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EFFECT OF HEAT MOISTURE TREATMENT OF SAGO STARCH ON ITS NOODLE QUALITY

E.Y. Purwani[a], Widaningrum[a], R. Thahir[a], and Muslich[b]

[a]*Indonesian Center for Agricultural Postharvest Research and Development, Jalan Tentara Pelajar No.12 Bogor 16114, West Java, Indonesia*

[b]*Department of Agricultural Industrial Technology, Bogor Agricultural University, Darmaga Bogor 16680, West Java, Indonesia*

ABSTRACT

Sago starch has potential as source of flour for noodle. However, noodle made of sago starch has only been limitedly utilized due to the absence of gluten and lack of desired functional properties. Heat moisture treatment (HMT) is a promising technique for improving quality of sago noodle. The objectives of the present work were to study the effect of HMT of sago starch on its noodle quality. Four different origins of sago starch, i.e. Tuni, Ihur, Molat, and Pancasan, were treated with HMT method. HMT was performed by exposing the starch to high temperature (110°C for 16 hours) at moisture content of 25%. Sago starch was then processed into noodle. It was prepared by mixing the sago starch with binder (completely gelatinized starch and additive) into dough. The dough was pressed manually through a container with holes in the base. Noodles strains were steamed for 2 minutes and dried at 50°C in a convection drier. As the control, non-HMT sago starch was used and evaluated. Parameters evaluated were starch properties, physical strength, and cooking and sensory quality of the noodles. Analyses of variance was subjected to all parameters. Research results showed that the starch exposed to HMT changed its pasting profile from initial type A before treated to type B after treated. The noodle quality was also improved. Noodles resulted from starch treated with HMT showed higher firmness and elasticity, but they have lower stickiness compared to those of non-HMT. Less cooking loss and rehydration weight were also found, however, HMT increased cooking time of the noodles. HMT on Pancasan sago starch resulted in noodles which were preferred most by panelists. However, consumer testing is recommended to further validate consumers' preferences to the sago starch noodles. The study indicated that sago starch could be potentially used as raw material for noodle to increase the consumption of sago-based food.

[*Keywords*: *Sago starch, noodle, heat moisture treatment*]

INTRODUCTION

Sago palm (*Metroxylon* sp.) is one of the important sources of starch. The plants are mostly found in Papua New Guinea (Sepik and Gulf Province), Indonesia (Papua, Maluku, Sulawesi, Riau Island, and Mentawai Island), Malaysia (Sabah, Serawak and West Malaysia), Thailand (South Thailand), and the Philippines (Mindanao). The world estimated area of sago palm was 2.25 million ha of wild stands and 0.2 million ha of semicultivated (Flach 1997). Indonesia has the largest sago palm area followed by Papua New Guinea, Malaysia, and the Philippines. Sago produces higher starch compared to other crops; it yields around 2-3 tons starch per ha per year, compared to cassava which is 2 tons and maize 1 ton (Stantan 1992).

Sago starch has been the staple food for many people in eastern areas of Indonesia, especially Papua. They have various traditional food such as *papeda* (sago pudding), *colo-colo* (a hot sour soup and tuna fish), and *sagu ega* (sago paste wrapped with sago leaves). In recent years, sago consumption in Papua decreased; in 1994 sago consumption was 126 kg per capita, but in 1997 it was only 95.53 kg per capita (Hutapea *et al.* 2003). This may be due to the psychological barrier associated with sago as poor and primitive food.

One prospective use of sago is noodle, a popular product for Indonesian people. Currently, most noodles are made from imported wheat flour. In 2002, Indonesia imported wheat flour about 400,000 tons (Departemen Perindustrian dan Perdagangan 2003); 29.7% of it was processed to noodles (wet noodles and instant noodles). Interestingly, noodles made of sago starch are commercially found in West Java, especially in Bogor, Sukabumi, and Cianjur. Starch noodles are obviously different from other types of noodles, such as pasta and wheat flour, since it is made from gluten-free starch. Thus, starch itself plays an essential role in both starch noodle processing and the final starch noodle quality. Excellent starch noodles would have clear or transparent and fine threads, high tensile strength, and low cooking loss even with prolonged cooking (Collado *et al.* 2001).

Studies on the use of different starch for noodles conducted by Lii and Chang (1981) and Galvez *et al.*

(1994) using starch from legume, and Collado and Corke (1997) and Collado *et al*. (2001) using sweet potato starch, revealed that in the absence of gluten in the starch, pregelatinized starch must be used as binder then mixed with ungelatinized starch to facilitate extrusion in producing qualified noodle. It was found that a qualified noodle depend on its brabender amylogram/visco amylogram pasting profile which is characterized by constant or even increase in its viscosity during continuous heating and shearing process. To produce such good hot-paste stability, starch can be treated with heat moisture treatment (HMT). In principle, the HMT involved exposing of the starch to higher temperatures (normally above the gelatinization temperature) at very restricted moisture content (< 35%) (Collado *et al*. 2001). HMT is considered to be more natural and safe compared to chemical treatment.

HMT is potential to improve sago starch for noodle since sago starch lacks of stability during heating process. Ahmad *et al*. (1999) observed two types of pasting properties on sago starch. Some samples were characterised by a maximum consistency immediately followed by sharp decrease in consistency, while the others were characterized by a plateu when the maximum consistency was reached. The present work aimed to study the effect of HMT of sago starch from different origins of sago palms on its noodle quality.

MATERIALS AND METHODS

Sago Starch Samples

Sago starch of four origins used in the study were Tuni, Molat, Ihur which were widely distributed at Maluku, and one from Pancasan, Bogor West Java. According to Haska (1995), Tuni, Molat, and Ihur belong to *Metroxylon rumphi*, *M. sagu* and *M. sylvestre*, respectively, whereas Pancasan sago palm was identified as *M. sagu* (Haryanto and Pangloli 1992). Tuni and Ihur are categorized as spiny palms, while Molat and Pancasan are spineless palms. All the sago starch was sun dried and sieved using 100 mesh before being processed to noodles.

Heat Moisture Treatment

One hundred gram of sago starch was weighed and placed in an uncovered glass petri dish. Lid of the petri dish was put on then the starch was equilibrated at 4°C overnight. Moisture content of the starch was adjusted to 25% by mixing thoroughly with approximately 14.77 g of distilled water, then the dish was ovened at 110°C for 16 hours. The starch was occasionally shaken by using a mixer glass to get even distribution of heat. After treatment (HMT), the starch was dried at 50°C overnight and then processed to noodle.

Noodle Preparation

Twenty grams of the non-HMT or HMT treated sago starch was pregelatinized in distilled water (1:7 w/v) to serve as binder and then mixed with the remaining (180 g) of the starch. The mixture was kneaded into uniform dough then it was manually extruded in a self-made lab-scale cylindrical extruder (200 g capacity). Noodle strains were steamed for 2 minutes, dried at 50°C in a convection drier, cooled into room temperature, and finally sealed in a plastic bag until used for analysis and sensory evaluation.

Analytical Method

Analyses were subjected to both non-HMT and HMT sago starch, including starch characteristics and noodle evaluation as described below.

Starch Characteristics

Chemical compositions of the starch before HMT were analysed. Amylose content was determined using iodine colorimetry at 620 nm (Yuliano 1979), whereas moisture, ash, crude fiber, and fat were analysed according to the AOAC (2000). Crude protein was determined by using Micro Kjeldahl method with a conversion factor of 6.25.

Pasting characteristics of the starch were examined in a Brabender Amylograph using 75 rpm and torque of 700 cm.g equivalents to 1000 BU. The starch slurry (40 g in 360 ml water) was heated with a heating rate of 1.5°C from 30°C to 93°C, held at 93°C for 20 minutes, cooled to 50°C at the same rate, and finally held at 50°C for 20 minutes. Measurements assessed were gelatinization temperature (°C), peak temperature (°C), peak viscosity (BU), viscosity at 90°C and after being held at 90°C for 20 minutes (90/20), viscosity at 50°C and after being held at 50°C for 20 minutes (50/20).

Noodle Evaluation

Physical characteristics of the noodles such as firmness, stickiness, and elasticity were measured using a Texture Analyzer TA-XT2 conducted at the Food Technology Laboratory of Bogor Agricultural University. The noodles were first rehydrated as follows:

noodles (10 cm long) were cooked in 100 ml boiling water for 9 minutes, taken out and drained. Two strains of the rehydrated noodles (10 cm long) were placed in a test cell and subjected to deformation by compression with a cylindrical probe (35 mm) speed of 1 mm per second using a single cycle. The maximum force to compress the noodle (gf) was noted as firmness. The stickiness is expressed as gfs, i.e. force (gf) times s (period) in second required for the noodles to return to original position. Elasticity (gf) that is maximum force to break noodles by extention was determined by attaching a noodle strain on a sample holder.

Cooking time of the noodles was measured as follows: noodles (5 g) were cut into 2-3 cm long then cooked in 200 ml boiling distilled water in a covered beaker. Every 30 second, a noodle strain was removed and pressed between two pieces of watch glass. Optimum cooking time was achieved when the center of the noodles was fully hydrated.

Cooking loss was measured by evaporating the cooking water to dryness. The noodles were rinsed with fresh distilled water, placed in a preweighed glass beaker, dried in an oven at 110°C for 10 hours and weighed. Percentage of weight differences before and after cooking was calculated as cooking loss.

Rehydration weight was assessed by cooking 3 g of noodles in 40 ml boiling water for 9 minutes, placed it in a strainer and allowed to drain and weighed. Rehydration weight was presented as percentage of initial weight.

Color was determined with a chromameter CR-300 (Minolta, Japan). Noodle strains were spreaded on a white paper. Lightness (L), color hue (a*), and saturation (b*) values were recorded. A provided white standard tile ($L^* = 100$, $a^* = 0$, $b^* = 0$) was used to calibrate the chromameter.

Organoleptic Quality

Plain noodles were boiled and cooked at optimum condition, and presented to 25 panelists of the Indonesian Center for Postharvest Agricultural Research and Development for evaluation. Panelist preferences were rated in 9-point scales; 1 was extremely rejected, 9 was 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 least square differences. Pearson correlation coefficients were calculated on physical characteristics and cooking quality mean. All analyses were done using SPSS 10 (Santosa 2001).

RESULTS AND DISCUSSION

Starch Characteristics

Sago starch used in this study had distinctive colors. The starch of Molat, Tuni, and Pancasan origin were white in color, while Ihur was red (Fig. 1). The sago starch color is greatly affected by genetic factors and starch extraction conditions. No further information was available on the genetic and extraction conditions of the starch used in this study since the starch was obtained from local starch producers. However, it was reported that heavy metal ions in the processing water promote the oxidation of polyphenols that dye the starch irreversibly (Flach 1997). Red color of Ihur might be contributed to phenolic compound.

The chemical compositions of the starch showed that in general there was no distinctive difference amongst characters evaluated (Table 1). The moisture content of sago starch ranged from 14% to 17%, which is typical for commercial starch. The ash content of all sago starch was low (0.18-0.27%) and the crude protein and fat contents were also low i.e. 0.25-0.48% and 0.03-0.12% respectively. The amylose content, however, which ranged from 37.24% to 42.13%, was higher than that reported by Ahmad *et*

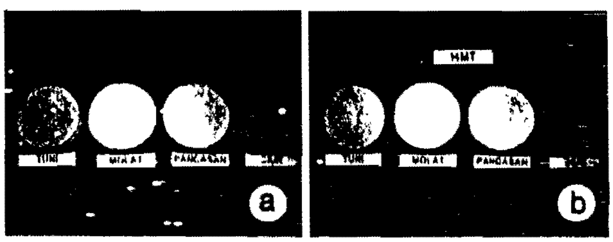

Fig. 1. Sago starch from four different kind of origin: (a) non-heat moisture treatment (HMT), (b) HMT.

Table 1. Chemical compositions of four different origins of sago starch used in this study.

Component	Sago starch origin			
	Tuni	Molat	Ihur	Pancasan
Moisture (%)	16.90	17.03	17.03	14.01
Ash (%)	0.27	0.22	0.26	0.18
Protein (%)	0.30	0.48	0.25	0.37
Fat (%)	0.06	0.03	0.12	0.09
Carbohydrate (%)	82.55	82.37	82.27	85.29
Crude fiber (%)	0.87	0.63	0.70	0.62
Amylose (% db)	40.70	42.13	37.24	39.71

al. (1999) which found around 24-30%. This difference may be due to genotype factor, environment, starch processing, and analysis method.

Data of the brabender amylogram curve (Table 2) showed that the pasting profiles of the four sago starch were classified as type A of the Schoch and Maywald (1968) *in* Chen (2003). Type B also has a high pasting peak, but much less thinning during cooking. Type C has no pasting peak but rather a very high viscosity which remains constant or increases during cooking, whereas for type D, the amount of starch must be increased two or three fold to give a significant hot-paste viscosity of type C. The present study was in agreement with that reported by Ahmad *et al.* (1999) who found no significant variation amongst properties evaluated.

The starches exposed to HMT changed their pasting profiles from initial type A before treated to become type B after treated. This changing was probably due to alteration of their internal granule as found by Stute (1992). Stute (1992) demonstrated that the internal granule of potato starch treated with HMT was altered as shown from the X-ray diffraction patterns. The effect of HMT on pasting characteristics of the Ihur, Tuni, and Molat sago starches were higher than that on Pancasan sago. In the Ihur, Tuni and Molat sago starch, HMT significantly increased setback viscosity values, indicating that the starch is easier to retrograde.

Physical Strength and Cooking Quality of Sago Starch Noodles

Sago starch treated with HMT resulted in improved noodle qualities, i.e. having higher firmness and elasticity, but the stickiness was lower compared to those non-HMT (Tabel 3). More firmer noodles mean that they are not easily broken under cooking condition.

Cooking quality of the sago starch noodles was presented in Table 4. In general, increase in cooking time decreased the cooking losses and rehydration weight of the noodles. Cooking time of the sago starch noodles ranged from 7 to 9 minutes which were comparable to cooking time of commercial spaghetti marketed in Indonesia which was 9 minutes.

Table 3. Firmness, stickiness, and elasticity of sago starch noodles.

Sago	Treatment	Firmness (gf)	Stickiness (gf.s)	Elasticity (gf)
Tuni	Non-HMT	1303.87c	64.43b	8.47c
	HMT	2345.43a	27.30b	16.67a
Molat	Non-HMT	1252.13e	73.23a	6.60b
	HMT	2137.80b	48.47d	10.20d
Pancasan	Non-HMT	1608.87d	52.73c	10.33cd
	HMT	1978.67c	28.47b	11.43bc
Ihur	Non-HMT	1241.43a	33.83e	8.97c
	HMT	1621.30d	21.47g	12.13b

Numbers followed with different letters in the same column are significantly different at $p<0.05$.

Table 4. Cooking time, cooking loss, and rehydration weight of sago starch noodles.

Sago	Treatment	Cooking time (min.)	Cooking loss (%)	Rehydration weight (%)
Tuni	Non-HMT	7.33b	4.15b	326.89b
	HMT	8.50a	2.86d	252.08d
Molat	Non-HMT	7.33b	6.19a	324.88b
	HMT	8.67a	3.84bc	301.38bc
Pancasan	Non-HMT	7.33b	4.04b	333.46b
	HMT	8.33a	2.88d	309.01bc
Ihur	Non-HMT	7.50b	3.21cd	379.25a
	HMT	8.33a	2.01e	283.79c

Numbers followed with different letters in the same column are significantly different at $p<0.05$.

Table 2. Pasting properties of non-HMT and HMT sago starch.

Properties	Non-HMT				HMT			
	Pancasan	Ihur	Tuni	Molat	Pancasan	Ihur	Tuni	Molat
Gelatinization temperature (°C)	71.25	66	72	71.25	72.75	72	71.25	72.75
Peak temperature (°C)	81	84.75	85.5	87	80.25	82.5	78.75	83.25
Peak viscosity (BU)	1100	1230	990	890	1000	1470	1370	1240
Viscosity at 93°C (BU)	1000	840	650	720	990	1470	1170	1160
Viscosity 93/20 (BU)	650	520	350	350	860	1390	1090	1160
Viscosity at 50°C (BU)	1340	1020	710	690	1450	2390	1880	2000
Viscosity 50/20 (BU)	1280	950	710	680	2230	2040	1680	1680
Breakdown viscosity (BU)	450	710	640	540	140	80	280	80
Setback viscosity (BU)	690	500	360	340	590	1000	790	840
Type[1]	A	A	A	A	B	B	B	B

[1]According to Schoch and Maywald (1968) *in* Chen (2003)

Cooking loss of the non-HMT sago starch noodles varied between 3.21% and 6.19%, while those treated with HMT was 2.01-3.84%, higher than those reported on sweet potato starch noodles with an average of 1.5% (Collado and Corke 1997) and potato starch with cooking loss of 0.2-1.2% (Kim and Wiesenborn 1996). Apparently, the cooking loss of sago starch noodles was similar to that of mungbean (2.93-7.68%) as found by Lii and Chang (1981) and Galvez *et al.* (1994).

The average rehydration weight of the untreated sago noodles was 324-380%, higher than that of the HMT (252-309%). Collado *et al.* (2001) reported that HMT on sweet potato starch noodles resulted in higher rehydration weight (262%) compared to noodles from untreated sweet potato starch (234%).

Correlation analyses of physical strength and cooking characteristics showed negative for the firmness to the stickiness ($r = -0.541$, $p<0.01$), but it was positive for the firmness to the elasticity ($r = 0.799$, $p<0.01$) (Table 5). This indicates that measurement of physical strength could be represented by single parameter. Negative correlation was also found between firmness and cooking losses ($r = -0.470$, $p<0.05$) and rehydration weight ($r = -0.716$, $p<0.01$). However, significant positive correlation ($p<0.01$) was observed between firmness and cooking time, stickiness and cooking losses ($r = 0.943$), stickiness and rehydration weight ($r = 0.544$) indicating that physical strength can be used as a tool to evaluate cooking quality of sago starch noodles.

Color

Color evaluation of sago starch noodles before and after rehydration (Table 6) expressed in three values (1) L*, index of lightness/darkness, 2) a*, index of color hue, and 3) b*, index of yellowness. Noodle color was significantly affected by sago starch origin (species) and HMT. Low value of lightness and high value of hue and yellowness was observed on the noodles from Ihur.

Organoleptic Quality

Panelists preferred HMT sago starch noodles of Tuni and Pancasan. These two noodles had lower stickiness level (27-28 gf.s) and firmness (1978-2345 gf), but more elastict (11-16 gf) (Table 3). The color of the noodles made from Ihur variety was rated below the lowest acceptable score, which means that the panelists did not familiar with the red Ihur noodle color since most noodles found in Indonesia are yellow or white.

Table 5. Pearson correlation coefficient for physical strength and cooking characteristics of sago starch noodles.

	Firmness	Stickiness	Elasticity	Cooking loss	Rehydration weight	Cooking time
Firmness	1.000					
Stickiness	-0.541**	1.000				
Elasticity	0.799**	-0.851**	1.000			
Cooking loss	-0.470*	0.943**	-0.804**	1.000		
Rehydration weight	-0.716**	0.544**	-0.649**	0.488*	1.000	
Cooking time	0.804**	-0.705**	0.700**	-654**	-0.713**	1.000

* = significantly different at $p<0.054$, ** = significantly different at $p<0.01$

Table 6. Color of sago starch noodles before and after rehydration.

Sago	Treatment	Before rehydration			After rehydration		
		L	a	b	L	a	b
Tuni	Non-HMT	54.41^{e}	7.193^{f}	16.06^{e}	43.56^{e}	3.28^{e}	10.03^{d}
	HMT	51.81^{c}	7.37^{g}	13.52^{d}	42.61^{d}	3.99^{f}	8.92^{c}
Molat	Non-HMT	54.94^{f}	5.82^{c}	14.06^{d}	42.74^{d}	2.12^{c}	6.98^{f}
	HMT	50.11^{b}	6.36^{d}	12.17^{b}	41.48^{c}	2.52^{d}	6.79^{f}
Pancasan	Non-HMT	57.37^{g}	3.22^{a}	12.69^{c}	47.52^{g}	0.73^{a}	2.83^{a}
	HMT	53.60^{d}	3.57^{b}	11.28^{a}	46.34^{f}	1.00^{b}	2.60^{a}
Ihur	Non-HMT	51.62^{c}	7.16^{e}	13.85^{d}	40.53^{b}	3.50^{f}	9.13^{c}
	HMT	47.58^{a}	7.41^{g}	12.88^{c}	39.19^{a}	4.04^{h}	11.54^{e}

L = index of lightness, a = index of color hue, b = index of yellowness.
Numbers followed with different letters in the same column are significantly different at $p<0.05$.

Table 7. Sensory evaluation of rehydrated noodles.

Sago	Treatment	Color	Firmness	Elasticity	Stickiness	Preferences
Tuni	Non-HMT	5.58h	4.74d	3.96b	3.78b	3.56a
	HMT	4.36d	5.42h	5.44f	5.46g	5.08f
Molat	Non-HMT	5.26g	3.74b	3.84a	2.42a	3.94b
	HMT	4.24c	5.12g	4.00b	4.98e	4.90d
Pancasan	Non-HMT	5.22f	2.96a	5.22e	4.00c	4.10d
	HMT	4.76e	4.38c	4.84d	5.00f	5.44g
Ihur	Non-HMT	3.82b	4.88f	4.34d	4.52d	4.00c
	HMT	2.76a	4.76c	4.36c	5.84h	4.98e

Numbers followed with different letters in the same column are significantly different at $p<0.05$.

The study showed that HMT improved significantly sago starch noodles and the noodles were accepted by panelists especially for their firmness and stickiness. This indicated that sago starch is potential as an alternative to develope sago-based food, thus increasing the consumption of sago starch. Further study is required to up scale the study involving more panelists from different back-ground of societies which may have difference in their preferences for sago starch noodles.

CONCLUSION

The four sago starch under investigation showed type A pasting profile, but HMT performed on the starch changed the pasting profile into type B. Significant differences in physical strength, cooking, and sensory quality of the noodles produced from non-HMT and HMT starch were observed. Firmness, elasticity, and stickiness of non-HMT sago starch noodles were 1621.30-2345.43 gf, 10.20-16.67 gf, and 21.47-48.47 gf.s, respectively, while those of HMT sago starch noodles were 1241-1608.87 gf, 6.60-10.33 gf, and 33.83-73.23 gf.s, respectively. Cooking loss of non-HMT and HMT sago starch noodles were 2.01-6.19% and 2.01-3.83%, respectively. Cooking time of sago starch noodles ranged from 7 to 9 minutes. The average rehydration weight of the non-HMT sago starch noodles was 324-380%, higher than that of the HMT sago starch noodles.

Sensory evaluation showed that noodles made from HMT sago starch were more accepted by panelists. However, consumer testing is recommended to further validate its acceptability. The result of the study indicated that sago starch could be potentially used as raw material for noodle making. If it is fully developed, the consumption of sago-based food would be promoted.

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