (FAME)
The fatty acid composition was determined after conversion of the oil into methyl esters (FAME) according to the method of Cocks and van Rede \(^{28}\), and analyzed on a gas chromatograph (Shimadzu GC-14A, Shimadzu Corporation, Kyoto, Japan) fitted with an FID detector. A polar capillary column BPX70 (0.32 mm internal diameter, 30 m length and 0.25 μm film thickness; SGE International Pty, Ltd., Victoria, Australia) was used at a column pressure of 10 psi. The initial temperature of column was 90°C and increased to 110°C, held for 1 min. Then, it was increased at the rate of 8°C/min to 220°C for 1 min. The temperature of the injector and detector was maintained at 240°C \(^{26}\). Individual peaks of fatty acid methyl esters were identified by comparing their retention times with those of standards.

2.6 Determination of triacylglycerol (TAG) profile
The system used was a Shimadzu LC-10AD liquid chromatograph, equipped with a Shimadzu SIL-10 AD auto-injector, Shimadzu system controller SLC-10A, and RID-6A Shimadzu refractive index detector (Shimadzu Corporation, Kyoto, Japan). The separation of TAG was performed on a commercially packed RP-18 column (250 × 4 mm) with particle size 5 μm (Merck, Darmstadt, Germany). The mobile phase was acetone:acetonitrile (63.5:36.5, v/v) and the flow rate was 1 mL/min at 30°C. The injector volume was 10 μL of 5% (w/w) oil in chloroform. The total run time of a sample was 1 h. The TAG peaks identification was based on the retention time of TAG standards (OLL, OOL, POL, OO, POO, PPO and SOO; Sigma-Aldrich, Inc. St. Louis, California, USA) and the results of Ghazali et al. \(^{29}\). Percent unknown TAG was calculated by obtaining the percentage of the sum of peak areas of unknown TAG divided by the sum of peak areas of TAG after 10 minutes of elution time \(^{31}\).

2.7 DSC thermal analysis
For thermal analysis, a Perkin-Elmer differential scanning calorimeter equipped with a thermal analysis data station (PYRIS™ Diamond DSC, Perkin-Elmer Corporation, Shelton, Connecticut, USA) was used. The instrument was
2.8 Solid fat content (SFC) analysis by Pulse NMR

SFC was measured using a Bruker Minispec (Model mq20) pulse Nuclear Magnetic Resonance (pNMR) spectrometer (Karlsruhe, Germany). Measurements were taken according to PORIM parallel method (Method I). The sample in an NMR tube was first melted at 60°C for 30 min, followed by chilling at 0°C for 60 min, and then held at each measuring temperature for 30 min prior to measurement. Melting, chilling, and holding of the samples were carried out in pre-equilibrated thermostated water baths (JEIO TECH Model VTRC-620 Desktop Refrigerated Circulator), accurate to 1°C. SFC of the sample was measured at 5, 10, 15, 17 and 20°C. The signals were recorded and integrated by a computer to obtain the percent SFC (%).

2.9 Color determination

Liquid oil samples were placed into a 1 inch cell and the color was determined using a Lovibond tintometer Model E (Salisbury, England) at 30°C by achieving the best possible match with the standard color slides of blue (B) and yellow (Y) indices.

2.10 Aroma profiling

The aroma (volatile compounds) profiles of papaya seed oil were analyzed using an Ultra-Fast GC Analyzer (zNose, Model 7100, Electronic Sensor Technology Company, Newbury Park, CA). Analysis was done by placing the seed oil in universal bottles filled to half capacity. Then, the bottles were covered with two layers of parafilm and heated at 60°C in an oven for 15 min. This procedure was to allow the emission of aroma compounds. The vapor sample was introduced into the electronic nose via the sample inlet. The column (Model DB-5, J & W Scientific, Agilent Technologies, USA) temperature was programmed from 40°C to 200°C and Surface Acoustic Wave (SAW) quartz microbalance detector temperature was 60°C. The helium gas flow was 3.5×10⁻⁶ m³/min. Chemical analysis time of flavor was accomplished within 20 s by a very fast separation of chemical sampled vapors. Profiles obtained are presented as zNose (ultrafast GC) chromatograms and Vaporprint.

2.11 Statistical analysis

In all analyses, two replicates were used and the results were expressed as mean value ± standard deviation. Data were statistically analyzed by one-way analysis of variance (ANOVA), by using Tukey’s Test of MINITAB (version 15) statistical package at 0.05 probability level.

3 Results and Discussion

3.1 Proximate composition and oil quality of papaya seed

Proximate analysis of the papaya seed of the Hong Kong/Sekaki variety showed that it contained 6.2±0.8% moisture, 27.0±2.2% oil, 28.2±0.11% protein, 21.8±0.45% crude fiber, 2.4±0.58% ash and 14.4±1.69% carbohydrate (by difference) (Table 1). As shown in Table 1, these values were comparable to those of the other varieties reported previously. The seed oil obtained from this sample had a golden yellow in color (15.2Y 5.2R). On the other hand, the oil color reported for Batek Batu variety was reddish yellow (24Y 4R). The color of papaya seed oils of Tainoung No. 2 variety from Taiwan is ranging from bright to dark yellow depending on the expelling process.

According to Table 1, the free fatty acid content of papaya seed oil obtained in this study was 0.91% which is comparable to free fatty acid content of papaya seed oil obtained by Marfo et al. (0.94%) and Harvey et al. (0.94%). However, the unsaponifiable matter content of Batek Batu variety (2.11%) was slightly higher than that of theHong Kong/Sekaki variety (1.52%).

According to the data presented in Table 2, the IV and SV of the oil extracted from the Hong Kong/Sekaki variety was slightly higher than those of the values recorded for the oil sample from the Batek Batu variety. However, the values of these two parameters of the Hong Kong/Sekaki variety were seemingly closer to the values of other varieties reported by Malacrida et al., Marfo et al. and Harvey et al.

3.2 Fatty acid composition

As shown in Table 3, the fatty acid composition of the oil from the Hong Kong/Sekaki variety is compared with those of the other varieties reported in the literature. The present oil sample contained 78.33% unsaturated fatty acids with oleic (73.47%) acid being the dominant fatty acid. Papaya seed oil is comparable to the commercial high-oleic acid vegetable oils which are derived from sunflower (>80%), safflower (77%) and canola (75%).

Palmitic, in this sample, was found as the most abundant (15.82%) saturated fatty acid. According to previous report of Puangsri et al., Batek Batu variety from Malay-
N. A. M. Yanty, J. M. N. Marikkar, B. P. Nusantoro et al.


sia contained 80.5% unsaturated fatty acids, out of which around 73% was oleic acid and around 3 to 4% was linoleic acid. In this sample too, palmitic was the major saturated fatty acid, followed by around 5% of stearic acid. These values were in good agreement with the patterns of fatty acid distribution reported for papaya seed oil from other countries. Papaya seed oil from Taiwan was found to have the highest stearic acid content, while that of Nigerian was found to have the lowest stearic acid content. Interestingly, Lee et al., Malacrida et al., and Singh19 reported that papaya seed oil contained small amount of behenic acid which is not found in the present study. On the other hand, some of the minor fatty acids found in the present sample were not observed by Marfo et al.18.

3.3 Triacylglycerol (TAG) composition

A typical TAG profile of papaya seed oil extracted from the Hong Kong/Sekaki variety is shown in Fig. 1 and the relative percent distribution of different TAG are given in Table 4. Being a sample rich in oleic acid (Table 3), papaya seed oil contained OOO (40.4%) as the most prominent TAG followed by POO (29.1%) and SOO (9.9%) where P, O and S are palmitic, oleic and stearic acids, respectively. In this sample, there were some unknown TAG peaks which were around 5.9% of the total TAG content. According to previous report of Lee et al., and Puangsri et al., a similar TAG profile was observed for oil extracted from Tainoung No.2 and Batek Batu varieties. As such, they also contained OOO (43.77 and 44.6%), POO (33.83% and 30.5%) and SOO (8.37% and 9.8% respectively) as the major TAGs. These two reports suggest that TAG profile of papaya seed oil is apparently similar to that of olive oil. According to previous report, olive oil is found to possess large amount of oleic acid rich TAG molecules. Unlike polyunsaturated oils, oleic acid rich oils are highly regarded in food application mainly due to its thermal-oxidative stability. Therefore, these oils are suitable for sautéing or

Table 1  Proximate composition (%) of papaya seeds.

<table>
<thead>
<tr>
<th>Composition (%)</th>
<th>Determined values*</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>6.2 ± 0.1</td>
<td>7.2</td>
<td>n.d</td>
<td>6.2</td>
<td>6.43</td>
</tr>
<tr>
<td>Oil</td>
<td>27.0 ± 2.2</td>
<td>30.7</td>
<td>25.3</td>
<td>28.3</td>
<td>29.16</td>
</tr>
<tr>
<td>Protein</td>
<td>28.2 ± 0.0</td>
<td>28.3</td>
<td>24.3</td>
<td>27.8</td>
<td>25.63</td>
</tr>
<tr>
<td>Fiber</td>
<td>21.8 ± 0.5</td>
<td>19.1</td>
<td>17.0</td>
<td>22.6</td>
<td>n.d</td>
</tr>
<tr>
<td>Ash</td>
<td>2.4 ± 0.6</td>
<td>8.2</td>
<td>8.8</td>
<td>3.5</td>
<td>8.27</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>14.4 ± 1.7</td>
<td>26.6</td>
<td>32.5</td>
<td>11.7</td>
<td>n.d</td>
</tr>
</tbody>
</table>

*Each value in the table represents the mean ± standard deviation of duplicate.


Abbreviation: n.d. not determined

Table 2  Iodine, saponification, unsaponifiable matter and free fatty acid values of papaya seed oils.

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Determined values*</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iodine value (g I2/100 g)</td>
<td>76.9 ± 0.2</td>
<td>66.0</td>
<td>74.8</td>
<td>74.8</td>
<td>68.4</td>
<td>64.1</td>
<td>79.95 ± 1.25</td>
</tr>
<tr>
<td>Saponification value (mg KOH/oil g)</td>
<td>193.5 ± 0.1</td>
<td>154.7</td>
<td>193.4</td>
<td>197.0</td>
<td>185.4</td>
<td>183.3-185</td>
<td>96.4 ± 1.37</td>
</tr>
<tr>
<td>Unsaponifiable matter (%)</td>
<td>1.5 ± 0.1</td>
<td>1.39</td>
<td>2.11</td>
<td>0.72</td>
<td>n.d</td>
<td>4.5-5.3</td>
<td>1.35 ± 0.14</td>
</tr>
<tr>
<td>Free fatty acid (%)</td>
<td>0.9 ± 0.5</td>
<td>0.33</td>
<td>0.94</td>
<td>0.94</td>
<td>n.d</td>
<td>n.d</td>
<td>1.27 ± 0.04</td>
</tr>
</tbody>
</table>

* Each value in the table represents the mean ± standard deviation of duplicate.


Abbreviation: n.d, not determined

Fig. 1  HPLC chromatogram of papaya seed oil.
deep fat-frying and used to maintain product quality and enhance palatability. Oleic acid is also important for oleochemicals and nonfood applications. Nonfood applications of high-oleic oils include cosmetic formulations and vegetable based lubricants. Corbett and Ashton reported that high-oleic oils is also good for health as it may decrease the risk of coronary heart disease by decreasing low density lipoprotein (LDL).

3.4 Thermal behavior

The thermal behavior of papaya seed oil closely resembles the one reported for olive oil. This consistency may be due to the fact that papaya seed oil has a high amount of unsaturated fatty acids (78.33%) with oleic acid (73.47%) as the predominant fatty acid. The DSC melting and cooling thermograms are shown in Fig. 2. According to Fig. 2, the melting curve (A) of papaya seed oil showed one broad endothermic heat transition at −0.3°C with a shoulder peak at −6.5°C. In contrast, the crystallization curve (B) showed two distinct exothermic heat transitions; a smaller broad peak at −6.5°C and a sharp narrow peak at −39.5°C. Papaya seed oil in this study has a relatively low melting point (12.4°C) and crystallization temperature point (−48.2°C). According to the previous report of Puangsri seed oil from Batek Batu variety had a crystallization curve very much closer to the present one. However, its melting profile was found to differ slightly. The melting point and crystallization temperature of papaya (Batek Batu variety) seed oil was 10.5°C and −42.2°C, respectively. Papaya (Batek Batu variety) seed oil has higher unsaturated fatty acids content. Hence, the melting point of papaya (Batek Batu variety) is lower and crystallization temperature point is higher than the values obtained from this study.

3.5 Solid fat content

The solid fat content (SFC) of papaya seed oil was shown in Fig. 3. At 0°C, the SFC of the papaya seed oil was 9.8%. This value percentage is consistent with the fact that papaya seed oil has high unsaturated fatty acid. There is no solid fat content (0%) when the papaya seed oil was placed at 20°C, remaining liquid at that temperature and beyond.

3.6 Aroma profile

The aroma of fats and oils is one of the most important criteria influencing quality and sensory characteristics associated with foods. The aroma profile of papaya seed oil is shown in Fig. 4 as both the zNose (ultrafast GC) chromatogram and VaporPrint™. There were no reports found on volatile constituent of papaya seed oil. It can be clearly seen from the polar plot (VaporPrint™) that the papaya seed oil has distinct aroma profiles compared to rambutan.

Table 3 Fatty acid composition of papaya seed oils.

<table>
<thead>
<tr>
<th>Fatty acid (%)</th>
<th>Determined values*</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lauric/Dodecanoic acid (C12:0)</td>
<td>n.d</td>
<td>n.d</td>
<td>n.d</td>
<td>0.40</td>
<td>0.01</td>
<td>0.28</td>
<td>n.d</td>
</tr>
<tr>
<td>Myristic/Tetradecanoic acid (C14:0)</td>
<td>0.3 ± 0.1</td>
<td>n.d</td>
<td>0.2</td>
<td>0.04</td>
<td>0.04</td>
<td>0.72</td>
<td>0.20</td>
</tr>
<tr>
<td>Palmitic/Hexadecanoic acid (C16:0)</td>
<td>15.8 ± 0.1</td>
<td>14.8</td>
<td>13.9</td>
<td>16.20</td>
<td>16.60</td>
<td>19.7</td>
<td>16.16</td>
</tr>
<tr>
<td>Palmitoleic/Hexadecenoic acid (C16:1)</td>
<td>0.4 ± 0.4</td>
<td>n.d</td>
<td>0.2</td>
<td>0.08</td>
<td>n.d</td>
<td>0.36</td>
<td>0.27</td>
</tr>
<tr>
<td>Margaric/Heptadecanoic acid (C17:0)</td>
<td>0.1 ± 0.1</td>
<td>n.d</td>
<td>0.1</td>
<td>n.d</td>
<td>n.d</td>
<td>n.d</td>
<td>0.13</td>
</tr>
<tr>
<td>Stearic/Octadecanoic acid (C18:0)</td>
<td>5.1 ± 0.0</td>
<td>4.2</td>
<td>4.9</td>
<td>5.00</td>
<td>1.90</td>
<td>6.68</td>
<td>4.73</td>
</tr>
<tr>
<td>Oleic/Octadecenoic acid (C18:1)</td>
<td>73.5 ± 0.2</td>
<td>71.0</td>
<td>76.8</td>
<td>74.30</td>
<td>79.10</td>
<td>66.74</td>
<td>71.30</td>
</tr>
<tr>
<td>Linoleic/Octadecadienoic acid (C18:2)</td>
<td>4.0 ± 0.2</td>
<td>4.0</td>
<td>3.0</td>
<td>0.40</td>
<td>2.57</td>
<td>6.06</td>
<td></td>
</tr>
<tr>
<td>Linolenic/Octadecatrienoic acid (C18:3)</td>
<td>n.d</td>
<td>0.9</td>
<td>0.2</td>
<td>n.d</td>
<td>n.d</td>
<td>0.17</td>
<td>0.22</td>
</tr>
<tr>
<td>Arachidic/Eicosanoic acid (C20:0)</td>
<td>0.4 ± 0.1</td>
<td>1.1</td>
<td>0.4</td>
<td>0.90</td>
<td>n.d</td>
<td>0.38</td>
<td>0.38</td>
</tr>
<tr>
<td>Gadoleic/Eicosanoic acid (C20:1)</td>
<td>0.4 ± 0.1</td>
<td>0.7</td>
<td>0.3</td>
<td>n.d</td>
<td>n.d</td>
<td>0.46</td>
<td>0.32</td>
</tr>
<tr>
<td>Behenic/Docosanoic acid (C22:0)</td>
<td>n.d</td>
<td>n.d</td>
<td>n.d</td>
<td>1.6</td>
<td>n.d</td>
<td>1.34</td>
<td>0.23</td>
</tr>
<tr>
<td>Unsaturated FA</td>
<td>78.3</td>
<td>76.6</td>
<td>80.5</td>
<td>74.78</td>
<td>81.67</td>
<td>70.9</td>
<td>78.17</td>
</tr>
<tr>
<td>Saturated FA</td>
<td>21.7</td>
<td>23.40</td>
<td>19.5</td>
<td>25.22</td>
<td>18.55</td>
<td>29.1</td>
<td>21.83</td>
</tr>
</tbody>
</table>

*Each value in the table represents the mean ± standard deviation of duplicate.


Abbreviation: n.d, not determined; FA, fatty acid
This is also contrary to the report by Eckey who found that papaya oil extracted from an unknown variety was odorless. On the other hand, volatile compounds of fruit from different papaya variety have been reported by researchers from different parts of the world. Almora et al. reported that butanol, 3-methylbutanol, benzyl alcohol and α-terpineol as a predominant volatile components in papaya (Maradolroja variety) fruits while Pino et al. reported that the predominant volatile components in papaya (Maradol variety) fruits were methyl butanoate, ethyl butanoate, 3-methyl-1-butanol and 1-butanol. Further, linalool, benzyl isothiocyanate and phenylacetonitrile were found as the predominant volatile components in Solo variety of papaya fruit. Previous study also reported that papaya fruits contained methyl butanoate as the major constituent with particular reference to glucosinolate products and it is suggested that this component is the one mainly responsible for the pronounced sweaty odor quality.

Table 4 Triacylglycerol (TAG) composition of papaya seed oils.

<table>
<thead>
<tr>
<th>TAG (%)</th>
<th>Determined values*</th>
<th>Reported values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>LLL</td>
<td>n.d</td>
<td>n.d</td>
</tr>
<tr>
<td>OLL</td>
<td>0.8 ± 0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>PLL</td>
<td>n.d</td>
<td>n.d</td>
</tr>
<tr>
<td>OOL</td>
<td>4.7 ± 0.1</td>
<td>3.7</td>
</tr>
<tr>
<td>POL</td>
<td>3.3 ± 0.0</td>
<td>2.3</td>
</tr>
<tr>
<td>PPL</td>
<td>0.2 ± 0.1</td>
<td>n.d</td>
</tr>
<tr>
<td>OOO</td>
<td>40.4 ± 0.1</td>
<td>44.6</td>
</tr>
<tr>
<td>POO/POO+SOL</td>
<td>29.1 ± 0.2</td>
<td>30.5</td>
</tr>
<tr>
<td>PPO</td>
<td>5.9 ± 0.1</td>
<td>5.1</td>
</tr>
<tr>
<td>OOGa</td>
<td>n.d</td>
<td>n.d</td>
</tr>
<tr>
<td>SOO</td>
<td>9.9 ± 0.0</td>
<td>9.8</td>
</tr>
<tr>
<td>PSO</td>
<td>3.3 ± 0.1</td>
<td>3.8</td>
</tr>
<tr>
<td>SOS</td>
<td>0.3 ± 0.1</td>
<td>n.d</td>
</tr>
<tr>
<td>PSS</td>
<td>0.4 ± 0.3</td>
<td>n.d</td>
</tr>
<tr>
<td>Unknown</td>
<td>1.7 ± 0.1</td>
<td>n.d</td>
</tr>
</tbody>
</table>

* Each value in the table represents the mean ± standard deviation of duplicate.

1 Puangsri et al. 2005; 2 Lee et al. 2011
Abbreviation: n.d, not determined; L, linoleic; O, oleic; P, palmitic; Ga, gadoleic; S, stearic
of some papaya fruit. In addition, Idstein et al. reported that papaya pulp contained butanoic acid as a major volatile acid compounds.

Conclusion

Among the fatty acids, oleic acid is particularly stable to thermal-oxidative, due to the presence of only one unsaturation in its structure. Hence, it is suitable for sautéing or deep fat-frying. These oils are used to maintain product thermal-oxidative, due to the presence of only one unsaturation in its structure. Hence, it is suitable for sautéing or deep fat-frying. These oils are used to maintain product quality and to increase palatability. It is suitable as spray oils for snacks, crackers, cereals, dried fruit and bakery products. In addition, the oil with higher proportion of monounsaturated fatty acid content, are usually used in emollient skin care products, bath oils, hair conditioners, and makeup. These properties suggest that papaya seed oil might have potential as a new source of high-oleic oil for both food and nonfood industries.

Acknowledgement

The authors wish to acknowledge the grant awarded to H. M. Ghazali under the Malaysia IRPA Program, which made this research possible.

References


20) Ekey, E. W. Vegetable Fats and Oils. Reinhold Pub-