Proximate composition and antioxidant potential of selected tubers peel


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Abstract

This study is aimed to investigate the nutritional composition, phytochemicals and antioxidant activity of red and purple variety of Ipomoea batatas (sweet potato) peels and Manihot esculenta (cassava) periderm and cortex layers. The proximate composition (carbohydrate, protein, fat, moisture, ash and minerals) was determined using standard methods while phytochemical contents (phenolic, flavonoid, anthocyanin and carotenoid) and antioxidant activity [2,2-diphenylpicrylhydrazyl (DPPH), ferric reducing antioxidant power (FRAP), and 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) assays] were determined spectrophotometrically. Proximate analysis showed that both I. batatas and M. esculenta contained high carbohydrate content ranged from 75.07% to 87.04% but zero protein and low-fat contents (0.83-2.2%). For the mineral contents, I. batatas contained higher potassium, sodium, iron and magnesium than M. esculenta. However, calcium was found higher in M. esculenta as compared to I. batatas. For the phytochemical study, total anthocyanin content showed the lowest value (0.43-3.08 µg c-3-gE/g) for both tubers as compared to total phenolic (37.28-71.79 µg GAE/g), flavonoid (4.98-16.50 µg RE/g) and carotenoid (14.54-46.66 µg BC/g) contents. For the antioxidant study, both purple and red variety of I. batatas showed higher percentages of inhibition using DPPH assay with 87.93% and 87.62%, respectively compared to M. esculenta. Meanwhile, FRAP assay displayed lower values than ABTS assay for both tubers. In conclusion, both tubers, I. batatas and M. esculenta have close values of nutritional compositions. However, I. batatas contained higher total flavonoid and total anthocyanin contents while M. esculenta contained higher total phenolic and carotenoid contents. Hence, this study suggested that tuber’s by-products have great potential for use in functional food as they are cheap and readily available as well as reducing waste disposal.

1. Introduction

Tubers are generally known as one of the important staple crops for human consumption. Sweet potato (Ipomoea batatas) and cassava (Manihot esculenta) has been ranked in top five most important crops on a fresh weight basis in developing countries together with rice, maize, and corn (Nawiri et al., 2013). Different tubers grow widely in different countries and conditions based on a few factors such as soil composition and climate. With a different environment, the composition of the tubers may vary due to the factors mentioned. Plants including tubers are potential source of natural antioxidants and act as secondary metabolites. Antioxidants can be found not only in the flesh but also in the peel of the tubers. Natural antioxidants or phytochemical antioxidants such as phenolic, flavonoid, anthocyanin, and carotenoid possess many functions such as prevent deterioration of the tubers, thus extending its shelf life. In addition, antioxidants have the ability in reducing the risk of diseases such as cancer. The searching for natural antioxidants to be used in the industry has increased due to its low toxicity, safe, and generally accepted (Ghasemzadeh et al., 2012).

Over years, consumption of fresh tubers has been decreasing as more tubers are peeled and processed into value-added products such as mashed potatoes, fries, and chips to meet demand from the consumers who want fast and convenience food. Large quantities of peels disposal...
have been concerned and looked into consideration especially towards environmental sustainability. For these reasons, this research aims to investigate the nutritional composition, phytochemicals and antioxidant activity of red and purple variety of sweet potatoes (*I. batatas*) peels and the periderm and cortex layer of cassava (*M. esculenta*).

2. Materials and methods

2.1 Sample preparation

The tubers were washed, cleaned and peeled. The peels were dried for 48 hrs at 55°C in the oven until there was no change in weight of the peels. The peels were ground into powder form, placed in zip lock polyethylene bags and left at 4°C in the refrigerator until further analysis.

2.2 Sample extraction

Peels powder of 0.01 g was mixed with 100 mL of methanol, agitated for an hour and filtered using Whatman filter paper. Each test was done in triplicate to ensure the accuracy of the results (Wong et al., 2006).

2.3 Proximate analysis

Determination of moisture content was done using moisture analyser. At the end of the experiment, the percentage of moisture content was recorded (Nielsen, 2010). Carbohydrate content was determined according to AOAC (1995) and Anhwange (2008). The carbohydrate value was calculated using this formula: Percentage of carbohydrates (%) = 100 % - (moisture content (%)) + Crude fat content (%)) + Crude protein content (%). Analysis of protein was done using the Kjeldahl method involving three steps (i.e. digestion, distillation, and titration). The results of the protein content were obtained directly from the machine in percentage (%) value (AOAC, 1995). Fat analysis was done according to Soxhlet method (AOAC, 1975). The percentage of fat content was calculated using this following equation: % Fat = (Weight before extraction - Weight after extraction)/(Sample weight) x 100%. For the determination of ash content, 1 g of dried samples were placed in a furnace, 550°C up to 10 hrs until ash was obtained (Abbasi et al., 2014). The ash content was calculated by using this equation: % Ash = (W3-W1)/W2 x 100% where W1 = weight of oven-dried empty crucible, W2 = weight of sample, and W3 = weight of ash and crucible.

2.4 Determination of mineral content

Mineral content was determined using the atomic absorption spectrophotometer, Perkin Elmer PinAAcle 900F (AOAC, 2005).

2.5 Determination of phytochemical content

2.5.1 Total phenolic content

Total phenolic content was determined as described by Hassan and Bakar (2013). The absorbance values were measured spectrophotometrically at 750 nm. Gallic acid was used to make a calibration curve and the value obtained from the equation was expressed as µg gallic acid equivalents per g (µg GAE/g).

2.5.2 Total flavonoid content

Total flavonoid content was determined using the colorimetric aluminium chloride method (Elfalleh et al., 2012). The absorbance values were measured spectrophotometrically at 430 nm. Rutin was used to make a calibration curve. Total flavonoid content of the sample was expressed as µg rutin equivalents per gram (µg RE/g).

2.5.3 Total anthocyanin content

Total anthocyanin content was determined by the pH differential method (Abu Bakar et al., 2016). The results were expressed as µg of cyanidin-3-glucoside equivalents per g (µg CGE/g). The total anthocyanin content was calculated with the following equation:

\[
\text{Total anthocyanin content (µg/g)} = \left( A \times M_w \times D_F \times 10 \right) / \left( \varepsilon \times C \right)
\]

Where A is the absorbance = [(A510 nm - A700 nm) pH1.0 - (A510 nm - A700 nm)pH4.5]; MW is molecular weight for cyanidin-3-glucoside = 449.2; DF is a dilution factor of the samples; \( \varepsilon \) is the molar absorptivity of cyaniding-3-glucoside = 26,900; and \( C \) is the concentration of the buffer in mg/mL.

2.5.4 Total carotenoid content

Total carotenoid content was measured at 350 nm by using spectrophotometer (Abu Bakar et al., 2016). β-carotene was used to form a calibration curve and the results were expressed as µg of β carotene equivalent per g sample (µg BC/g).

2.6 Determination of antioxidant activity

2.6.1 2,2-diphenyl-1-picrylhydrazyl (DPPH)

A total of 5.9 mg of DPPH powder was mixed with 100 mL of methanol. Then, 3 mL of the DPPH solution was added into 100 µL of the sample. The sample was left for 15 mins in dark room before being read at an absorbance of 517 nm against blank using spectrophotometer. The equation below was used to determine the radical scavenging activity (Miliauskas et al., 2004).

\[
\text{Scavenging activity} (\%) = (1-(\text{Absorbance of sample/})
\]

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Absorbance of control) x 100%

2.6.2 Ferric reducing antioxidant power (FRAP)

FRAP assay was measured spectrophotometrically at 595 nm (Lusa et al., 2015). The results were expressed as millimoles ferric ion reduced per gram of sample (mM Fe/g).

2.6.3 ABTS (2,2’-azinobis (3-ethylbenzthiazoline)-6-sulphonic acid) radical scavenging assay

ABTS radical cation decolorization assay was done according to Re et al. (1999). The absorbance was measured at 734 nm using a spectrophotometer.

2.7 Statistical analysis

All the results were expressed as mean ± standard deviation of triplicate in three independent experiments. Data were assessed by a one-way Analysis of Variance (ANOVA) where the mean values were considered significantly different when the value of p<0.05 was obtained using Statistical Package for the Social Sciences (SPSS) software.

3. Results and discussion

3.1 Nutritional composition

Tubers are always known as a rich starchy food. The results of the proximate composition of the tubers peel are presented in Table 1 while the mineral contents of the peels are presented in Table 2. The peels of I. batatas and M. esculenta showed significant values of carbohydrate content (p<0.05) as compared to the other components. The percentage values ranged from 75.07% to 87.04% with the peels of M. esculenta had a slightly higher amount of carbohydrate than I. batatas. On the other hand, protein content had been found to be 0% for both tubers, I. batatas and M. esculenta. The fat and moisture contents of both I. batatas and M. esculenta were almost similar and found to be very low ranging from 0.83% to 2.2% and 5.77% to 7.17%, respectively. For the ash content, I. batatas (purple and red varieties) had the higher percentage value with 16.96% and 14.18% as compared to that of M. esculenta (4.46-9.24%) with all the samples tested showed significantly different (p<0.05).

A study was done by Aro et al. (2010) on the M. esculenta peels collected in Nigeria showed that the protein, fat, ash and moisture contents of 4.2%, 3.26%, 7.47% and 82.1%, respectively whereby the protein, fat and moisture contents of M. esculenta peels were higher than that of M. esculenta cortex and periderm layers in this study except for the ash content. The different results obtained were due to the different parts used. In 2010, Adeyosoye et al. showed that I. batatas peels contained 3.06% protein content and 7.00% fat content which were higher compared to I. batatas peels for both red and purple varieties in this study. However, the carbohydrate content of I. batatas peels in this current study (red variety: 78.3%, purple variety: 75.07%) were almost similar with the previous study with the value of 78.94% (Adeyosoye et al., 2010). Few factors such as genetic origin, geographical sources, the level of soil fertility and the harvesting periods might cause a variation in the proximate analysis results (Bhandari et al., 2003).

Ash composition is very important in determining minerals content (Nollet, 2004). Table 2 indicates the mineral contents for I. batatas and M. esculenta such as zinc, potassium, sodium, calcium, iron, and magnesium. Based on the results obtained, all the samples tested showed significantly different (p<0.05) between each other. Calcium was the most abundant minerals found in all the samples tested ranging from 85.82 mg/L to 116.3 mg/L except for I. batatas (purple variety). However, I. batatas (purple variety) had the highest amount of iron.

Table 1. Proximate composition of the tubers peel in (%)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Carbohydrate</th>
<th>Protein</th>
<th>Fat</th>
<th>Moisture</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ipomoea batatas (red variety)</td>
<td>78.3</td>
<td>0±0.00</td>
<td>0.83±0.06</td>
<td>6.69±0.31</td>
<td>14.18±0.84</td>
</tr>
<tr>
<td>Ipomoea batatas (purple variety)</td>
<td>75.07</td>
<td>0±0.00</td>
<td>1.77±0.21</td>
<td>6.02±0.42</td>
<td>16.96±0.33</td>
</tr>
<tr>
<td>Manihot esculenta (periderm layer)</td>
<td>87.04</td>
<td>0±0.00</td>
<td>1.33±0.15</td>
<td>7.17±1.27</td>
<td>4.46±0.09</td>
</tr>
<tr>
<td>Manihot esculenta (cortex layer)</td>
<td>82.79</td>
<td>0±0.00</td>
<td>2.2±0.2</td>
<td>5.77±0.07</td>
<td>9.24±0.19</td>
</tr>
</tbody>
</table>

The results were expressed as mean ± standard deviation in triplicate

Table 2. The minerals content of the tubers peel in (mg/L)

<table>
<thead>
<tr>
<th>Samples</th>
<th>Zinc</th>
<th>Potassium</th>
<th>Sodium</th>
<th>Calcium</th>
<th>Iron</th>
<th>Magnesium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ipomoea batatas (red variety)</td>
<td>0±0.00</td>
<td>19.38±0.03</td>
<td>1.62±0.53</td>
<td>100.2±0.85</td>
<td>63.46±12.20</td>
<td>3.12±0.02</td>
</tr>
<tr>
<td>Ipomoea batatas (purple variety)</td>
<td>0±0.00</td>
<td>19.49±0.01</td>
<td>5.6±1.56</td>
<td>62.62±2.06</td>
<td>62.71±8.59</td>
<td>3.07±0.02</td>
</tr>
<tr>
<td>Manihot esculenta (periderm layer)</td>
<td>0±0.00</td>
<td>11.61±0.01</td>
<td>2.2±0.24</td>
<td>85.82±1.32</td>
<td>44.94±5.36</td>
<td>2.78±0.02</td>
</tr>
<tr>
<td>Manihot esculenta (cortex layer)</td>
<td>0.27±0.04</td>
<td>11.67±0.02</td>
<td>0.99±0.39</td>
<td>116.3±0.8</td>
<td>6.12±1.2</td>
<td>3.05±0.02</td>
</tr>
</tbody>
</table>

The results were expressed as mean ± standard deviation in triplicate.
The results were expressed as mean ± standard deviation in triplicate with the value of 62.71 mg/L. In addition, no samples contained zinc (0 mg/L) except for M. esculenta cortex layer which had almost zero value (0.27 mg/L). With the identification of the nutritional composition, it shows that the peels of the tubers have the potential to be developed as a new food product such as chips. Despite being thrown away as waste, this new food product can help the economics of the food industries. In fact, the previous study has developed new food product such as banana peel jelly which contained higher nutritional composition (Lee et al., 2010).

3.2 Phytochemical content

The results of the phytochemical content are presented in Table 3. M. esculenta (cortex layer) displayed the highest total phenolic content with the value of 71.79±5.57 µg gallic acid equivalent/g significantly different (p<0.05) to the other samples. Flavonoids are very effective antioxidants as it reduces the oxidation of low-density lipoproteins which helps in preventing cardiovascular diseases (Johnson and Williamson, 2003). Total flavonoid content was found to be highest in I. batatas (red variety) with the value of 16.50±0.56 µg rutin equivalent/g significantly different (p<0.05) to the other samples (p>0.05). A study on Annona cherimola Mill. (cherimoya) peel and pulp showed that the amount of total phenolic content and total flavonoid content in the peel were higher than in the pulp (Loizzo et al., 2010).

Anthocyanin is responsible for contributing a wide range of red, magenta, violet, purple, and blue colour towards the plants. Even though anthocyanin is less established compared to the other phytochemical, but it contributes commonly in food colorant (Tsuda, 2012). The highest amount of total anthocyanin content with the value of 3.08±1.07 µg cyanidin-3-glucoside equivalents/g was obtained from I. batatas (purple variety) but the value showed no significant difference (p>0.05) with M. esculenta (cortex layer). The purple colour of the I. batatas peels (purple variety) itself might be the reason why it contained the highest total anthocyanin content in this study compared to other samples tested.

Abundant of carotenoids can be found in nature and β-carotene is one of it that has the ability as provitamin A in the human body (Fennema, 1996). Lycopene is one of the carotenoids aids in reducing the risk of cancer, arteriosclerosis, and coronary heart diseases (Sass-Kiss et al., 2005). M. esculenta (periderm layer) showed significant difference (p<0.05) as compared to the other samples with the highest amount of total carotenoid content, 46.66±0.42 µg β-carotene/g.

3.3 Antioxidant activity

Table 4 shows the results of the antioxidant activity of the tubers peel. DPPH assay performs on the samples possess the mechanism of scavenging activity. I. batatas variety showed a significantly higher scavenging activity than M. esculenta. The highest activity was observed in I. batatas (purple variety) with the value of 87.93±7.91% and the lowest was observed in M. esculenta (periderm layer) with the value of 24.69±4.28%.

In FRAP assay, the FRAP values obtained were lower for all the samples and they did not show any significant difference (p>0.05) between each other. However, M. esculenta (cortex layer) displayed the slightly higher value of FRAP with 4.45±1.26 mM ferric ion reduced/g.

Table 4. Antioxidant activity of the tubers peel

<table>
<thead>
<tr>
<th>Sample</th>
<th>Antioxidant activity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DPPH Scavenging activity (%)</td>
</tr>
<tr>
<td>I. batatas (red variety)</td>
<td>87.62±5.20</td>
</tr>
<tr>
<td>I. batatas (purple variety)</td>
<td>87.93±7.91</td>
</tr>
<tr>
<td>M. esculenta (periderm layer)</td>
<td>24.69±4.28</td>
</tr>
<tr>
<td>M. esculenta (cortex layer)</td>
<td>57.44±4.21</td>
</tr>
</tbody>
</table>

The results were expressed as mean ± standard deviation in triplicate.

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In ABTS assay, ABTS values were found to be highest in *I. batatas* varieties with 37.38±0.38 µg ascorbic acid/mL and 37.22±1.55 µg ascorbic acid/mL, respectively for red and purple variety. The values were not found to be significantly different with *M. esculenta* (periderm layer) but had a significant difference (p<0.05) with *M. esculenta* (cortex layer) (25.24± 1.69 µg ascorbic acid/mL).

### 4. Conclusion

In this study, both tubers, *I. batatas* and *M. esculenta* peel contained almost similar content of nutritional compositions. However, *I. batatas* showed higher mineral contents (potassium, iron, magnesium and sodium) and antioxidant activity than *M. esculenta*. For the phytochemical content, *I. batatas* contained higher total flavonoid and total anthocyanin contents while *M. esculenta* contained higher total phenolic and carotenoid contents. Both peels have great potential for use in complementary and alternative medicines as they are cheap and readily available. At the same time, the usage of the peels may aid in reducing the waste disposal problem and thus protecting the environment.

### Conflict of Interest

The authors do not have any conflicts of interest regarding the content of the present work.

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