Characterization of Starch in Two Cultivars of Ubi Gadong *(Dioscorea Hispida Dennst)*

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Characterization of Starch in Two Cultivars of Ubi Gadong (*Dioscorea Hispida Dennst*)

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Abstract. The ubi gadong or *Dioscorea Hispida Dennst* (*D. hispida*) is a carbohydrate plant that contain about 75.2 % in the form of starch in its tuber. In this study, two cultivars of *D. hispida* namely yellow tuber or 'gadong pulut' and white tuber or 'gadong beras' were identified. The starch content in two cultivars of *D. hispida* was extracted and analyse their chemical and physical properties by comparing their thermal analysis, granule morphology and others physicochemical properties. Observation on the texture of starch extract from yellow tuber shows that starch in yellow tuber is stickier and requires a long time for the drying process compared to the white tuber. The colour parameter of tuber was measured the yellowness colour (b*) using choma meter showed the yellow tuber is 52.88 more yellowish than white tuber which is about 34.16. Results showed, for both starch samples solubility and swelling power gradually increased with the increasing of temperature ranging from 75°C to 95°C. SEM analysis of the starch granules indicate the polyhedral shapes with size between 1.3µm to 4.3µm. The results obtained from DSC showed the both starches transition temperature (To, Tp and Tc) were in range 74.53 – 74.58°C, 79.34 – 79.39°C and 83.35 – 83.40°C while, the enthalpy of gelatinization (ΔHgel) was in range 4.11 – 4.16 Jg^{-1}.

1. Introduction

Tuberous plant plays an important roles in food security, source of animal feed, medicinal purpose and raw material for industrial use. Tuberous plants store approximately 65 to 85% of carbohydrates in the form of starch in their tubers [1]. Starch is abundant carbohydrates in plants that can be found in the plant organs. Starch synthesized from the plant cells can be divided into amylose and amylopectin. Previous study has shown that various source of starch have different physicochemical properties. The physicochemical properties of starches varies depending on the types and ages of sources, geographical regional, and climate conditions [2].

Dioscorea hispida Dennst (*D. hispida*) or locally known as "ubi gadong" in Malaysia is a type of wild yam plant that can be found in secondary forest, near with river and also can lived in variety of weather condition. It has a hard thin tuber, brown yellowish and sometimes a bit darker in skin colour depending on the type of soil. It is harvested as many rounded shape individual tubers which are clump together, with fibrous root on all over tuber skin (Fig.1). This tuber has been consumed as staple food in tropical and subtropical regions but is rarely eaten by natives nowadays due to toxic compound of dioscorine inside the tuber [3].

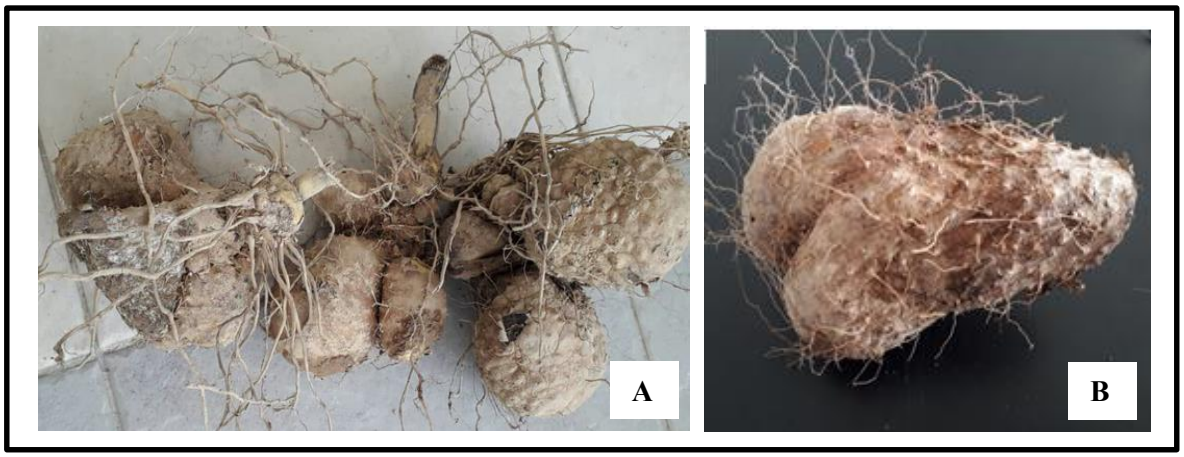

Figure 1. *Dioscorea hispida Dennst (D. hispida)* tuber. A) Yellow tuber "gadong pulut". B) White tuber "gadong beras".

There are two types of *D. hispida* cultivar can be found in Malaysia which is yellow tuber "gadong pulut" and white tuber "gadong beras". The differences between both cultivars obviously can be seen through its tuber flesh colour. Local people in east coast of Peninsular Malaysia especially in Terengganu and Kelantan just simply name both cultivar based on its tuber flesh colour. Yellow tuber has more intense yellow colour rather than white tuber. Previous research has been carried out to analyse the antioxidant, antimicrobial and antifungal effect of *D. hispida* [4]. However, there are only a few studies on the starches content *in D. hispida* tuber that probably have greatly potential to be used for industries purposes has been reported. Thus, in this study we focused on the analysis of starch on the chemical and physical properties between two different cultivars of *D. hispida* of yellow tuber "gadong pulut" and white tuber "gadong beras". The detailed analysis of starch extract from two different cultivars of *D. hispida* will provide a valuable information to the development of bio based industry.

2. Experimental

2.1 Starch extraction

Two cultivars of *D. hispida* tuber known as 'gadung pulut' or yellow tuber and 'gadung beras' or white tuber were collected from Tanah Merah, Kelantan. A method for starch extraction was modified from Elvis (2014). The fresh tubers were washed, peeled, and pulp diced 1 to 2 cm cubes for easy disintegration during maceration. Pulverized was using a kitchen blender for 2 min at low speed. The pulp was suspended in adequate amount of distilled water before the slurry was filtered through a muslin cloth. The filtrate was allowed to stand for 3 hours for starch to settle and the supernatant was discarded. The sediment or starch was dispersed on aluminium foil and placed on the oven at 55°C until it was completely desiccated before sealed in the plastic bag.

2.2 Colour analysis by colorimeter

Two fresh tuber from cultivars of *D. hispida* were cut in the size of 2 cm ×4 cm ×2 cm. Then, the samples were analysed by using Konica Minolta Chroma Meter CR-400/410. The L*, a* and b* reading is taken and recorded.

2.3 Starch analysis

2.3.1 pH measurement was measured with 1 g of each starch samples was weighed and properly mixed with 3 mL of distilled water. Boiling distilled water was poured into the mixture to make up 20 mL of slurry. The slurry was allowed to cool. Then the pH of the solution was measured by using a pH meter.

2.3.2 Water Binding Capacity (WBC) of starch was determined using the method described by Okunlola & Odeku, (2011) where 0.1 g of starch was dissolved in 1.5 mL of distilled water. The mixture was mixed by using incubator shaker for 1 hour and centrifuged at 3000 rpm for 10 minutes. The supernatant was discarded and the residue was drained and weighed. Percentage of water binding capacity was calculated as in Equation 1:

$$\text{Water Binding Capacity (\%)} = \frac{\text{Bound water}}{\text{Weight of sample (dry basis)}} \times 100 \quad (1)$$

2.3.3 Morphology of starch by Scanning Electron Microscope (SEM) was observed on magnification 1000× by using dried cube tuber of *D. hispida* and coated with gold under vacuum to make the sample conductive to the electron which resulting in the desired image obtained.

2.3.4 Solubility and swelling power of starch were determined by heating 0.03 g dried sample in 3 mL distilled water and immerse in the water bath at 55°C, 65°C, 75°C, 85°C and 95°C for 30 minutes. The samples were cooled until it reached at room temperature and centrifuged at 3000 rpm for 15 minutes [7]. The supernatant was evaporated overnight at 105°C while the precipitated part was weighed. The solubility and swelling power were calculated as follows in Equation 2 and 3:

$$\text{Solubility (\% SOL)} = \frac{\text{Weight of dried supernatant (g)}}{\text{Weight of sample (dry basis)(g)}} \times 100 \quad (2)$$

$$\text{Swelling power (g/g)} = \frac{\text{Weight of wet sendiment (g)}}{\text{Weight of the sample (dry basis)(g)}} \quad (3)$$

3. Results and Discussion

3.1 Differentiating colour a of two cultivars of D. hispida tuber

From the result, it showed that L* of colour between fresh flesh tuber of two types of *D. hispida* was different which is where the yellow *D. hispida* was 76.10 and white *D. hispida* was 77.97. From these lightness reading, the white *D. hispida* was lighter compared to yellow *D. hispida*. The yellowness of colour (b*) indicate the yellow colour of *D. hispida* which was 52.88 and white *D. hispida* was 34.16. These indicate explain that the yellow *D. hispida* was more yellowish than the white *D. hispida*. For the redness of colour (a*), the flesh of fresh tuber yellow *D. hispida* was 1.32 whereas white *D. hispida* was 0.41 where the detected red colour for both cultivars was very low. The differences in a* of both cultivars were too minimal to notice with naked eyes and can only be detected using the colorimeter (Table 1).

Table 1. Colorimeter reading of two cultivars of *D. hispida* tuber

Yellow *D. hispida*	**White *D. hispida***
L*=76.10	L*=77.97
a*=1.32	a*=0.41
b*=52.88	b*=34.16

L*: Lightness, a*=Red-green colour, b*: blue-yellow colour

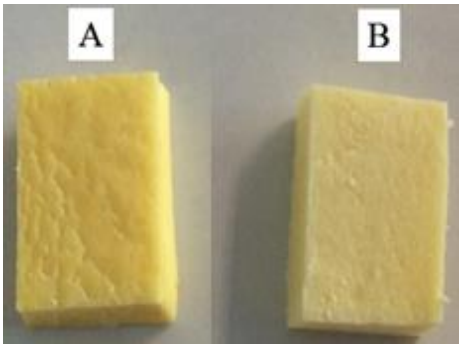

Figure 2. Different colour of two cultivars of *D. hispida* tuber. A) 'gadung pulut' or yellow tuber, B)'gadung beras' or white tuber

It can be concluded that the L*, a* and b* value in Table 1 show that these two cultivar doesn't match in colour (Fig. 2). The value show that the yellow *D. hispida* is light and more yellow. Different from white D. hispida, it also lights in colour but less yellow compared to yellow *D. hispida*. The result is one of the information that can be used in further research which helps to differentiate between this two cultivars [6].

3.2 Analysis of starch in two different cultivars of D. hispida tuber

pH values for both starch samples were in acidic condition with the pH value 4.98 for yellow tuber and 5.45 for white tuber, respectively. The pH values of both cultivars were almost similar to the previously reported by Ashri et al., (2014) approximately 4.48 ± 0.03. In this study, pH value for yellow tuber is lower or more acidic compared to white tuber. The high acidity of starch sample is due to the hydroxyl group of starch that tends to form hydrogen and covalent bonds with starch chains rather than water [9].

The comparison of water binding capacity on starch content for both cultivars of *D. hispida* showed that the yellow tuber was lower than white tuber about 173% and 237% respectively. According to Davies et al., (2015) the value of water binding capacity is depends on the amount of water that starches granules are able to hold and also on capacity of starch molecule to hold water through hydrogen bonding. Moreover, the different value of water binding capacity for both cultivars were indicate that the differences in the intensity of the hydrogen bonds and probably caused by the degree of availability of water binding sites among the starches [7]. Previous studied on water binding capacity of 5 types of *Dioscorea* species tubers namely *D. opposita Thunb., D. alata Linn., D. nipponica Makino, Dioscorea bulbifera Linn.* and *D. septemloba* Thunb., shows that *D. hispida* is in the range of 141% to 557% same like other *Dioscorea* species [11]. The crystalline properties of the starch are the main of factor that contribute to the percentage of water binding capacity. According to Peroni et al., (2006) the most of starch content is damaged during a product milling because too much shear stress is placed on the starch granules. The losing their order and crystallinity is depends on the percentages of starch granules thus

it will be affected the level of water absorbs. In addition, the higher water binding capacity also caused by characteristics of starch composition and other factors [9].

Based on Fig. 3 which is picture taken by SEM on magnification 1000× show the starch granule distribution on all over tuber surface, so it proves that the *D. hispida* tuber is rich with starchy material. Its shows the shape of starch granule of both cultivar, which can be seen full of polygonal shape of starch.

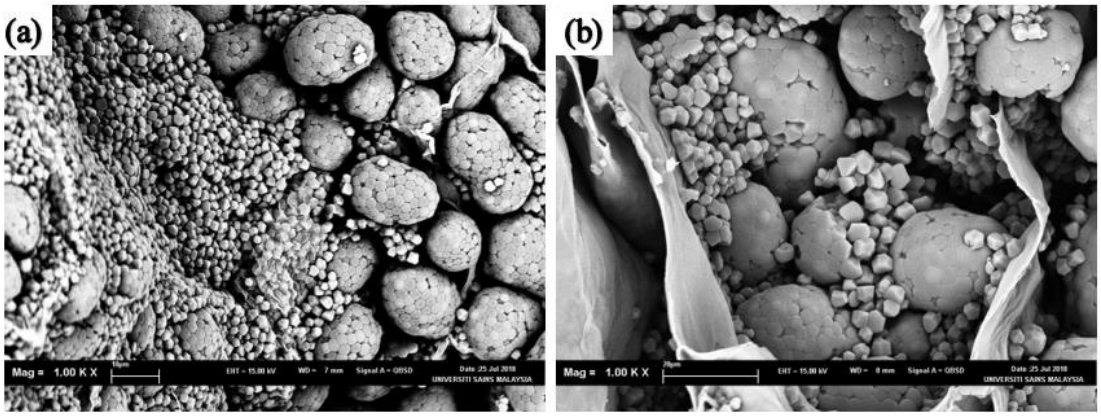

Figure 3. Morphology of two cultivars of *D. hispida* on magnification 1000×; (a) white *D. hispida*; (b) yellow *D. hispida*

The results indicated that starch that extracted from yellow tuber had fairly restricted swelling power ranging from 2.18 g/g to 6.17 g/g compared to starch extracted from white tuber from 2.80 g/g to 13.97 g/g. Starch extracted from yellow tuber also showed lowest solubility from 2.66% to 17.65% when compared with starch extracted from white tuber from 3.48% to 20.47% over a temperature range of 55°C to 95°C.

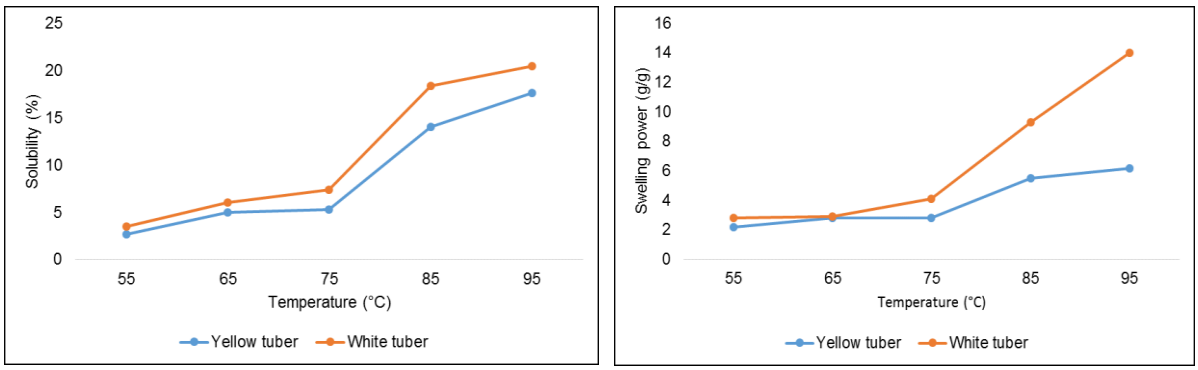

Figure 4. Solubility and swelling of two cultivars of *D. hispida*

From the results obtained, solubility and swelling power in starch extracted from both types of *D. hispida* were directly influenced by the different of temperature. In solubility pattern showed that starches extract from *D. hispida* was treated at a range 55°C to 75°C, which is less soluble. However, starches treated at range 75°C to 95°C were more soluble and faster than below gelatinization temperature. Starch from white tuber is more soluble compared to starch from yellow tuber at low temperature may be due to loss granular structure and also release of amylose fraction of the starch [13]. Which the amylase molecules are leached from swollen starch granules thus it preferentially solubilized [14]. Reported by Lin et al., (2003) at lower temperature also, the cross-linked starch was less soluble than the gelatinization temperature may be due to inhibit solubility and swelling of starch cross-linking.

4. Conclusion

The analysis of starch in two cultivars of ubi gadong (*Dioscorea Hispida Dennst*) namely yellow tuber "gadong pulut" and white tuber "gadong beras" were investigated. It can be concluded that these two cultivar doesn't match in colour. The value show that the yellow *D. hispida* is light and more yellow compared to the white *D. hispida*. In this study, pH value for yellow tuber is lower or more acidic compared to white tuber. Water binding capacity on starch content for both cultivars of *D. hispida* showed that the yellow tuber was lower than white tuber about 173% and 237% respectively. Morphology study of starch in *D. hispida* tuber showed it rich with starchy material with polygonal shape of starch granule. The results of starch for swelling power indicated that yellow tuber had fairly restricted ranging from 2.18 g/g to 6.17 g/g compared to starch from white tuber from 2.80 g/g to 13.97 g/g. Meanwhile the solubility starch for yellow tuber showed lowest from 2.66% to 17.65% compared with starch from white tuber.

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