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Physico-chemical properties of local native starches

(Ciri fizikokimia kanji asli tempatan)

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

Abstrak

Artikel ini membincangkan ciri fizikokimia kanji asli tempatan daripada sagu, ubi kayu dan dua varieti ubi keledek (varieti Bukit Naga dan Gendut). Keempat-empat jenis kanji tersebut berwarna putih. Pada amnya, kandungan lemak, abu dan protein dalam keempat-empat jenis kanji itu rendah. Seratus peratus kanji sagu dan ubi kayu dapat melalui ayak (saiz 125 µm). Walau bagaimanapun, hanya 85.9% kanji ubi keledek Bukit Naga dan 75.5% kanji ubi keledek Gendut yang dapat melalui ayak tersebut. Pes kanji ubi kayu mempunyai suhu penggelatinan, kelikatan puncak, kelikatan pada suhu 50 °C, nilai ‘set back’ dan kekonsistenan yang terendah. Masa pes tersebut menjadi gel dan masa untuk mencapai kelikatan puncak didapati paling singkat. Pes kanji sagu mempunyai kelikatan puncak yang tertinggi selaras dengan daya pemekatannya yang tinggi. Kelikatan pes kanji ubi keledek Gendut paling stabil semasa dipanaskan.

Daya pengembungan butiran kanji sagu pada suhu 75–95 °C tertinggi berbanding dengan daya pengembungan kanji yang lain. Kanji sagu mempunyai kandungan amilosa yang tertinggi manakala kandungan amilosa kanji ubi kayu terendah.

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.

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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*

Starch	Colour**				% starch which passed through 125 µm sieve
	L	*a*	*b*	C	
Standard plate	97.83 ± 0.01	–0.38 ± 0.01	1.94 ± 0.01	1.98 ± 0.01	
Sago	92.16 ± 0.02	0.72 ± 0.02	7.07 ± 0.02	7.10 ± 0.03	100.0 ± 0.01
Tapioca	96.50 ± 0.01	–0.38 ± 0.01	3.64 ± 0.01	3.66 ± 0.01	100.0 ± 0.01
Sweet potato					
Bukit Naga	94.49 ± 0.01	–0.83 ± 0.01	4.65 ± 0.02	4.72 ± 0.02	85.9 ± 0.03
Gendut	96.16 ± 0.01	–0.43 ± 0.01	3.06 ± 0.01	3.09 ± 0.01	75.5 ± 0.03

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

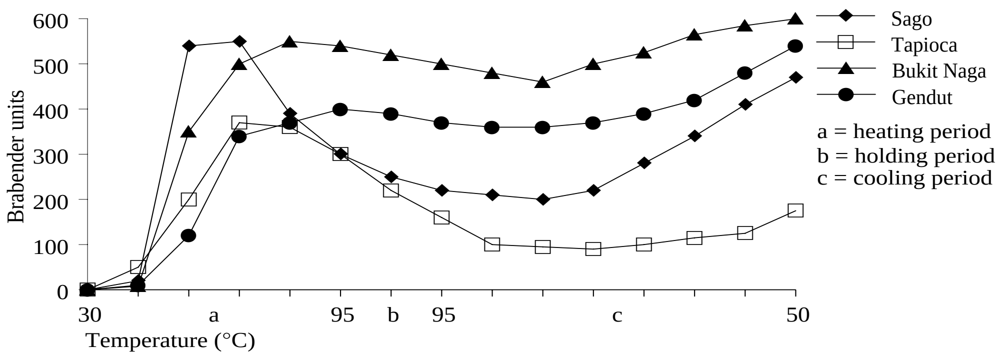

Figure 1. Pasting characteristics of sago, tapioca and sweet potato (var. Bukit Naga and Gendut) starches

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.), viscosity at 50 °C (610 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.), set back value (-202 B.U.), consistency (78 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. The strength and character of the micellar network within the granule is the major factor controlling swelling behaviour of 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*

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

*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

pH

The pH of most foods is less than 7. The specification for the aqueous pH of sago and tapioca starches is 4.5–6.5. The pH of tapioca starch was slightly lower at 4.2 *(Table 3).*

Amylose

Among the starches, sago starch had the highest amylose content (44.7%) while tapioca starch had the lowest (33.1%). The amylose content is usually related to the gelatinization temperature whereby high amylose starches will have high gelatinization temperature. However, this is not true for sago and sweet potato starches. This could be due to the differences in their granular size, shape and crystalline structure (Tian et al. 1991).

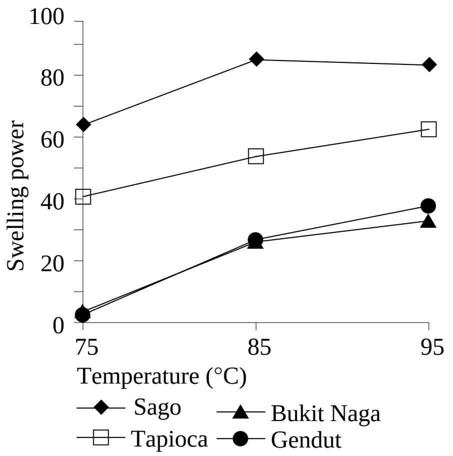

Figure 2. Swelling power of sago, tapioca and sweet potato (var. Bukit Naga and Gendut) starches

Other constituents

Generally, the fat, ash and protein contents of the starches were low. The higher ash content for sweet potato starches could be due to the presence of a larger amount of phosphorus (Takeda et al. 1986; Tian et al. 1991).

Conclusion

The four local native starches exhibited high degree of whiteness. The particle size of sago and tapioca starches met the requirement of the Malaysian standard. For sweet potato starches, the particle size can be further reduced with extra grinding during the preparation process.

The four starches differed in their pasting characteristics. The sweet potato starch pastes had the highest gelatinization temperatures and took a longer time to gel than sago and tapioca starch pastes indicating higher energy requirement during cooking. This was further elaborated by the higher swelling power of sago and tapioca starches. Starches of sago, tapioca and sweet potato of variety Bukit Naga had high breakdown values during the amylographic heating and holding cycle. This breakdown resulted in a loss of the thickening power of the starch after subsequent cooking.

The local native starches have limitation in their properties to suit certain food products. To be widely used in the food industries, these starches have to be modified to be more stable and flexible to withstand the processing, storage and handling conditions in the industries.

Table 3. Chemical properties of four native starches*

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

*Mean of two replicates
**Ajimilah, N. H., Food Technology Centre, MARDI, Serdang, pers. comm. 1996

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