Physicochemical and thermal properties of durian seed flour from three varieties of durian native of Sabah


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Abstract

This study was aimed at assessing the physicochemical and thermal properties of flour, acquired from the seeds of three native Sabah durian species. The three durian species concerned are the Dalit, Sukang and Pulu. Flour deriving from the seeds of the dalit (DDSF), sukang (DSSF) and pulu (DPSF) durian species, were put through a physicochemical, pasting and thermal characteristics assessment process. The protein content in flours, derived from the seeds of durian native to Sabah, demonstrated a high capacity for the absorption of both water \((r = 0.855, p<0.01)\), and oil \((r = 0.921, p<0.01)\). DPSF, which holds the most protein content at 6.92%, demonstrated the lowest water absorption capacity, and greatest oil absorption capacity \((p<0.05)\). Moreover, DPSF was observed to have the lowest swelling power, solubility and peak viscosity \((p<0.05)\). In terms of pasting temperature, no outstanding disparities were detected between the three durian seed flours \((p>0.05)\), but they were considered to have high pasting temperatures. The lowest setback viscosity \((p<0.05)\) displayed by DPSF, is an indication that the following gelatinization, will quickly dissolve. Additionally, the enthalpy \(\Delta H\) of DPSF revealed as 0.29 J/g \((p<0.05)\) is deemed significantly low. This undertaking delves into the physicochemical and thermal characteristics of durian seed flour, to its use as composite flour.

1. Introduction

Durian, which is heralded ‘the king of fruits’ in Southeast Asia, comes from the Bombacaceae family and the Durio genus (Noor Raihana et al., 2015). There are a total of 23 species of durian spread throughout Malaysia. The lowland forests, of Peninsular Malaysia and Sabah, are homes to 13 different varieties of durian, while Sarawak is home to 16 varieties (Salma, 2011). However, out of these many durian species, only nine are suitable for human consumption. These edible varieties are the *D. dulcis* (lahong), *D. grandiflorus* (durian monyet), *D. graveolens* (dalit), *D. kinabaluensis*, *D. kutejensis* (lai), *D. lowianus* (durian daun), *D. oxleyanus* (durian sukang), *D. testudinarum* (durian kura-kura) and *D. zibethinus* (durian putih).

Among the durian species native to Sabah, the most well-known and most widely cultivated are the durian dalit, durian sukang and durian pulu. The flesh of the durian dalit varies in colour from yellow to a darker shade of yellow or orange, and from pink to red. According to Hanif et al. (2013), durian dalit holds roughly 13 fatty acid components, and a lesser saturated than unsaturated fatty acid content. While the colours of the durian pulu flesh are similar to those of the durian dalit, the thorns of the former are not as prickly. Durian Sukang comes with an intense aroma and flesh closely similar in appearance, to that of durian putih. However, the flavour of durian Sukang is on the tart side, and sweet (Salma, 2011). Generally, compared to durian Dalit and durian Pulu, durian Sukang comes in a smaller size, and with thorns less pointed.

The seeds of durian, which make up 20% to 25% of whole fruit, are regularly disposed of as agro-waste (Mohd Nazrul Hisham et al., 2012; Srianta et al., 2012). Previous investigations in this area have revealed that the seed of durians holds 6.6% moisture, 4.8% crude fibre, 0.4% fat, 7.6% protein, 3.8% ash, 76.8% carbohydrate, and 52.9% in overall dietary fibre content (Amiza and Roslan, 2009). Durian seed meal can be employed as an alternative to wheat flour or as a thickening agent during the manufacture of food products such as angkak (Srianta et al., 2012), pasta (Mirhosseini et al., 2015),
cage, cookies and soup (Amiza et al., 2004). A gum extracted, from D. zibethinus seed flour, demonstrated its capacity for exceptional water and oil absorption, as well as stability, when used in mayonnaise (Cornelia et al., 2015).

Of late, the feasibility of using the seeds of durians native to Sabah, as a substitute for composite flour, is drawing much attention. This undertaking focused on assessing the physicochemical and thermal properties of flour, generated from three separate durian varieties, cultivated in Sabah, Malaysia.

2. Materials and methods

2.1 Raw materials

The Sabah districts of Menumbok, Tenghilan and Tamparuli were the sources of the Dalit, Sukang and Pulu durian species used for this investigation. These indigenous durians were harvested during the durian season from July to September. Each fruit weighed approximately 5 kg. Following the manual separation of the flesh from the seeds, sterile distilled water was used to meticulously cleanse the seeds. After the cleansing process, 1 kg of durian seeds was put in storage under a temperature of -20°C.

2.2 Preparation of flour

The preparing, of the Dalit, Sukang and Pulu durian seed flour, was following the procedure recommended by Mukprasirt and Sajjaanantakul (2004), albeit with minor alterations. The preparation procedure began with the lye-peeling of the seeds with 0.5% NaOH, for 30 mins, before they were rinsed with water. The seeds were then subjected to boiling (15 mins), and allowed to cool down at room temperature (30 mins), before the spermoders were skinned off by hand. A mixer was used to chop up the cotyledons for 2 min and the resulting mash was dried in a cabinet dryer set at 60°C, until an invariable weight was attained. The Kjeldahl technique was used to establish protein content, the Soxhlet method using the Soxtec 2050 instrument (FOSS, Denmark) was employed to measure fat content, the crude fibre was determined using Fibretherm (Gerhardt, Denmark), ash content was acquired by computing the weight left behind after the overnight heating of the samples (at 550°C), and the carbohydrate content was computed by difference through the formula 100 - (g/100 g moisture + g/100 g protein + g/100 g fat + g/100 g crude fibre + g/100 g ash). All the samples were examined based on dry weight.

2.4 Water absorption capacity and oil absorption capacity

A centrifugal method, described by Tizazu and Emire (2010), was harnessed to establish the water absorption capacity and oil absorption capacity, of the flour samples. Around 2 g of the sample was mixed with 20 mL of distilled water (for water absorption capacity) and refined corn oil (for oil absorption capacity) using a vortex mixer for approximately 30 s. The samples were set aside for 30 mins at ambient temperature, before undergoing centrifugation for 10 mins at 2000×g. A 10 mL graduated cylinder was utilized to ascertain the volume of the supernatant. The density of water was taken at 1 g/mL, while the density of oil was taken at 0.944 g/mL.

2.5 Swelling power and solubility

The procedure employed by Ikegwu et al. (2010) was used to gauge swelling power and solubility. A weight of 1 g of the sample was introduced into a 50 mL centrifuge tube. Following the addition of approximately 30 mL of distilled into the centrifuge tube, a vortex mixer set at slow was used to merge the contents. The resulting slurry was subjected to heating in a water bath, at constant temperatures of 30, 40, 50, 60, 70, 80 and 90°C, for 15 mins. During this period, the sample was incessantly agitated, to deter the starch from bunching. To separate the gel and supernatant, the suspension was subjected to heating of the samples (at 550°C), and the carbohydrate content was computed by difference through the formula 100 - (g/100 g moisture + g/100 g protein + g/100 g fat + g/100 g crude fibre + g/100 g ash). All the samples were examined based on dry weight.

\[
\text{Swelling power of sample (g/g)} = \frac{w_2 - w_1}{\text{weight of sample}}
\]

\[
\text{Solubility (}) = \frac{w_3}{\text{weight of sample}}
\]
2.6 Pasting properties

In compliance with the approach employed by Kaur and Singh (2005), a rapid visco analyser (RVA) (Newport Scientific, Australia) was used to ascertain the pasting attributes. Following the placement of 3 g of flour sample (~10% moisture content) into a dry vacant canister, 25 mL of distilled water was added to the sample, bringing the total weight of the sample to 28 g. The solution was briskly stirred, and the canister was securely installed into the RVA. The slurry was subjected to heating at 50°C to 95°C, with a 7 min holding phase at 95°C, a cooling stage from 95°C to 50°C (6°C/min), followed by a 5 min holding phase at 50°C. Thermocline software was engaged for the interpretation of peak viscosity, trough, breakdown, final viscosity, setback, peak time and pasting temperature from the pasting profile. The viscosity measurement was put across in centipoises (cP).

2.7 Thermal properties

Gelatinization characteristics of the durian seed flours were measured by way of a differential scanning calorimeter (DSC) (Perkin Elmer, USA), furnished with a liquid nitrogen intracooler system. This approach is in keeping with that utilized by Kaur et al. (2007). A mass of 1 mg of the sample was placed in an aluminium pan, followed by the addition of distilled water weighing 3 mg. The pan was subsequently sealed securely and equilibrated at room temperature overnight. The pan holding the sample was then subjected to heat ranging from 30°C to 110°C, with the rate of heating set at 10°C/min. The thermogram was referred to for ascertaining the onset temperature (T_o), peak temperature (T_p), conclusion temperature (T_c) and enthalpy (ΔH). A procedure recommended by Vasanthan and Bhatty (1996) was employed to establish the gelatinization range (T_c-T_o).

2.8 Statistical analysis

The analysis was performed in triplicates. The SPSS version 20 (IBM, New York, USA) was used to perform the analysis of variance (ANOVA), and test of significance (through the Tukey procedure), with a confidence level of 95%. The same software was utilized for computing the Pearson correlation coefficients (r), for associations between the properties of the flours.

3. Results and discussion

3.1 Chemical composition

Table 1 exhibits the chemical composition of flours, deriving from seeds of native Sabah durians. As can be observed, the moisture content of the durian Sukang seed flour (DSSF) is significantly lowest (p<0.05) among the flours. The low moisture content level serves to enhance the stability of the flour, by inhibiting the growth of mould while reducing the occurrence of biochemical reactions (Omimawo and Akubor, 2012). The content of fat in DSSF (0.62%), DSSF (0.58%) and DPSF (0.74%) were less than that in jackfruit seed flour (0.99% to 2.19%) (Tulyathan et al., 2002; Mukprasit and Sajjaanantakul, 2004) and bambara groundnut flour (6.18%) (Adegunwa et al., 2014). On the other hand, the content of fat in DDSF, DSSF and DPSF, is more than the content of fat in durian putih (D. zibethinus) (Mirhosseini et al., 2015). As displayed in Table 1, the protein content of DSSF (p<0.05) is the least among the flours investigated. As such, its swelling power is more pronounced than that of DDSF and DPSF. This is portrayed in Table 1 and Figure 1. The protein content of DSSF, DPSF and DDSF, which ranges between 6.03% and 6.92% (Table 1), is roughly half the protein content in wheat flour (13.7%). This is an indication that flour derived from indigenous durian seed, is deficient in gluten, and therefore unsuitable for the making of bread (Amiza and Roslan, 2009). Though inapplicable in the bakery industry, durian seed flour may find its place in other areas, through its amalgamation with other types of flour.
3.2 Water absorption capacity and oil absorption capacity

Among the most essential functional qualities of flour, is its capacity for absorbing water and swelling, to enhance the consistency of food (Adepeju et al., 2011). As displayed in Table 1, the capacity to absorb water (0.91 g/g) is greater in DSSF than in the other flours. This could be attributed to its depleted fat content, which contributes towards a higher capacity for the absorption of water (Shevkani et al., 2014). Besides that, water absorption capacity was also enhanced by moisture and high crude fibre content (Akubor et al., 2013). At the same time, the oil absorption capacity plays a key role in flavour retention, enhancing delectableness, as well as in prolonging the shelf life of bakery and meat products (Adebowale and Lawal, 2004). In comparison to lentil (Kaur and Sandhu, 2010), field pea and pigeon flours (Kaur et al., 2007), the oil absorption capacity of DDSF, DSSF and DPSF is deemed inferior. As portrayed in Table 1, the oil absorption capacity of DPSF (p<0.05) is superior to that of DDSF and DSSF.

As illustrated in Table 2, protein content is strongly correlated to water absorption capacity, with r = -0.855 (p<0.01). Differences in protein, as well as carbohydrate portions, contribute towards disparities in the water absorption capacity in flours (Kaur and Sandhu, 2010). It has been revealed, that the water absorption capacity of jackfruit seed (Tulyathan et al., 2002; Chowdhury et al., 2012) and African star apple kernel flour (Akubor et al., 2013), is superior to that of the indigenous durian seed flours under investigation.

Table 2. Pearson correlation coefficients between various physicochemical and thermal properties of Sabah indigenous

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Protein</th>
<th>SP</th>
<th>PV</th>
<th>ΔTc-To</th>
</tr>
</thead>
<tbody>
<tr>
<td>OAC</td>
<td>0.921**</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Solubility</td>
<td>-0.888**</td>
<td>0.986**</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>WAC</td>
<td>-0.855**</td>
<td>0.940**</td>
<td>0.918**</td>
<td>-</td>
</tr>
<tr>
<td>PT</td>
<td>0.441</td>
<td>0.479</td>
<td>-0.407</td>
<td>-</td>
</tr>
<tr>
<td>ΔH</td>
<td>-0.919**</td>
<td>0.948**</td>
<td>0.974**</td>
<td>0.400</td>
</tr>
</tbody>
</table>

** p<0.01. OAC: Oil Absorption Capacity, WAC: Water Absorption Capacity, PT: Pasting Temperature, SP: Swelling Power, PV: Peak Viscosity, ΔTc-To: range of gelatinisation, ΔH: enthalpy

The capacity of flour, for oil absorption, is determined by intrinsic factors that include amino acid composition, protein conformation and surface polarity or hydrophobicity (Chandra and Samsher, 2013). The hydrophobicity of proteins in flour enhances the binding of lipids, which consequently influences the oil absorption capacity of the flour. As shown in Table 2, a positive correlation was exhibited between protein content and the oil absorption capacity of indigenous durian seed flours (r = 0.921, p<0.01). This is verified by the fact that DPSF, with the highest protein content (6.92 %), is also superior to DDSF and DSSF in terms of oil absorption capacity (0.70 g/g).

3.3 Swelling power and solubility

As shown in Figure 1, as the temperature climbed from 30°C to 90°C, the swelling power and solubility of the indigenous durian seed flours were enhanced. Also, as displayed in Table 2, the solubility of flour enhances in tandem with the increase in swelling power. In terms of swelling power (Figure 1a) and solubility (Figure 1b), DSSF claims top spot in both these areas. The swelling power of DDSF, DSSF and DPSF was revealed to be greater than tiger nut flour (Oladele and Aina, 2007), but lesser than jackfruit seed flour (Mukprasirt and Sajjaantakul, 2004). As illustrated in Figure 1, the swelling power and solubility of DDSF, DSSF and DPSF peaked, when the temperature reached 80°C. Ikegwu et al. (2010) stated that swelling power and solubility are greatest, at temperatures ranging between 80°C and 95°C.

While heading the list for protein content (Table 1), DPSF is at the bottom for swelling power (Figure 1a) and solubility (Figure 1b). The lack of swelling power and solubility of DPSF could be attributed to the
profound bonding strength in its protein-amylose complexes. According to Shimelis et al. (2006), the attraction of opposite charges, which occurs between protein and starch complexes during gelatinization, hampers the swelling process. In the context of swelling, starch can be separated into four categories: high swelling, moderate swelling, restricted swelling and highly restricted swelling (Ikegwu et al., 2010). Accordingly, the lower the swelling power value, the more restricted the swelling of indigenous durian seed flours.

3.4 Pasting properties

According to the RVA results exhibited in Table 3, in terms of pasting profile (Figure 2), there are significant differences (p<0.05) between the three indigenous durian seed flours considered for this undertaking. Gelatinization is defined as the alterations that occur during the heating of a starch and water combination. These alterations include the swelling of granules, rise in viscosity, and increased clearness and solubility of the slurry, as well as the decline in anisotropy (Ikegwu et al., 2010). The minimum temperature required for the cooking of flour samples is referred to as the pasting temperature (Shimelis et al., 2006). According to the results acquired, the pasting temperatures of DDSF, DSSF and DPSF, are not significantly different (Table 3). As portrayed in Table 2, the pasting temperature is correlated to protein content and swelling power. An elevated quantity of protein encourages protein-starch interactions, which serve to diminish the swelling of starch. This situation triggers a climb in the pasting temperature (Liu et al., 2007).

While the pasting temperatures of the three indigenous flours are not much different, their peak viscosities differ significantly, with DPSF at 1266 cP (the lowest), DDSF at 1750 cP, and DSSF at 1927 cP. Peak viscosity refers to the capacity of starch with regards to water absorption (Ikegwu et al., 2010). Table 2 shows a positive correlation in that both parameters (r = 0.918, p<0.01). The peak viscosity of all three indigenous durian seed flours were above those of pea, chickpea (Chung et al., 2008) and lentil flours (Kaur and Sandhu, 2010). The raised peak viscosity of DDSF, DSSF and DPSF is an indication that they are applicable for the manufacture of high gel strength products (Ikegwu et al., 2010).

According to Adebowale et al. (2005), flours with a high breakdown viscosity, have a low tolerance for heat and shear stress, during cooking. As displayed in Table 3, the breakdown viscosity for the indigenous durian seed flours stretches from 179.00 to 357.67 cP. The results, from an investigation conducted by Shevkani et al. (2014), revealed that the relationship between protein content, and breakdown viscosity, is detrimental in nature. The results from our study indicate that DPSF has a greater protein content (Table 1), and a lower breakdown viscosity (Table 3) than DSSF and DSSF. Besides that, the stability of flour products hinges on breakdown viscosity (Kaur and Singh, 2005).

Oloyede et al. (2016) observed that during cooling, flours with a low content of amylose, demonstrated a low setback viscosity, as well as low retrogradation (Falade and Christopher, 2015). DPSF demonstrated a lower setback viscosity, as well as lower retrogradation, in comparison to DDSF and DSSF (Table 3).

3.5 Thermal properties

Gelatinization is when starch particles heated in excess water, go through an ordered-disordered transition (Mukprasirt and Sajjaanantakul, 2004). The obvious disparities in gelatinization activities among DDSF, DSSF and DPSF (p<0.05) are exhibited in Table 4.

![Figure 2. Pasting profile of indigenous durian seed flours](image)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>DDSF</th>
<th>DSSF</th>
<th>DPSF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasting Temperature (°C)</td>
<td>77.52±2.49a</td>
<td>76.35±2.18a</td>
<td>80.60±4.73a</td>
</tr>
<tr>
<td>Peak Viscosity (cP)</td>
<td>1750.67±111.55a</td>
<td>1927.00±72.92a</td>
<td>1266.00±46.87b</td>
</tr>
<tr>
<td>Breakdown (cP)</td>
<td>309.00±53.25a</td>
<td>357.67±58.35a</td>
<td>179.00±5.00b</td>
</tr>
<tr>
<td>Setback Viscosity (cP)</td>
<td>793.00±69.54a</td>
<td>810.67±52.44a</td>
<td>530.67±22.30b</td>
</tr>
</tbody>
</table>

Values are presented as mean±SD. Values with different superscripts within the same are significantly different (p<0.05). DDSF: durian dalit seed flour, DSSF: durian sukang seed flour, DPSF: durian pulu seed flour.

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Table 4. Thermal properties of Sabah indigenous durian seed flours

<table>
<thead>
<tr>
<th>Parameters</th>
<th>DSSF</th>
<th>DSSF</th>
<th>DPSF</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔT (°C)</td>
<td>70.87±0.06a</td>
<td>67.03±0.53b</td>
<td>67.95±0.56b</td>
</tr>
<tr>
<td>Tp (°C)</td>
<td>75.15±0.36a</td>
<td>72.94±0.69b</td>
<td>72.24±0.63b</td>
</tr>
<tr>
<td>Tc (°C)</td>
<td>78.84±1.08abc</td>
<td>79.19±0.38a</td>
<td>77.39±0.29b</td>
</tr>
<tr>
<td>ΔTc-ΔTp(°C)</td>
<td>7.97±1.03b</td>
<td>12.16±0.15a</td>
<td>9.44±0.55b</td>
</tr>
<tr>
<td>ΔH (J/g)</td>
<td>0.77±0.06b</td>
<td>0.92±0.07c</td>
<td>0.29±0.01c</td>
</tr>
</tbody>
</table>

Values are presented as mean±SD. Values with different superscripts within the same are significantly different (p<0.05). DSSF: durian dalit seed flour, DSSF: durian sukang seed flour, DPSF: durian pulu seed flour, To: onset temperature, Tp: peak temperature, Tc: conclusion temperature, ΔH: enthalpy.

The onset temperature (T_o) is associated with the depletion of birefringence, during the gelatinization process (Mukprasirt and Sajjaantakul, 2004). During our investigation, the highest onset temperature (T_o) (p<0.05) exhibited by DSSF, suggests that in comparison to the other flours, its gelatinization can be expected to be more demanding. The T_o of DSSF, DSSF and DPSF, which stretched between 67.03°C and 70.87°C, is comparatively greater than those of jackfruit seed flour (63.43°C) (Mukprasirt and Sajjaantakul, 2004) and chickpea flour (65.4°C – 67.9°C) (Kaur and Singh, 2005).

The peak temperature (T_p) relates to the stability of starch crystallites, upon their exposure to heat (Aprianita et al., 2009). An elevated T_p value is indicative of highly resistant and stable starch. The highest T_p was credited to DSSF, which indicates that the stability, and heat resistance levels of its starch, is superior to those of DSSF and DPSF (p<0.05). The disparities, in gelling temperatures between flours, can be put down to variations in the size, shape and distribution of starch granules in flours, as well as differences in the internal arrangement of starch fractions within the granule (Kaur and Singh, 2005).

The enthalpy of gelatinization (ΔH) for DSSF, DSSF and DPSF were observed to be considerably dissimilar (p<0.05), which related to characteristics of the starch granule, including crystallinity and granule size (Bogracheva et al., 2006). Bhupender et al. (2013) suggested that starch with a depleted ΔH needs a lesser amount of energy to gelatinize. This also applies in reverse order. According to the results derived through our investigation, the ΔH of DPSF is the lowest among the indigenous durian seed flours. As such, in terms of gelatinization, DPSF will require a lesser amount of energy than DSSF and DSSF (p<0.05). Moreover, as can be observed in Table 2, there is a strong correlation between ΔH with protein (r = -0.919) and swelling power (r = 0.948).

The gelatinization range (T_c-T_o) of DSSF is very much greater (p<0.05) than that of DSSF and DPSF. This is illustrated in Table 4. And as the gelatinization range (T_c-T_o) is constructively linked to ΔH (Table 2), it follows that for the gelatinization of starch, DSSF will require more energy than DSSF and DPSF. In contrast, DPSF, with the lowest T_c and ΔH (Table 4) among the indigenous flours, dissolves easily when gelatinized.

4. Conclusion

Durian Pulu Seed Flour (DPSF) had the highest capacity for oil absorption, but with the lowest water absorption capacity, swelling power, solubility, peak viscosity, breakdown viscosity, and setback viscosity. As DPSF is responsive to heat, it requires less energy to gelatinize, while dissolving easily when gelatinized, due to its low ΔH and T_c. Durian Sukang Seed Flour (DSSF) demonstrated a high-water absorption capacity, swelling power, solubility and gelatinization range (T_c-T_o), with low protein content. As for Durian Dalit Seed Flour (DSSF), its high T_o and T_p rendered gelatinization difficult, as its starch is less susceptible to heat.

Conflict of interest

The authors declare no conflict of interest.

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