Research Article

Physico-chemical and Antioxidant Properties of Eggplant Flour as a Functional Ingredient

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Abstract: Eggplant flour from different types of eggplant grown in Malaysia [Chinese eggplant (PL), Indian eggplant (PR), White eggplant (W) and Thailand eggplant (G)] had been produced by using oven drying, at 40 and 50ºC respectively. All eggplant showed the same trend for antioxidant properties following the order PR>PL>W>G. Among the eggplant grown in Malaysia, Indian eggplant flour which dried at 40ºC contained the highest amount of total phenolic content (3545.8 mg), total flavonoids content (2918.2 mg CAE/100 g), possessed the highest antioxidant activity by giving highest value in DPPH (92.70%) and FRAP assay. Higher drying temperature was found to inhibit the antioxidant activity of all types of eggplant flour except for white eggplant flour. All eggplant showed no significant changes in term of nutritional values. For Total Dietary Fiber (TDF) analysis, white eggplant flour had the highest content of total TDF (48.34%), which was 10x higher than in white wheat flour and 3x higher than in whole-grain wheat flour. Large portion of total dietary fiber in eggplant was found existed as insoluble fiber. Apparently, eggplant flour can be used as a functional ingredient in order to impart antioxidant and increase nutritional content of final products.

Keywords: Antioxidant, eggplant, flour, functional ingredient, phenolic content

INTRODUCTION

Food can provide nutritional support for our body while it can destroy life as well. Proper way of eating food can produce energy, maintain life, or stimulate growth while improper way of consuming food can cause disease. Taste is the major reason why consumers choose a particular food. Taste consistently outranks consumer’s concern about the nutritional quality, especially in young people. They seem to be more attracted to the fancy flavoring and packaging rather than the nutritional value of the food itself. Unfortunately, good-tasting foods are often high in fats. High fat food can lead to many chronic diseases such as diabetes, hypertension and cardiovascular complications. Diet high in saturated fat is correlated with the incidence of coronary disease (Liu et al., 1982). A recent statistic reported that cardiovascular disease is now the leading cause of medically-certified deaths among Malaysian women, with one in four dying of heart failure (Brighenti et al., 2013).

A great number of research activities have demonstrated a significant correlation between the regular intakes of phytochemicals and the prevention of life-style related diseases such as cardiovascular diseases, arteriosclerosis and obesity (Gresele et al., 2011). Phytochemicals including polyphenol compounds, other nutrients and non-nutrient compounds (minerals, vitamins and dietary fiber) are the components in plants that confer health promoting abilities (Gonzáles-Molina et al., 2010). These beneficial ingredients of fruits and vegetables can be extracted and serve as the functional ingredients in producing functional food with added dietary value.

According to Hasler et al. (2000), functional food is defined as food that consists of added physiological active compounds that provides health benefit beyond basic nutrition. Functional food is also known as conventional food that enriched with bioactive substances such as antioxidants or synthesized food ingredients such as prebiotics (Choudhary and Tandon, 2009). Solanum melongena L. commonly known as eggplant, aubergine, guinea squash or brinjal, is an economically important vegetable crop of tropical and temperate parts of the world (Kashyap et al., 2003). Eggplant can exist in different shapes, sizes and colors, depending on the cultivar. Eggplant fruits usually are purple, white or striped in color. The coloration of the purple color type eggplant fruit is caused by the presence of anthocyanin, where the purple one is commercially more important.
Eggplant is ranked as one of the top ten vegetables due to its high oxygen radical scavenging capacity (Jung et al., 2011). According to Lintas (1992), eggplant is also rich in dietary fibers. According to Jacob et al. (2012), antioxidant capacity is one of the common features of functional ingredient. Hence, eggplant is suggested to use as a functional ingredient in producing functional food with added nutritional value. Therefore, the objective of this research is to determine the nutritional contents, the antioxidant capacity and total dietary fiber in different varieties of eggplant flour produced, which are grown solely in Malaysia.

MATERIALS AND METHODS

Plant material: Four varieties of eggplant were purchased from market and Tesco supermarket in Penang. The eggplants purchased were fresh and free from physical damage. There are Chinese Eggplant (purple color and long shape), Indian Eggplant (purple color, moderate size and oval shape), white eggplant (white color, moderate size and oval in shape) and Thai eggplant (green color, small size and round in shape).

Preparation of eggplant flour: The eggplants were washed thoroughly under running tab water to remove soils and foreign particles. They were cut into slices without peeling off the skin by using electrical slicer, so that they were in uniform thickness and size. Each type of eggplant was dried at two temperatures, which is 40 and 50°C in hot air oven (AFOS Dryer) for 72 h. The dried eggplants were grinded into powder form by using heavy duty blender (Juicemaking Blender, BL-767) and sieved through 250 μm siever on a shaker (Retsch Vibrator Stever Shaker, AS 200 BASIC). All grounded samples were packed into plastic bag. They were sealed properly and wrapped with aluminum foil to protect the samples from light. Then, they were stored in a freezer at -20°C.

Proximate analysis:

Moisture: Moisture content of sample was determined by using moisture analyzer (AND MX-50). The results are recorded as % of moisture content.

Ash: Dry ashing method from AOAC (2000), Method 923.03 was referred to analyze the content of ash.

Crude protein: Crude protein content was determined by using protein analyzer (Protein Analysis System Gerhardt, KB 205), following the 960.52 in the AOAC (2000).

Fat: Soxhlet method, method 960.39C in AOAC (2000) was used to determined fat content in samples.

Crude fiber: Gravimetric method which is method 962.09 of AOAC (2000) was used to determine crude fiber.

Carbohydrate: The content of carbohydrate was not determined through any chemical analysis but through calculation. The content of carbohydrate (dry basis) was determined through the following equation:

% Carbohydrates (dry basis) = 100% - Moisture% - Fat%-Protein%-Ash%

Sample extraction for determination of antioxidant activity: Extraction of sample was carried out with modification according to the method by Fu et al. (2011). 1 g of sample was weighted into a conical flask which wrapped with aluminum foil and 100 mL of 80% methanol was added into the flask. The mixture was shaken for 24 hours at 160 rpm, at 27°C with an orbital shaker (Lab Companion, Model SL600R). The mixture was then centrifuged at 2500 rpm for 30 minutes (KUBOTA 5100 Centrifuge, Japan) in order to obtain a clear supernatant. The supernatant was used for further determination of phenolic content and antioxidant capacity.

Determination of Total Phenolic content (TP): TP content of the sample extract was determined by FC assay with slightly modification of the method described by Singleton and Rossi (1965). 2 mL of 10 times pre-diluted FC reagent was mixed with 400 μL properly diluted sample extract and the mixture was allowed to stand for 5 minutes at room temperature. After that, 1.6 mL of 7.5% w/v sodium carbonate solution was added. The solution was mixed and allowed to stand at room temperature for 1 hour. The absorbance was then measured at 765 nm. A standard curve was prepared by using gallic acid solution. Standard curve was prepared by using standard solution of gallic acid with known concentration (0, 20, 40, 60, 80, 100 mg/L; r² = 0.995, refer appendix A for the standard curve). The results obtained were expressed as weight basis as mg Gallic Acid Equivalents (GAE) /100 g of sample.

Determination of Total Flavonoids content (TF): Colorimetric assay developed by Zhishen et al. (1999) was referred and some modification has done onto the method in order to determine TF content. 1 mL of properly diluted sample extract was mixed with 4 mL of distilled water and at zero time, 300 μL of (5% w/v) sodium nitrite (NaNO2) was added. After 5 min, 300 μL of (10%) Aluminium Chloride (AlCl3) was added. At 6 minutes, 2 mL of 1 M of NaOH solution was added and then the volume of the mixture was made up immediately by addition of 2.4 mL of distilled water to 10 mL. The mixture was shaken vigorously and the absorbance was read at 510 nm against blank. Blank was prepared by 1 mL of distilled water instead of diluted sample extract. A standard curve was prepared by using catechin solution. Standard curve was prepared by using standard solution of catechin with known concentration (0, 20, 40, 60, 80, 100 mg/L; r² =
0.998, refer appendix B for standard curve). The results obtained were expressed as weight basis as mg Catechin Equivalents (CEQ)/100g of sample.

**DPH free radical-scavenging assay:** The determination of the antioxidant activity through the evaluation of the free radicals scavenging effect on DPH was based on the slight modification of method done by Xu and Chang (2007). An aliquot (1 mL) of sample extract was mixed with 6 mL of DPH solution. Negative control was prepared by mixing 1 mL of methanol with 6 mL of DPH solution. All the mixtures to be tested were prepared in test tubes with lid, which were wrapped with aluminum foil. The mixture was vortexed and kept in the dark for 30 minutes at room temperature. Absorbance was measured at 517 nm wavelength using UV-Vis spectrophotometer (Shimadzu UV-Visible Recording Spectrophotometer Model UV-160A) against blank. The results obtained were calculated and expressed in the term of % DPH inhibition by using the formula below: \( \% \text{inhibition of DPH} = \left( \frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}} \right) \times 100\% \)

**Ferric Reducing Antioxidant Power (FRAP) assay:** A modified method of FRAP assay was carried out based on the method proposed by Benzie and Strain (1999). An aliquot amount of 200 µL properly diluted sample extract was mixed with 3mL of FRAP reagent, whereas for blank sample distilled water is mixed with FRAP reagent instead of sample extract. The mixture was then incubated in water bath at 37°C for 30 min. After 30 min, the absorbance of sample was determined against blank at 593 nm wavelength. A standard curve of ferrous sulphate heptahydrate (FeSO₄·7H₂O) with known concentration (0, 200, 400, 600, 800 µM; \( r^2 = 0.996 \), refer appendix for the standard curve). The values obtained were expressed on weight basis as micromoles of ferrous equivalent Fe (II) per gram of dried sample.

**Total Dietary Fiber (TDF) analysis:** Enzymatic and gravimetric methods following AOAC (2000) method 985.29 and 960.52 was used in TDF analysis.

**RESULTS AND DISCUSSION**

The eggplant flour produced were labelled as PR 40 (Indian eggplant dried at 40°C); PR 50 (Indian eggplant dried at 50°C); G 40 (Thai eggplant dried at 40°C); G 50 (Thai eggplant dried at 50°C); PL 40 (Chinese eggplant dried at 40°C); PL 50 (Chinese eggplant dried at 50°C); W 40 (white eggplant dried at 40°C) and W 50 (white eggplant dried at 50°C).

**Proximate analysis:** Nutritional analysis of four different varieties of eggplant was carried out on dry basis and it was reported in the Table 1. The moisture content of all types of eggplant flour obtained was in the range of 8.47-9.45%. Sample PR 40 had the highest moisture, while sample G 50 had the lowest moisture content. Moisture content that we obtained is found to be higher than the result of moisture reported by Hussain et al. (2011). This is due to the fact that higher temperature was used in the research by Hussain et al. (2011). All samples that were subjected to 40°C drying temperature had higher moisture content compared to the samples subjected to 50°C.

The highest ash content was obtained from sample W 50 (8.73%) and the lowest content was obtained from sample G 40 (8.13%). Ash content of eggplant reported by Hussain et al. (2011) was 8.9%, which was comparable to the ash content obtained in our research. Eggplants of white variety (W 40 and W 50) were found to be consisting higher amount of minerals due to the higher ash content among all the varieties. Ash content represents the mineral contents in food because ash is the inorganic residues left over after complete ignition or oxidation of organic compounds in food (Harbers and Nielsen, 2003). Calcium, magnesium, phosphorus, potassium, iron and sodium are some of the major minerals that contained in eggplant. Savvas

**Statistical analysis:** The results of the present study were represented as mean values±SD. One way analysis of variance (ANOVA) was performed and significant differences between mean values were determined by Duncan test at a level of significance of \( p<0.05 \). Statistical analysis were conducted using SPSS (Statistical Package for Social Science) version 17.0 (SPSSInc., Chicago, USA).

**Table 1: Proximate compositions (g/100 g) of various types of eggplant flour**

<table>
<thead>
<tr>
<th>Samples</th>
<th>Moisture</th>
<th>Ash</th>
<th>Fat</th>
<th>Protein</th>
<th>Crude Fiber</th>
<th>Carbohydrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>PR 40</td>
<td>9.45±0.15^a</td>
<td>8.14±0.09^a</td>
<td>2.34±0.16^a</td>
<td>12.98±0.06^a</td>
<td>67.10±0.13^a</td>
<td></td>
</tr>
<tr>
<td>PR 50</td>
<td>9.11±0.18^b</td>
<td>8.24±0.04^a</td>
<td>1.21±0.08^a</td>
<td>15.63±0.04^a</td>
<td>65.81±0.23^b</td>
<td></td>
</tr>
<tr>
<td>G 40</td>
<td>9.42±0.05^b</td>
<td>8.13±0.04^a</td>
<td>5.18±0.05^b</td>
<td>14.53±0.03^a</td>
<td>62.73±0.07^a</td>
<td></td>
</tr>
<tr>
<td>G 50</td>
<td>8.47±0.43^a</td>
<td>8.24±0.02^a</td>
<td>2.75±0.04^a</td>
<td>15.20±0.11^a</td>
<td>65.34±0.51^a</td>
<td></td>
</tr>
<tr>
<td>PL 40</td>
<td>8.60±0.05^a</td>
<td>8.46±0.06^a</td>
<td>1.48±0.04^a</td>
<td>13.40±0.02^a</td>
<td>68.07±0.04^a</td>
<td></td>
</tr>
<tr>
<td>PL 50</td>
<td>8.58±0.39^a</td>
<td>8.42±0.05^a</td>
<td>0.88±0.02^a</td>
<td>15.75±0.05^a</td>
<td>66.37±0.29^a</td>
<td></td>
</tr>
<tr>
<td>W 40</td>
<td>8.67±0.12^a</td>
<td>8.52±0.07^a</td>
<td>4.23±0.09^a</td>
<td>14.52±0.03^a</td>
<td>64.05±0.06^a</td>
<td></td>
</tr>
<tr>
<td>W 50</td>
<td>8.64±0.09^a</td>
<td>8.73±0.14^a</td>
<td>2.51±0.03^a</td>
<td>13.55±0.02^a</td>
<td>66.57±0.21^a</td>
<td></td>
</tr>
</tbody>
</table>

Data is expressed as mean±standard deviation (n = 3); means in column sharing the same superscript letter are not significantly different (p<0.05); PR: Purple Round/Oval; Eggplant (Indian Eggplant); G: Green Long Eggplant (Thai Eggplant); PL: Purple Long Eggplant (Chinese Eggplant); W: White Eggplant
Eggplant flour gave the highest value in carbohydrate content among all the proximate analysis, which indicated that eggplant, is made up of large portion of carbohydrates. Vegetables are composed primarily of carbohydrates, which are chiefly in the form of simple sugars and complex carbohydrates (Lintas, 1992).

The showed that eggplant flour had high nutritional value and it is a better source for minerals, natural fats, protein and crude fiber. Eggplant flour contained lower amount of moisture and carbohydrate. There is an inverse relationship between moisture content and storage stability of flour, as lower the moisture content of flour, the better its storage stability. An investigation also found that flour with the lowest moisture content had the maximum resistance against fungal growth and pest infestation during storage. Flour having moisture content of 9% to 10% is suitable for extended shelf life (Nasir et al., 2003). Hence, it was believed that eggplant flour produced could have greater shelf life and higher storage stability compared to wheat flour due to the lower moisture content.

**Total dietary fiber analysis:** Table 2 shows the insoluble dietary fiber, soluble dietary fiber and total dietary fiber content of all the four varieties of eggplant flours. Dietary fibers in all the four types of eggplant flours were higher compared to Wheat Flour (WF) and whole Wheat Flour (WG) (FrØLich and Asp, 1981). IDF of eggplant flours ranged from 25.31-39.32%, and it was approximately ten times higher than the amount of IDF in WF and two times higher than the IDF amount in WG. SDF of eggplant flours ranged from 5.68-12.28%. SDF content in WF and WG were significantly lower than in eggplant flours. For TDF content, eggplant flours contained more than ten times the amount of IDF in WF and two times higher than the amount of IDF in WG. SDF content in all the four varieties of eggplant flours was higher compared to Wheat Flour (WF) and whole Wheat Flour (WG) (FrØLich and Asp, 1981).

Table 2: Insoluble dietary fiber, soluble dietary fiber and total dietary fiber content in various types of eggplant flour.

<table>
<thead>
<tr>
<th>Samples</th>
<th>IDF (%)</th>
<th>SDF (%)</th>
<th>TDF (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PR 40</td>
<td>26.87±1.31a</td>
<td>6.22±0.080d</td>
<td>33.09±1.291f</td>
</tr>
<tr>
<td>PR 50</td>
<td>27.06±0.804a</td>
<td>8.19±0.110d</td>
<td>35.26±0.748b</td>
</tr>
<tr>
<td>G 40</td>
<td>36.83±0.343c</td>
<td>7.23±0.170e</td>
<td>44.07±0.377c</td>
</tr>
<tr>
<td>G 50</td>
<td>37.37±0.531c</td>
<td>5.68±0.229c</td>
<td>43.05±0.717e</td>
</tr>
<tr>
<td>PL 40</td>
<td>25.31±1.612f</td>
<td>11.86±0.227d</td>
<td>37.18±0.428c</td>
</tr>
<tr>
<td>PL 50</td>
<td>28.01±1.165f</td>
<td>12.28±0.396c</td>
<td>40.97±0.136d</td>
</tr>
<tr>
<td>W 40</td>
<td>39.19±0.595f</td>
<td>7.02±0.121c</td>
<td>46.21±0.508f</td>
</tr>
<tr>
<td>W 50</td>
<td>39.32±0.128g</td>
<td>9.01±0.235g</td>
<td>48.34±0.360g</td>
</tr>
</tbody>
</table>

Data is expressed as mean±standard deviation (n = 3); Means in column sharing the same superscript letter are not significantly different (p<0.05); PR: Purple Round/Oval; Eggplant; G: Green Long Eggplant (Thai Eggplant); PL: Purple Long Eggplant (Chinese Eggplant); W: White Eggplant

and Lenz (1996) also found that eggplant provide relevant quantities of some minerals such as phosphorus, potassium, calcium and magnesium.

For fat determination, the results obtained fell on a big range of 0.88-5.18%. Our results are in accordance with the work by Lawande and Chavan (1998). They have reported that fat content for eggplant range about 0.33-5.20%. Sample G 40 showed the highest fat content (5.18%) and followed by sample W 40 (4.23%); sample PL 50 had the lowest fat content (0.88%) and PR 50 had the second lowest fat content (1.21%). The results obtained indicated that different types of eggplant have different fat content, which was in agreement with the previous study by Nisha et al. (2009).

Sample PL 50 had the highest amount of protein, which was 15.75% whereas sample PR 40 had the lowest amount of protein, which was 12.98%. Results of protein content obtained from all four varieties of eggplant are higher compared to the work by Hussain et al. (2011), which was about 9.7% of protein content. This may due to the different fertilizers used by the farmers in Malaysia to cultivate the eggplants. According to Mut et al. (2010), the addition of animal manure as fertilizer to soil can increase the protein content of plants. Considerable increases in protein content of plants with increasing nitrogen application also observed by some of the researchers (Behrens et al., 2001; Rathke et al., 2005).

For Crude Fiber (CF) analysis, sample W 50 contained 19.0% of CF, which was the highest amount compared to other varieties. While, sample G 50 contained the lowest CF among all varieties, which was 13.19%. Our results also showed that different drying temperature had no effect on the crude fiber content.

PL 40 was found to show the highest carbohydrate content, whereas G 40 had the lowest carbohydrate content, which was 68.07 and 62.73%, respectively. Results of the present investigation are similar to the carbohydrate content obtained by Hussain et al. (2011). Eggplant flour gave the highest value in carbohydrate content as well as in the paper, which was 68.07 and 62.73%, respectively.

According to the results in Table 2, the ascending order of the amount of TDF was PR 40 (33.09%) < PR 50 (35.26%) < PL 40 (37.18%) < PL 50 (40.97%) < G 50 (44.07%) < G 40 (43.05%) < W 40 (46.21%) < W 50 (48.34%). TDF had the same trend as in IDF content in this study. Research of Khanum et al. (2000) found fresh eggplant contributes 83% of IDF in TDF of fresh eggplant. The high amount of TDF obtained suggests...
that consuming foods that were produced from eggplant flour is able to prolong the feeling of fullness because the bulking properties of dietary fiber can affect satiation and satiety (Burton-Freeman, 2000). The TDF content of all types of eggplant flours was higher when compared to WF and WG (FrOßlich and Asp, 1981). This is further confirmed by the identical trend observed in crude fiber and TDF. Therefore, it is believed that eggplant flour can be used as a functional ingredient and be incorporated to produce functional or fiber fortified food.

**Total phenolic content:** Phenolic solubility in different types of extraction solvent can influence the recovery of type and amount of phenolics from plants. The phenolic extracts of plants are always a mixture of different classes of phenols, which are selectively soluble in the solvents. Methanol was selected as the solvent for phenolics extraction. Some previous investigations had concluded that methanol extraction had greater recovery of phenolics (Shi et al., 2005; Chirinos et al., 2007). Methanol is efficient and effective in extracting phenolics such as hydroxycinnamic derivatives, flavonols, flavan 3-ol monomers, flavanones and flavones (Chirinos et al., 2007). According to Mohammadi et al. (2008), the usage of alcoholic solution as a solvent in the isolation of phenolic compounds of plants gave satisfactory yield.

Table 3 showed the Total phenolic of all the four samples measured by using FC reagent. The eggplant flours ranged from 1184.3-2043.2 mg GAE/100 g for G, 2010.9-2419.6 mg GAE/100 g for W, 2219±52.6 mg GAE/100 g for PR, 1184.3-2043.2 mg GAE/100 g for PL. Samples that were dried at 40°C had higher TP than samples that were dried at 50°C. This could be attributed to the heat sensitivity of antioxidant. High drying temperature can cause degradation of antioxidant. However, W did not show the consistent trend of the effect of drying temperature on TP as PR, PL and G. The different trend of the drying temperature effect on samples W suggests that the effect of thermal processing on phenolic activities may vary in some eggplant varieties.

**Total flavonoids content:** The TF of different eggplant flours are shown in Table 2. TF content follows the order PR>PL>G-W. TF content in both purple varieties (PR and PL) was found to be higher than the W and G. Previous observation had found that purple-colored eggplant had higher TP and TF content than the white-green colored eggplant, pale green eggplant and long green eggplant (Akanitapichat et al., 2010). According to the results, drying temperature showed a significant difference on TF where higher drying temperature gave lower TF, except for W. The decrease of TF level in flour subjected to higher drying temperature could be due to part of the anthocyanin had been degraded during heating. Generally, treatment at higher temperature can influence level of anthocyanin in fruits and vegetables. According to Schieber et al. (2001), the loss of macromolecules such as flavonoid during heat treatment might be due to the drying conditions, which are the temperature and duration used. The trend shown by the effect of drying temperature on the TF was inconsistent. This could be due to the different varieties of eggplant used in this study.

Table 3: Total phenolic content, total flavanoids content and antioxidant capacity of various types of eggplant flour

<table>
<thead>
<tr>
<th>Eggplant</th>
<th>Total phenolic content (mg GAE/g fresh weight)</th>
<th>Total flavanoids (mg CEQ/g fresh weight)</th>
<th>FRAP (µmol Fe (II)/g fresh weight)</th>
<th>(%DPPH inhibition)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PR 40</td>
<td>3757.6±24.1 a</td>
<td>3775.4±5.2 d</td>
<td>624.5±11.2 b</td>
<td>92.7±1.5 c</td>
</tr>
<tr>
<td>PR 50</td>
<td>3711.8±21.1 f</td>
<td>3775.4±5.2 d</td>
<td>624.5±11.2 b</td>
<td>92.7±1.5 c</td>
</tr>
<tr>
<td>G 40</td>
<td>1184.3±11.8 e</td>
<td>1158.2±5.6 g</td>
<td>211.9±8.3 e</td>
<td>82.6±1.6 f</td>
</tr>
<tr>
<td>G 50</td>
<td>1184.3±11.8 e</td>
<td>1158.2±5.6 g</td>
<td>211.9±8.3 e</td>
<td>82.6±1.6 f</td>
</tr>
<tr>
<td>PL 40</td>
<td>1953.7±10.2 c</td>
<td>1982±68.9 c</td>
<td>466.4±9.1 f</td>
<td>89.1±0.9 d</td>
</tr>
<tr>
<td>PL 50</td>
<td>1791.4±34.1 d</td>
<td>1781±76.2 c</td>
<td>409.7±7.5 c</td>
<td>87.8±0.7 c</td>
</tr>
<tr>
<td>W 40</td>
<td>1819.1±13.7 b</td>
<td>909.4±13.7 d</td>
<td>287.5±7.7 d</td>
<td>85.9±0.4 b</td>
</tr>
<tr>
<td>W 50</td>
<td>2010.9±12.9 a</td>
<td>1294.3±15.4 b</td>
<td>353.1±3.4 a</td>
<td>87.3±1.7 c</td>
</tr>
</tbody>
</table>

Data is expressed as mean±standard deviation (n = 3); Means in column sharing the same superscript letter are not significantly different (p<0.05); PR: Purple Round/Oval; Eggplant (Indian Eggplant); G: Green Long Eggplant (Thai Eggplant); PL: Purple Long Eggplant (Chinese Eggplant); W: White Eggplant
**DPPH free radical scavenging assay:** DPPH solution change color from purple to yellow when the DPPH radical is scavenged by antioxidants (Karagözler et al., 2008). Antioxidants act as hydrogen donors when react with DPPH radical, where the hydrogen from radical scavenging antioxidant pairs with the odd electron of DPPH. DPPH radical is then reduced to DPPH⁻ and decreases the absorbance. The scavenging ability of antioxidant is based on the hydrogen donating ability which causes discoloration of DPPH solution (Razak, 2012).

Table 2 shows the DPPH scavenging activities of all the four different samples. It follows the order of PR>PL>W>G. Antioxidant activity of PR was remarkably higher than the other three samples. The low DPPH scavenging activity showed by G is similar with the results of previous research by Akanitapichat et al. (2010). According to Shahidi et al. (2011), delphinidin-3-cafeoylrutinoside-5-glucoside was a major component in anthocyanin of eggplant that found to be possessed the highest radicals scavenging activity towards DPPH.

All samples show significant differences in drying temperature on the DPPH inhibition. This indicates that drying temperature can influence the capability of antioxidants present in eggplant to inhibit DPPH radical. Higher drying temperature caused a decrease in DPPH scavenging activity in PR, G and PL. This could be due to thermal degradation of some antioxidant in eggplant such as ascorbic acid and anthocyanin. As in earlier study of tomato, the higher drying temperature decreased the value of ascorbic acid in tomato, *Solanum lycopersicum* (Idah et al., 2010). However, higher temperature caused an increase in DPPH inhibition capability in W could due to the formation of polyphenolic degradation products from the thermal destruction of anthocyanin. These products formed may possess antioxidant activity. Nonetheless, there is still limited information available on the temperature stability of anthocyanin and the products formed in the thermal degradation of anthocyanins.

**FRAP assay:** FRAP assay is commonly used to study the antioxidant capacity of plant materials by measuring the reducing ability of an antioxidant. FRAP assay depends on the reduction of a ferric tripyridyltriazine, Fe(TPTZ)³⁻ (III) complex to the ferrous tripyridyltriazine, Fe(TPTZ)²⁺(II) complex by an antioxidant in acidic medium, at a low pH of 3.6. This reduction process produces intense blue complex that has absorption at 593nm (Moon and Shibamoto, 2009). Reduction capability of ferric ion can be monitored by measuring the change in absorption at 593 nm.

Antioxidant capacity that analyzed by FRAP assay had identical trend as the DPPH free radical-scavenging assay. Based on Table 2, similarly, samples PR had the highest FRAP value, from 484.7-624.5 μmole Fe (II)/g sample, followed by PL, from 409.7-466.4 μmole Fe (II)/g sample; W, from 287.5-353.1 μmole Fe (II)/g sample and G, from 211.9-377.5 μmole Fe (II)/g sample. The identical trend in DPPH and FRAP assay could be due to the reaction mechanism of DPPH and FRAP are similar with each other, which involves the reduction activity and reduction ability of antioxidants on certain compounds, which are DPPH⁺ radical and ferric ions (Alothman et al., 2009). This is understandable as both DPPH and FRAP assays are based on electron-transfer reaction.

Not only DPPH and FRAP analysis share the identical trend, but the same trend was also observed in TP and TF of all these four varieties of eggplant flour. Results obtained show the strong association between high antioxidant activity and phenolic content as this has been previously verified in eggplant by Noda et al. (2000) and Huang et al. (2004). The same trend in TP, DPPH and FRAP was also on a par with the earlier investigation on eggplant from different varieties (Razak, 2012). Therefore, it can be concluded that phenolic compounds serve as the main constituents that contribute to the antioxidant properties in eggplant flour. On the other hand, the same trend in TF suggests that flavonoids are the most important phenolic group that contributes to the antioxidant activities of eggplant. Flavonoids that can be found in eggplant are delphinidin-3-(p-coumaroylrutinoside) - 5-glucoside, delphinidin-3-rutinoside, delphinidin-3-glucoside, petunidin-3-(p-coumaroylrutinoside)-5-glucoside and delphinidin- 3-cafeoylrutinoside-5-glucoside (Azuma et al., 2008), myricetin-3-galactoside, quercetin-3-galactoside and quercetin-3-rhamnoside (Singh et al., 2009).

**CONCLUSION**

The explosion of consumer interest in the relationship between diet and health has increased the demand for information on functional foods. Functional foods that have been identified as to be beneficial are foods containing phytochemicals, fibre, minerals and vitamin containing foods. The exploration of the properties of dietary phytochemicals in traditional and indigenous fruits and vegetables is important to develop new resources to serve as functional ingredients in producing value-added food in acquiring optimized health.

This current study involved the determination of the nutritional values, extraction of antioxidants, analyzing of antioxidant capacity and the determination of TDF content in different varieties of eggplant flour as we believed that eggplant flour can be used as new resource to serve as functional ingredient in preparation of functional foods. Different varieties of eggplant flour consisted of different nutritional composition. Drying
temperature did not show any effect on the crude fiber of eggplant flour. On the other hand, the level of ash, protein, fat and crude fiber in most of the eggplant floor in this study were found to be higher than in WF and WG.

The results obtained clearly showed that eggplant flour possess the ability to scavenge the free radicals which is carcinogenic to human body due to the presence of antioxidants. Flour produced from eggplant of purple varieties consisted of higher level of antioxidant compared to other varieties. Drying temperature did affect on the antioxidant capacity as we know that antioxidant is heat sensitive. However, the effect of drying temperature on antioxidant capacity also depends on the types of eggplant.

PL eggplant was most the suitable eggplant that can be used to obtain flour with better quality for the use in food application or in high fiber food for health promotion. The ideal drying temperature used was 40°C. This is because PL 40 was low in fat, moderate in promotion. The ideal drying temperature used was

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