Physico-chemical properties of local native starches
(Ciri fizikokimia kanji asli tempatan)

I. Khatijah* and H. Patimah*

Key words: starch, native, local, properties, physico-chemical

Abstract
This article discusses the physico-chemical properties of local native starches from sago, tapioca and two varieties of sweet potato (Bukit Naga and Gendut). The four starches exhibited a high degree of whiteness. Generally, the fat, ash and protein contents of the starches were low. One hundred per cent each of sago and tapioca starches passed through a 125 µm sieve while only 85.9% of the Bukit Naga starch and 75.5% of the Gendut starch passed through it. Tapioca starch paste had the lowest gelatinization temperature, peak viscosity, viscosity at 50 °C, set back value and consistency; shortest time to gel and to reach peak viscosity. Sago starch paste had the highest peak viscosity corresponding to a higher thickening power of the starch. The Gendut starch exhibited the highest paste viscosity stability during heating. The granule swelling power of sago starch at 75–95 °C was the highest compared to the other three starches. This starch had the highest amylose content while tapioca starch had the lowest.

*Food Technology Centre, MARDI Headquarters, P.O. Box 12301, 50774 Kuala Lumpur, Malaysia
Authors' full names: Khatijah Idris and Patimah Hasim
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**Introduction**

Native starches are starches extracted or separated from their natural sources, such as tuber (tapioca, potato and sweet potato) or trunk (sago) or seed kernel (corn and wheat). They have been traditionally used as food ingredient in a wide range of foods. They function mainly as thickening, texturising, stabilizing, emulsifying, shaping, moisture holding, gelling, glaze forming, binding, dusting and processing aid.

The properties of starches from different sources vary considerably. The chemical composition and physical characteristics are essentially typical to the biological origin of the starch. Although environmental and cultural factors can affect their characteristics, starches have their own characteristic functional properties due to their granular and molecular structural differences. It is, therefore, important to understand their physico-chemical properties to be able to choose the appropriate and reliable starch for use in different types of food products.

Studies on the physico-chemical properties of various starches have been carried out throughout the world. Swinkels (1985) reviewed the properties of potato, maize, wheat, tapioca and waxy maize starches. Takeda et al. (1986) worked mainly on the structure of amylose and amylopectin as well as the pasting characteristics of starches from three sweet potato varieties (Koganesengan, Minamiyutaka and Norin-2). Leelavathi and Indrani (1987) studied the pasting behaviour of corn, wheat and tapioca starches. Wiesenborn et al. (1994) investigated the behaviour of starches from 44 potato samples representing 34 genotypes and found that three of the varieties had high stability ratio (stable viscosity). Valetudie et al. (1995) reported the gelatinization characteristics of sweet potato, tania and yam starches.

Locally, similar studies on starches have also been conducted. The colour, particle size, pasting characteristics, pH and composition of 20 sago starch samples had been reported (Khatijah and Patimah 1995). Other studies reported on the evaluation of eight sago starches and the properties as well as the composition of 10 types of local tubers (Nik Ismail et al. 1988; Mohd. Nasir and Lim 1991).

However, information on local starches and their suitability for use is still lacking. This study was carried out to determine the physico-chemical properties of local native starches from sago (*Metroxylon* spp.), tapioca (*Manihot esculenta*) and two sweet potato varieties (*Ipomoea batatas* L.) as an initial step towards a more comprehensive study on local starches and their use.

**Materials and methods**

**Starch extraction**

The sago and tapioca starches were obtained from starch processing industries. The sweet potato starches were prepared from their tubers by peeling, chopping, grinding, washing in alkaline water followed by washing several times with water, drying in an oven at 45–50 °C to a moisture content of <12% and grinding to 150 µm (Knight 1969).

**Analysis**

The colour of the starches was measured by Chroma Meter CR200 (Minolta Camera Co.) based on the Hunter’s system (*L*, *a*, and *b* values). The standard white plate used has the *L*, *a* and *b* values of 97.83, –0.38 and +1.94 respectively. Chroma was calculated using the formula, \[ C = \sqrt{a^2 + b^2} \] where *a* and *b* are colour values from Chroma Meter CR200.

The particle size was measured according to the Malaysian standard (Anon. 1994). The size of the sieve used was 125 µm or 120 mesh. Pasting characteristics were determined by using a Brabender amylograph (700 cm-g and at 75 rpm). A 6% (d.b.) starch suspension was used and the cycle involved a heating period from 30 °C to 95 °C at a rate of 1.5 °C/min, holding period at 95 °C for 30 min followed by a cooling period to 50 °C.
The swelling power of the starch granules at 75, 85 and 95 °C was determined as described by Petersen (1975).

The pH, moisture, fat, ash, protein, crude fibre and starch contents were determined according to the AOAC methods (1984). The amylose content was determined by using a simplified assay for milled-rice amylose (Juliano 1971).

Results and discussion

Colour
All the starches studied had high degree of whiteness (Table 1). Among them, tapioca starch was the whitest while sago starch was the least white. The higher $a$ value for sago starch showed its tendency towards pinkish colour while negative $a$ value of the other starches showed their tendency towards greenish colour. The higher $b$ value for sago starch indicated its tendency towards yellow. The colour intensity of both sago and tapioca starches was higher than the specification (Malaysian standard, $L = 90$) (Anon. 1992, 1994).

Size
The sago and tapioca starches had smaller particle size than the sweet potato starches (Table 1). A higher percentage of the starches passed through the 125 µm sieve. Both sago and tapioca starches met the requirement of the Malaysian standard, i.e. 97.5% and 99% respectively should pass through the sieve.

Table 1. Colour and particle size of four native starches*

<table>
<thead>
<tr>
<th>Starch</th>
<th>Colour**</th>
<th>% starch which passed through 125 µm sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$L$</td>
<td>$a$</td>
</tr>
<tr>
<td>Standard plate</td>
<td>97.83 ± 0.01</td>
<td>-0.38 ± 0.01</td>
</tr>
<tr>
<td>Sago</td>
<td>92.16 ± 0.02</td>
<td>0.72 ± 0.02</td>
</tr>
<tr>
<td>Tapioca</td>
<td>96.50 ± 0.01</td>
<td>-0.38 ± 0.01</td>
</tr>
<tr>
<td>Sweet potato</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bukit Naga</td>
<td>94.49 ± 0.01</td>
<td>-0.83 ± 0.01</td>
</tr>
<tr>
<td>Gendut</td>
<td>96.16 ± 0.01</td>
<td>-0.43 ± 0.01</td>
</tr>
</tbody>
</table>

*Mean of two replicates
**$L$ = white
$a$ = greenish (negative value), pinkish (positive value)
$b$ = yellowish
$C = \sqrt{(a^2 + b^2)}$

Figure 1. Pasting characteristics of sago, tapioca and sweet potato (var. Bukit Naga and Gendut) starches
Amylographic properties

The four starches analysed exhibited a single stage gelatinization process indicating uniform distribution of forces within the granules (Figure 1). However, there were differences in the pasting curves of the native starches (Table 2). Among these starches, the Bukit Naga paste had the highest gelatinization temperature (78.8 °C), viscosity at the end of holding period (450 B.U.), peak viscosity (550 B.U.), viscosity at 50 °C (370 B.U.), viscosity at 50 °C (168 B.U.), set back value (-202 B.U.), and the longest time to gel (32.5 min). In contrast, tapioca starch paste had the lowest gelatinization temperature (65.3 °C), peak viscosity (370 B.U.), viscosity at 50 °C (168 B.U.), and the shortest time to gel (23.5 min) as well as to reach peak viscosity (30 min). Sago starch paste had the highest peak viscosity (560 B.U.) and breakdown value (360 B.U.). A higher pasting peak viscosity corresponds to a higher thickening power of the starch while a higher breakdown value indicates lower starch paste viscosity stability during the heating cycle. The Gendut starch exhibited the highest paste viscosity stability during the heating cycle while the lowest setback value of the tapioca starch paste denoted softness of the gel when cooled.

Among the starches, the sago starch granules had the highest swelling power at 75–95 °C (Figure 2). The sweet potato starches were most resistant to swelling at 75 °C. However, at 85 °C and above, the Gendut starch had slightly higher swelling power than the Bukit Naga starch. A highly associated starch with extensive, strongly-bonded micellar structure will be relatively resistant to swelling (Gujska et al. 1994). The presence of non-carbohydrate substances such as lipid or phosphate, may affect swelling (Tian et al. 1991). Further, a high amylose content may reduce swelling.

Table 2. Pasting characteristics of 6% (d.b.) native starches*

<table>
<thead>
<tr>
<th>Starch</th>
<th>Gelatinization temperature (°C)</th>
<th>Time taken to gel (min)</th>
<th>Peak viscosity (B.U.)</th>
<th>Time taken to reach peak viscosity (min)</th>
<th>Viscosity at the end of holding period (B.U.)</th>
<th>Viscosity at 50 °C (B.U.)</th>
<th>Set back (B.U.)</th>
<th>Consistency (B.U.)</th>
<th>Breakdown (B.U.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sago</td>
<td>72.0 ± 0.2</td>
<td>28.0 ± 0.2</td>
<td>560 ± 1</td>
<td>35.0 ± 0.2</td>
<td>200 ± 2</td>
<td>470 ± 2</td>
<td>-90 ± 1</td>
<td>270 ± 5</td>
<td>360 ± 1</td>
</tr>
<tr>
<td>Tapioca</td>
<td>65.3 ± 0.2</td>
<td>23.5 ± 0.2</td>
<td>370 ± 1</td>
<td>30.0 ± 0.1</td>
<td>90 ± 1</td>
<td>168 ± 2</td>
<td>-202 ± 1</td>
<td>78 ± 1</td>
<td>280 ± 0</td>
</tr>
<tr>
<td>Sweet potato</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bukit Naga</td>
<td>78.8 ± 0.2</td>
<td>32.5 ± 0.1</td>
<td>550 ± 2</td>
<td>44.0 ± 0.1</td>
<td>450 ± 1</td>
<td>610 ± 2</td>
<td>60 ± 5</td>
<td>160 ± 4</td>
<td>100 ± 1</td>
</tr>
<tr>
<td>Gendut</td>
<td>78.0 ± 0.2</td>
<td>32.0 ± 0.1</td>
<td>400 ± 2</td>
<td>44.5 ± 0.2</td>
<td>362 ± 1</td>
<td>520 ± 2</td>
<td>120 ± 0</td>
<td>158 ± 4</td>
<td>8 ± 4</td>
</tr>
</tbody>
</table>

*Mean of two replicates
d.b. = dry basis
Set back = viscosity at 50 °C – peak viscosity
Consistency = viscosity at 50 °C – viscosity at the end of holding period
Breakdown = peak viscosity – viscosity at the end of holding period
Table 3. Chemical properties of four native starches*

<table>
<thead>
<tr>
<th>Starch</th>
<th>pH of aqueous extract</th>
<th>Amylose (%)**</th>
<th>Moisture (%)</th>
<th>Fat (%)</th>
<th>Ash (%)</th>
<th>Protein (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sago</td>
<td>5.5 ± 0.1</td>
<td>44.7 ± 0.1</td>
<td>11.9 ± 0.10</td>
<td>0.1 ± 0.01</td>
<td>0.1 ± 0.01</td>
<td>0.6 ± 0.01</td>
</tr>
<tr>
<td>Tapioca</td>
<td>4.2 ± 0.2</td>
<td>33.1 ± 0.1</td>
<td>10.8 ± 0.20</td>
<td>0.1 ± 0.01</td>
<td>0.1 ± 0.01</td>
<td>1.0 ± 0.01</td>
</tr>
<tr>
<td>Sweet potato</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bukit Naga</td>
<td>4.5 ± 0.1</td>
<td>34.3 ± 0.1</td>
<td>7.3 ± 0.20</td>
<td>0.1 ± 0.01</td>
<td>0.5 ± 0.01</td>
<td>0.6 ± 0.01</td>
</tr>
<tr>
<td>Gendut</td>
<td>5.1 ± 0.1</td>
<td>34.5 ± 0.2</td>
<td>7.3 ± 0.01</td>
<td>0.2 ± 0.01</td>
<td>0.5 ± 0.01</td>
<td>2.6 ± 0.02</td>
</tr>
</tbody>
</table>

*pMean of two replicates

**Ajimilah, N. H., Food Technology Centre, MARDI, Serdang, pers. comm. 1996
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References

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