

BIHON TYPE NOODLES FROM HEAT MOISTURE TREATED STARCH OF FOUR VARIETIES OF SWEET POTATO

[Mi Tipe Bihun dari Pati Heat Moisture Treatment dari Empat Varietas Ubi Jalar]

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ABSTRACT

Sweet potato starch has limited uses in food industry, but modification of its properties may make it more suitable for use especially for starch based food such as bihon type noodle. The objective of this research was to study the effect of heat moisture treated starch from 4 varieties of sweet potato on the quality of its bihon type noodle. Four different varieties of sweet potato i.e. white, yellow, orange and purple tuber were treated with heat moisture treatment (HMT). The HMT was performed by exposing the starch to high temperature (110°C for 3 hours) at a moisture content of 25%. The HMT modified sweet potato starch was then processed into bihon type noodle. As a control, a commercial bihon type noodle made from rice starch was used. Parameters evaluated were the modified starch and bihon properties. The results showed that the modification of starch with HMT could increase the peak viscosity, setback viscosity, final viscosity and gelatinization temperature but lower the value of the breakdown viscosity. The best bihon from the four varieties of sweet potatoes was that made from white sweet potato starch because it has low cooking losses, low fat, but has high color/brightness and is preferred by panelist.

Keywords: bihon, heat moisture treatment, starch, sweet potatoes

ABSTRAK

Keterbatasan pemanfaatan pati alami di dalam industri pangan dapat diatasi dengan cara modifikasi pati sehingga dihasilkan pati dengan karakteristik yang diinginkan terutama pada produk pangan berbahan dasar pati seperti bihun instan. Penelitian ini bertujuan untuk mempelajari pengaruh varietas ubi jalar terhadap karakteristik bihun instan yang dibuat dari pati ubi jalar yang dimodifikasi dengan heat moisture treatment. 4 varietas ubi jalar yang digunakan yaitu ubi jalar berdaging umbi putih, kuning, orange dan ungu. Proses modifikasi pati dengan heat moisture treatment (HMT) dilakukan dengan cara mengatur kadar air pati hingga 25% dan dipanaskan pada suhu 110°C selama 3 jam, kemudian dilakukan karakterisasi fisikokimia dan fungsional pati termodifikasi, dan pembuatan bihun instan serta karakterisasi bihun instan dari pati termodifikasi HMT 4 varietas ubi jalar dengan menggunakan bihun instan komersial sebagai kontrol. Hasil penelitian menunjukkan modifikasi pati ubi jalar dengan HMT akan meningkatkan viskositas puncak, viskositas balik, viskositas akhir dan suhu gelatinisasi, tetapi akan menurunkan nilai viskositas breakdown dari pati pada keempat varietas ubi jalar. Pati ubi jalar dari varietas berdaging umbi putih yang dimodifikasi dengan HMT menghasilkan bihun instan terbaik dengan nilai kehilangan akibat pemasakan dan kadar lemak yang rendah tetapi memiliki warna dan kecerahan yang lebih tinggi serta lebih disukai oleh panelis.

Kata kunci: bihun, heat moisture treatment, pati, ubi jalar

INTRODUCTION

Sweet potato is an important root crop in Indonesia and other developing countries. Asia is the largest sweet potato producing region with 125 million tons of annual production. China accounts for about 90% of worldwide sweet potato production with an annual production of 117 million tons (IPC, 2011). Total production of sweet potato in Indonesia in 2011 was 2.196 tons, of which 191 tons was produced in North Sumatera (Statistics Indonesia of Republic Indonesia, 2012).

Sweet potato are rich in starch (6.9-30.7% on wet basis or 50-80% on dry basis) (Chen *et al.* 2003; Aprianita *et al.* 2009;

Zhu *et al.* 2011). Starch plays a vital role in developing food products either as a raw material or as a food additive such as thickener, stabilizer or texture enhancer (Aina *et al.* 2012). In China, sweet potato roots and its products have been widely used in starch noodles, bakery foods, snack foods, confectionery products, starch syrup production, alcohol production and in the brewing industries (Chen *et al.* 2003), whereas in Indonesia usually are used for household consumption either in boiled, fried or roasted form due to low level of processing and industrial utilization.

Sweet potato starch granules are round polygonal, polygonal, spherical and oval round with size ranging between 2–72 μm (Chen *et al.* 2003; Thao and Noomhorm, 2011; Odeku, 2013). Starch from sweet potato, cassava, potato and arrowroot is more free swelling and non-congealing. It also exhibits a Type A Brabender amylograph. Type A amylograph is characterised by a high pasting peak followed by rapid and

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major thinning on cooling (Collado *et al.* 2001). This characteristics limit its utilization in product that require starches with faster retrogradation rates like starch noodle. Gelatinization temperatures of sweet potato starches are reported in the range of 54°C to 75°C (Chen *et al.* 2003; Kitahara *et al.* 2005; Oladebeye *et al.* 2009).

Modification of starch by physical include heat gelatinization and chemical methods include enzymatic hydrolysis, acid hydrolysis and other various form of chemical modification may make it more suitable for use in traditional products that normally use other type of starches. Physical methods (heat-treatment) were the interest because chemical reagents are not required to impart a modifying effect and therefore, relatively cheaper to produce.

Heat Moisture Treatment (HMT) involves heating starch at temperature above its gelatinization point but with insufficient moisture to cause gelatinization (Haghighyeh and Schoenlechner, 2011). Modification of sago starch by HMT was done at 25% moisture content (Purwani *et al.* 2006) or 20% moisture content and heated at 100, 110 or 120°C of temperature (Pukkahuta and Varavinit, 2007). Modification of sweet potato starch by HMT decreased swelling and solubility of red sorghum starch but increased water absorption capacity and pasting temperature of the starch (Adebowale *et al.* 2005). HMT will also change the pasta profile of starch from Type A to Type C (Tsakama *et al.* 2011) or from Type A to Type B (Purwani *et al.* 2006) of Brabender Amylograph. The use of this process has the potential of giving starch desired physical properties for application in the manufacture of various starch based products, especially in acid food and retorted foods (Takashi *et al.* 2005), including the bion type noodles (Collado *et al.* 2001).

Bihon is made from gluten free starch and usually made from mung bean or rice starch. It is favorably consumed as a main dish or snack by people in Indonesia and other South East Asia countries. Starch noodles are a source of resistant starch (RS) since they are retrograded. Resistant starch has been defined formally as the fraction of dietary starch that is not digested in the small intestine of healthy individuals (Koksel *et al.* 2008; Lee and Shin, 2006; Sajilata *et al.* 2006).

Heat moisture treatment consists of autoclaving-cooling and cross-linking can be applied to obtain resistant starches and improve the yield of resistant starches (Abdoulaye *et al.* 2012; Aparicio-Saguilan *et al.* 2005; Onyango *et al.* 2006). The bion dough is made from 5% pregelatinized starch (acting as the gluten in wheat flour dough) mixed with 95% of the remaining (native) starch and water to a dough. The starch itself plays an essential role in both starch noodle processing and the final starch noodle quality (Collado *et al.* 2001). The objective of this research was to study the effect of sweet potato variety on quality of bion type noodle made from heat moisture treatment (HMT) starch.

MATERIALS AND METHODS

Materials

Sweet potato from four typical varieties of sweet potato, each is difference in tuber color i.e. white, yellow, orange and purple

tuber obtained from local market in Medan. The chemicals used for starch and modified starch analysis.

Isolation of starch

Starches were isolated according to Collado and Corke (1999) method with a little modification. Each kind of sweet potato tuber was washed thoroughly, macerated using mechanized grater, diluted 1:2 w/v with tap water and filtered through cheesecloth. Starch in the filtrate was allowed to settle for 12 h at room temperature (27-30°C). The supernatant was decanted and discarded while the starch was resuspended in water and kept at room temperature for 6 h to settle. The starch sediment was dried in a convection oven at 50°C overnight, cooled to room temperature, and equilibrated for 4 hours before samples were packed and sealed in polyethylene.

Characterization of physicochemical properties of starch

Native and HMT starch was analyzed for moisture (AACC, 1995), degree of acidity (BSN, 1989; SNI: 06-1451), color/whiteness by using *Whiteness Meter* (Kett Electric Laboratory C-100-3), size and shape of starch granule by using polarized light microscope (Olympus Optical Co.Ltd, Japan). Water and oil absorption index were determined according to the method of Adebowale and Lawal (2004). Starch samples (1 g) were suspended in 5 ml water (for water absorption index) or vegetable oil (for oil absorption index) in a centrifuge tube. The slurry was shaken on a platform tube rocker for 1 min at room temperature and centrifuged at 3000 rpm for 10 minutes. The supernatant was poured carefully into a tared evaporating dish. Water or oil absorption index was calculated as g water or vegetable oil absorbed by 1 g dry sample. Paste clarity was determined according to Ceballos *et al.* (2007), by boiling 1% aqueous solution of starch at 93°C with repeated shaking for 30 min. The solution was cooled and then transferred into a cuvette and transmittance was measured at 650 nm using a spectrophotometer.

Solubility of starch was determined as follows: Starch (0.5000 g) was mixed with 15 ml distilled water in a centrifuge tube and heated in an 85°C water bath for 15 minutes. The sample was then centrifuged for 15 minutes at 2200 rpm. The aliquot was transferred to a pre-weighed beaker and dried at 100°C. Solubility was calculated according to Muazu *et al.* 2011.

Properties of starch pasting

Pasting properties of starch were measured by a Rapid Visco Analyzer (RVA, Model Tecmaster Newport Scientific, Australia). A suspension of 3 g (14% w.b.) starch in 25 g of distilled water underwent a controlled heating-and-cooling cycle under constant shear where it was held at 50°C for 1 minutes, heated from 50 to 95°C at 6°C/minute, held at 95°C for 5 minutes. The following data were recorded: pasting parameters of time from onset of pasting to peak viscosity (P_{time}); temperature at which peak viscosity was reached (P_{temp}); peak viscosity (PV); viscosity at the end of hold time at 95°C or hot paste viscosity (HPV); breakdown, PV less than HPV; viscosity at the end of the hold time at 50°C or cold paste viscosity (CPV); and setback ratio (CPV/HPV).

Heat moisture treatment

The starch from 4 varieties of sweet potato were modified by heat moisture treatment according to Collado *et al.* (2001) with a little modification. The moisture of sweet potato starch was adjusted to 25% by adding the distilled water, and equilibrated at 6°C for 12 hours (refrigerated condition) and placed in a covered baking pan for 3 hours at 110°C. The sample was shaken occasionally for even distribution of heat. The sample was cooled to room temperature (about 30°C) and dried at 50°C for 4 hours, and sealed in polyethylene bags until use.

Preparation of bihon type-starch noodles

Bihon-type starch noodles were made from HMT starch from 4 varieties of sweet potato. The starch dough was prepared by partial gelatinization of 20% (w/w) rice flour of the total HMT starch to be used which serves as binder. Gelatinization was done by boiling rice flour and water (1:3 w/v), added 1% Sodium tripolyphosphate and 1% solution containing K₂CO₃, Na₂CO₃ and KH₂PO₄ for 5 minutes. Gelatinized starch was then mixed with 80% ungelatinized HMT starch and 0.5% Carboxyl Methyl Cellulose (CMC). The dough was kneaded manually for 20 minutes or until a uniform consistency was achieved. The starch dough was extruded using Hand Noodle Maker and steamed at 90°C for 3 minutes, dried at 60°C for 1 hour in a convection drier, cooled to room temperature, and sealed in polyethylene bags until used for analysis and sensory evaluation.

Noodles characteristics

Chemical characteristics of the noodles such as proximate analysis (protein content by Micro Kjeldhal, lipid content by Soxhlet Method using hexan as solvent, moisture and ash content and crude fibre (AOAC, 1995). Physical characteristics of the noodles such as texture (elongation) were measured using a Rheometer (RE-3305), color ((Chromameter Minolta Tipe CR-300, Japan), cooking loss and water uptake.

Cooking loss and water uptake of the noodles were determined as described in the AACC (2000) method. 10g of the noodles were added to a beaker containing about 200ml boiling water. The beaker was covered with a watch glass and noodles cooked until optimum cooking was reached. The cooked noodles were allowed to drain and rinsed with water, then drained again for 3 minutes and then weighed (A), dried in the oven at 100°C of temperature until the constant weight was reached, then weighed again (B). The cooking loss and water uptake were then calculated as given below:

$$\text{Cooking loss(\%)} = 1 - \frac{\text{Constant weight after drying}}{\text{sample weight (1-moisture fraction of noodle)}} \times 100\%$$

$$\text{Water uptake(\%)} = \frac{(A-B) - (\text{sample moisture} \times \text{sample weight})}{\text{sample weight (1-sample moisture)}} \times 100\%$$

Sensory evaluation of noodles were done for aroma, taste and texture. Plain bihon type-noodles were boiled and cooked at optimum condition, and presented to 15 semi trained panelists

of student at Department of Food Science And Technology University of Sumatera Utara. Panelist preferences were rated in 5-point scales; 1 was extremely disliked and 5 for extremely liked.

Statistical analysis

Mean data of all parameters evaluated were subjected to an analysis of variance (ANOVA). When significant differences were found, the means were tested by Duncane Multiple Range Test (DMRT). All treatment were done in five replicates.

RESULTS AND DISCUSSION

Physicochemicals properties of starch

The physicochemical characteristics of sweet potato starches were presented in Table 1. The moisture content of sweet potato starches both native and HMT starch showed high variation. The low moisture content of native starch from yellow tuber sweet potato (7.32%) and modified starch of orange tuber sweet potato (8.50%) was an evidence of good drying regime. The moisture content of sweet potato starch was dependant on the process used for drying (Ali *et al.* 2012). HMT process gave the significant effect (P<0.05) on degree of acidity of starch. HMT starch had a lower degree of acidity for 4 varieties of sweet potato compared to native starch. The lower value of degree of acidity caused by the addition water during the HMT, but it inversely proportional to the solubility of (Adebowale *et al.* 2005).

In order to study the relationship of the color of bihon type noodle with HMT starch, the color and paste clarity of native and HMT starch were determined. There was a significant effect (P<0.05) on the whiteness of modified starch, but there was no difference in whiteness of the native starch (Table 1). Whiteness value of HMT starch in white and purple tuber sweet potato was lower than native starch, but in yellow and orange tuber the whiteness of HMT starch was higher than their native starches. A high value of whiteness is desired for starches.

The size of native starch granules varied from 3-13 µm, and the shape was oval, round, spherical, polygonal, and round polygonal. The yellow tuber sweet potato has smaller granules than the others as shown in Figure 1a, 1b, 1c, and 1d. After modification, starch granules swelled and tended to appear as fused and less smooth than the native granules, but in general HMT does not change the size and shape of granule as shown in Figure 1e, 1f, 1g, and 1h. Similar results were also obtained by Singh *et al.* (2005), Matos *et al.* (2009), Adebowale and Lawal (2003) and Pukkahuta *et al.* (2008). The particle size of starch is one of the important characteristics, which may influence other physicochemical properties such as paste clarity and water absorption index (Singh *et al.* 2005). With these factors in mind the use of sweet potato starch may be applicable for food industry, especially products require starch that offers a smaller particle size. The previous study has indicated that the fine granules of taro starch improved binding and reduce breakage of a snack product (Huang *et al.* 2006).

Table 1. Effect of HMT on the physicochemical characteristics of starch from four varieties of sweet potato

Parameters	Starch	Variety of Sweet Potato			
		White Tuber	Yellow Tuber	Orange Tuber	Purple Tuber
Moisture content (%)	Native	15.54	7.32	11.53	10.29
	Modified	11.24	11.78	8.50	11.32
Degree of acidity	Native	2.28±0.06 ^a	2.41±0.12 ^a	2.22±0.07 ^a	2.18±0.19 ^a
	Modified	2.07±0.18 ^b	2.04±0.22 ^b	1.95±0.02 ^b	1.83±0.01 ^b
Whiteness (%)	Native	87.79±0.59 ^a	83.35±0.20 ^a	74.45±0.13 ^a	69.98±0.28 ^a
	Modified	85.73±1.36 ^b	83.67±0.26 ^b	75.58±0.18 ^a	68.68±1.49 ^b
Granule shape	Native	Round, oval, spherical, polygonal round polygonal	Round, oval, spherical, polygonal round polygonal	Round, oval, spherical, polygonal round polygonal	Round, oval, spherical, polygonal round polygonal
	Modified	Round, oval, spherical, polygonal round polygonal	Round, oval, spherical, polygonal round polygonal	Round, oval, spherical, polygonal round polygonal	Round, oval, spherical, polygonal round polygonal
Granule size (µm)	Native	4-13	3-8	3-7	3-10
	Modified	3-12	3-9	3-9	3-11
Water absorption index (g/g)	Native	0.98*	0.98*	NR	0.81*
	Modified	2.24±0.07 ^a	2.32±0.33 ^a	2.28±0.07 ^a	2.32±0.03 ^a
Oil absorption index (g/g)	Native	1.15*	0.95*	NR	1.04*
	Modified	2.25±0.17 ^a 2.30±0.07 ^{ab,AB} 2.14±0.11 ^{b,AB} 2.40±0.04 ^{a,A}	2.30±0.07 ^a	2.14±0.11 ^a	2.40±0.04 ^a
Pasta clarity (%T)	Native	89.28*	87.54*	NR	86.14*
	Modified	87.04±0.11 ^a	84.04±0.11 ^b	77.08±0.13 ^c	75.06±0.15 ^d
Solubility in cold water (%)	Native	NR	NR	NR	NR
	Modified	12.47±0.21 ^a	11.95±0.27 ^a	12.03±0.74 ^a	12.56±0.21 ^a

Means in a row for each variety with the same letters between native and modified starch were not significantly different at $p < 0.05$. All the values were the mean of 5 measurements. NR = Not Reported

* Data were taken from Julianti and Ridwansyah (2008)

The water and oil absorption index were higher in the HMT starches than in the native starch. The increasing of water absorption of HMT starch implies that hydrophilic tendency increased with increasing level of moisture treatment (Adebowale *et al.* 2005). The major component affecting oil absorption capacity is protein, which is composed of both hydrophylic and hydrophobic interactions with hydrocarbon chains of lipid (Eltayeb *et al.* 2011). Therefore the increasing of oil absorption capacity in HMT starch could be due to lipophilic nature on the granule surface and interior during HMT which were influenced for functional properties of starches (Babu and Parimalavalli, 2012).

The paste clarity of modified starches were lower than their native starches. The same result was obtained by Singh *et al.* (2005) and Adebowale *et al.* (2005). The highest paste clarity was found in HMT starch of white tuber sweet potato. There was a correlation found between the clarity of HMT starch pastes and the whiteness of their starches (0.969, $P < 0.05$). The starch paste clarity can be influenced by the interaction of several factors such as botanical source, particle size of granules, total solids concentration, degree of granule dispersion, and the capacity of granules to form aggregates (Amani *et al.* 2005) which have not been examined in this study. However the results indicated that the sweet potato starch may offer high enough paste clarity for use in food products.

Solubility in cold water of HMT starches of sweet potato are given in Table 1. The results indicate that the solubility in cold water of HMT starch from 4 varieties of sweet potato were not significantly different. The interaction between starch chains

within both the amorphous and crystalline domains is responsible for the solubility of starch (Zhang *et al.* 2005). HMT will increase the starch solubility by an increase in the low molecular weight linear fraction with hydroxyl groups that facilitated sulubilization in hot water (Güzel and Sayar, 2010; Campechano-Carrera *et al.* 2007).

Pasting properties

As shown in Table 2, after heat-moisture treatment, there was a marked increase in the peak viscosity (except in starch from white tuber sweet potato), a low decrease on breakdown viscosity and an increase of setback and final viscosity. The low breakdown and the high viscosity is a desirable property of starch because its paste has a noncohesive texture suitable for many food and industrial application (Singh *et al.* 2005).

The tendency of starch retrogradation can be predicted by using setback viscosity value. Table 2 shown that HMT increased setback viscosity values, indicating that the starch is easier to retrograde (Mali *et al.* 2003; Peroni *et al.* 2006). The higher peak viscosity of the starch was attributed to the high phosphorous and lower amylose content, which caused the higher swelling (Zaidul *et al.* 2007). The high viscosity of sweet potato starches would make them very useful in food application where high thickening power is desired as well as the small particle size being useful for noodle or bread production (Aprianita *et al.* 2009).

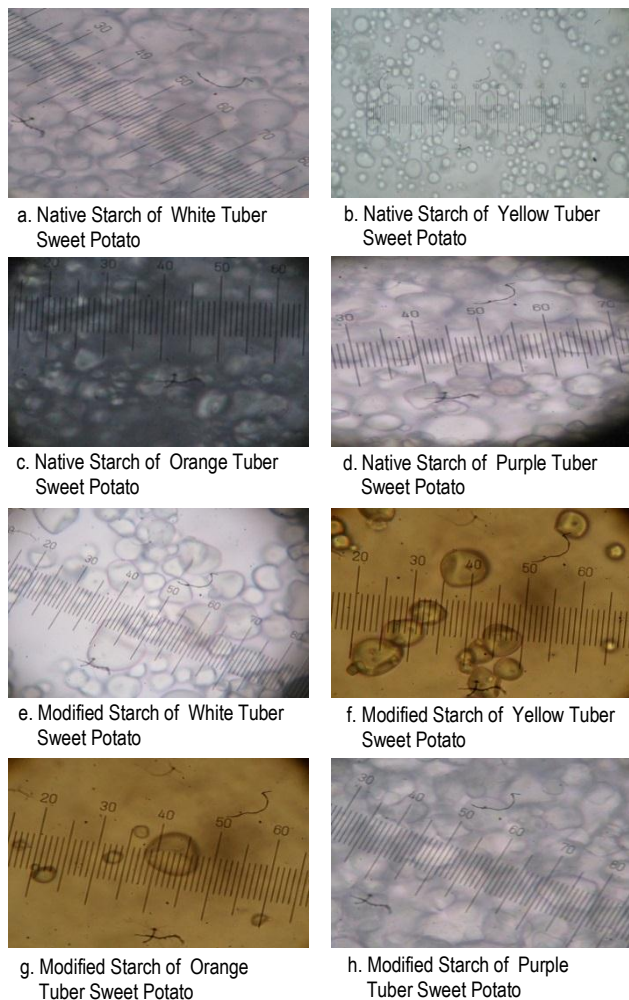


Figure 1. Light microscopy of starch granules from native and HMT process of 4 sweet potato varieties

Table 2. Effect of HMT on pasting properties of starch

Pasting Properties	Starch	Variety of Sweet Potato			
		White tuber	Yellow tuber	Orange Tuber	Purple Tuber
Peak Viscosity (cP)	Native	7810.40 ^a	7297.80 ^a	7574.00 ^a	6459.60 ^a
	Modified	4924.20 ^b	7325.80 ^a	7704.00 ^a	7613.60 ^a
Breakdown Viscosity (cP)	Native	4950.40 ^a	5247.60 ^a	3940.00 ^a	4201.40 ^a
	Modified	1342.20 ^b	4504.40 ^b	3039.80 ^b	3904.80 ^b
Setback Viscosity (cP)	Native	1272.20 ^a	1158.40 ^a	1625.20 ^a	1203.60 ^a
	Modified	1554.60 ^a	1363.40 ^a	1926.20 ^a	1257.80 ^a
Cold Paste Viscosity (cP)	Native	4132.60 ^a	3208.60 ^b	5259.20 ^b	3461.80 ^b
	Modified	5136.60 ^b	4184.80 ^a	6590.40 ^a	4966.60 ^a
Gelatinization Temp.(°C)	Native	72.47 ^a	70.05 ^a	70.85 ^a	69.84 ^a
	Modified	75.71 ^a	71.01 ^a	71.99 ^a	70.83 ^a

Means in a row for each variety with the same letters between native and modified starch were not significantly different at $p < 0.05$. All the values were the mean of 5 measurements

There is a difference results obtained in this study from the previous studies. The peak viscosity of HMT starches in this study was higher than in a native one except in HMT starch of

white tuber sweet potato, while in the previous study HMT will decrease the peak viscosity of starch and an increase in cold paste viscosity (Singh *et al.* 2005; Tsakama, 2011; Pukkahuta and Varavinit, 2007). This is probably due to the amount of water added to the process of modification was not sufficient to cause pregelatinized. HMT starch characteristics were influenced by the differences of process condition such as temperature (Adebowale and Lawal, 2003; Vermeylen *et al.* 2006; Pukkahuta and Varavinit, 2007), moisture content (Adebowale *et al.* 2005) and processing time (Collado and Corke, 1999).

Bihon-type noodles evaluation

Cooking and textural qualities are two main attributes of bihon type noodles. The characteristics of bihon-type noodles of HMT starch from 4 varieties of sweet potato shown in Table 3. There was no significant difference between HMT starch from 4 varieties of sweet potato on ash, lipid, protein content and water uptake, but there was a significant difference ($P < 0.05$) on crude fibre content, cooking loss, texture and color of bihon-type noodle as shown in Table 3. The lowest cooking loss found in bihon type noodle made from HMT starch of white tuber sweet potato, but the highest elongation found in bihon type noodle made from HMT starch of purple tuber. There is a correlation between peak viscosity of HMT starch and cooking loss of bihon-type noodle ($r = 0.943$, $p < 0.05$). This indicated that cooking loss of bihon-type noodles will be increased as increasing of peak viscosity.

Table 3. Physicochemical properties of bihon-type noodles of HMT starch from 4 varieties of sweet potato

Parameter of Bihon Quality	HMT Starch of White Tuber Sweet Potato	HMT Starch of Yellow Tuber Sweet Potato	HMT Starch of Orange Tuber Sweet Potato	HMT Starch of Purple Tuber Sweet Potato
Mositure (%db)	11.29	8.22	6.25	11.12
Ash (%db)	1.32±0.01 ^a	1.33±0.01 ^a	1.33±0.01 ^a	1.34±0.01 ^a
Lipid (%db)	1.40±0.10 ^a	1.42±0.03 ^a	1.36±0.01 ^a	1.46±0.02 ^a
Protein (%db)	1.68±0.02 ^a	1.73±0.07 ^a	1.69±0.02 ^a	1.75±0.03 ^a
Crude Fiber (% db)	0.56±0.03 ^d	0.77±0.01 ^c	1.03±0.05 ^b	1.73±0.13 ^a
Water Uptake (%)	97.91±0.49 ^a	98.20±0.42 ^a	96.92±2.91 ^a	98.41±0.66 ^a
Cooking Loss (%)	20.63±0.38 ^d	31.24±0.77 ^c	36.58±0.36 ^a	30.84±1.33 ^b
Texture (Elongation,%E)	27.20±2.29 ^b	24.74±2.57 ^c	17.45±1.75 ^d	34.90±0.73 ^a
Color (L value)	37.06±0.45 ^a	35.04±0.59 ^b	30.66±0.30 ^c	22.78±0.27 ^d

Samples means for each parameter quality followed by the same letter are not significantly different at $P < 0.05$ (DMRT Test). Each value is a mean of 5 replicates and \pm standard deviation

The L value (lightness) is the attribute that play important roles in the appearance of bihon type noodles. The L value of bihon-type noodles at various varieties of sweet potato was significant difference (Table 3). It was found that the whiteness of HMT starch had a high significant correlation with the L value ($r = 0.992$, $p < 0.01$) of bihon type noodles. There is also a

negative correlation between ash content and L value of bihon type noodles ($r = -0.921$, $p < 0.01$). This indicated that bihon-type noodle with high ash content had low in lightness (L value), because ash expressed the fine fibers or pigments remaining in starch after isolation which could be browned after drying. The transparent noodles were perceived as high quality product by consumers (Tan *et al.* 2009), therefore bihon-type noodle made from HMT starch of white tuber sweet potato was found to suitable for producing good quality of noodles.

Sensory evaluation of bihon-type noodles

Sensory properties of bihon-type noodle of HMT starch from 4 varieties of sweet potato shown in Table 4. There was no significant difference on texture and taste from each other. There is a correlation between elongation and the panelist preference of texture ($r = 0.81$, $p < 0.05$). This indicated that panelists preferred the bihon type noodles with more extensibility. The bihon made from HMT starch of yellow tuber sweet potato had a highest score for color than other varieties. Most panelist were not familiar with the color of bihon from HMT starches of sweet potato, and it makes they do not like its color.

Table 4. Sensory Evaluation of bihon-type noodles of HMT starch from 4 varieties of sweet potato

	HMT Starch of White Tuber Sweet Potato	HMT Starch of Yellow Tuber Sweet Potato	HMT Starch of Orange Tuber Sweet Potato	HMT Starch of Purple Tuber Sweet Potato
Taste	3.08±0.17 ^a	3.13±0.15 ^a	2.88±0.17 ^a	3.07±0.21 ^a
Color	3.00±0.19 ^b	3.13±0.19 ^a	3.07±0.08 ^a	2.89±0.07 ^b
Texture	3.10±0.11 ^a	3.08±0.07 ^a	2.96±0.10 ^a	3.09±0.17 ^a

Samples means for each sensory attribute followed by the same letter are not significantly different at $P < 0.05$ (DMRT Test). Each value is a mean of 5 replicates and \pm standard deviation

CONCLUSION

Modified starch with HMT on four varieties of sweet potato starch can increase peak viscosity except in white tuber of sweet potato starch, setback viscosity, final viscosity, and temperature of gelatinization of starch but lowers the value of the viscosity breakdown. The decline in the value of viscosity breakdown in the modified starch showed that starch granules become stronger and resistant to pressure and heat. High viscosity with a low breakdown is expected properties of starch as its pastes had a non-cohesive texture and making it suitable for most food products and industrial applications. The best varieties of sweet potato for making Bihon-type noodles was white tuber sweet potato which modified by heat moisture treatment, because it has the lower cooking loss and higher color/brightness and preferred by consumer.

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