

Agronomic Features and Starch Yield of Sago Palms Grown in the Islands in Southeast Asia and Melanesia

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The authors formerly found a large variation in the starch yield and its related components among sago palms grown in the Malay Archipelago. In this study, we report the morphological characteristics and agronomic features relating to the starch yield of sago palms grown in West Papua Province, Indonesia, East Sepik Province and New Ireland Province, Papua New Guinea and aim to compare key parameters limiting starch production in the islands in Southeast Asia and Melanesia.

Materials and Methods Twenty seven populations were selected in the islands in Southeast Asia (West Sumatra, South Sumatra, West Java, Southeast Sulawesi, Ternate, Halmahera and Seram in Indonesia) and the other twenty populations were selected in Melanesia (West Papua in Indonesia, East Sepik and New Ireland island in Papua New Guinea). After the harvesting, morphological parameters indicating palm size and yield components such as trunk length, trunk diameter, thickness of bark, pith density, dry-matter percentage of pith and starch concentration in pith were measured.

Results and Discussion The average starch yield calculated based on the yield components was 310 kg/plant and 244 kg/plant in the islands in Southeast and Melanesia, respectively. The variation of starch yield in Melanesia (CV: about 80%) was larger than that in the islands in Southeast Asia (CV: about 60%). The difference in starch yield in the islands in Southeast Asia was mainly attributed to the trunk diameter breast height and the dry-matter percentage of pith. In contrast, the differences in trunk length and dry-matter percentage of pith mainly accounted for the difference in starch yield in Melanesia. The sago palms in the islands in Southeast Asia had a comparatively thick and short trunk and those in Melanesia had a comparatively thinner and longer trunk. However, the average pith dry-matter yield was almost same level as 400 kg/plant in both the islands in Southeast Asia and Melanesia. The difference in starch yield between the two areas might be attributed to the difference in starch concentration in pith, 77% and 58% in the islands in Southeast Asia and Melanesia, respectively.

As described above, one of the limiting factors for sago starch yield was different in the Islands in Southeast Asia and Melanesia. This difference may be attributed to a comparatively lower harvesting pressure in Melanesia. The difference in starch yield between the two areas is considered to be related with the starch concentration in pith.

Photosynthetic Rate and Its Related Parameters of Sago Palm Seedling at Different Air Temperatures

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Sago palm (*Metroxylon sagu* Rottb.) habitats are widely spread across the area located within 10 degree north and south equator zone with elevation up to 700 meter above sea level and optimum air temperature from 25°C to 29°C. In Papua New Guinea, sago palm has also been found growing up to 1200 meter above sea level. The elevation levels cause variation of ambient air temperature in sago palm habitats which affect its physiological performance. This study was conducted to study the photosynthetic performance of sago palm under different air temperature condition which consequently affects the yield of this plant.

Materials and Methods The experiment was conducted in a phytotron set at 25°C (25 -29°C) and 29°C (29 -33°C) air temperature at Nagoya University, Japan, from January to March 2017. Six one-year-old sago palm seedlings with six fully developed leaves that were grown individually in a 1/10000a pot filled with vermiculite were used. The nutrients were supplied through the application of Kimura B culture solution. The portable photosynthesis system (LiCor Li-6400XT, USA) was used to measured diurnal leaf gas exchange and carbon response curve (A/Ci). The A/Ci data was fitted using A/Ci curves utility version 1.1. Light saturation curve (A/I) measurement was conducted using a photosynthesis yield analyzer (MINI-PAM) after 20 minutes of dark adaptation. Chlorophyll determinations were measured after acetone 80% extraction using a spectrophotometry (UV-1800 Shimadzu). Chlorophyll (Chl) and carotenoids concentration were calculated in $\mu\text{g gram}^{-1}$ sample.

Results and Discussion All photosynthetic parameters of sago palm seedlings showed higher values at 29°C than 25°C. However, the sago palm seedlings maintained the optimum net photosynthetic rate (P_n) for short period at both air temperatures as the down-ward trend of P_n begin around 11:00. The low point of air temperature tested at 25°C seems to be the limiting factor in P_n performance more than the higher air temperature tested at 29°C (29 -33°C). This can be interpreted from the photosynthetic supporting parameters observed at both air temperatures. According to A/Ci curve measurement, the low photosynthetic rate at 25°C was followed by lower value of Rubisco-limited photosynthesis (V_{cmax}) and RuBP-limited photosynthesis (J) than at 29°C. Parameters related to chlorophyll content (SPAD, Chl.a, Chl.b, Chl.a+b, and carotenoid) also showed higher value at 29°C. Further testing with photosynthetic parameters at light saturation curve (Y, ETR, qN & NPQ), and other supporting photosynthetic parameters (Y_{max} , E_{opt} , P_{max} , α_0 , qN_{max} , and, NPQ_{max}) were done. The sago palm seedlings placed at 29°C also performed higher value of E_{opt} , P_{max} , qN & NPQ than at 25°C air temperature.

Benefits of Oxidized Sago Starch in Chinese Noodles

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Sago palm is a plant native to the tropical wetlands of Indonesia, Malaysia and other South East Asian countries. Sago starch naturally accumulates in the trunk of the sago palm. Approximately 17,000 tons of sago starch is imported into Japan every year. Most of this amount is chemically modified into oxidized sago starch and then used as dusting flour for noodles. In Japan dusting flour that utilizes oxidized sago starch is widely used due it being highly spreadable. It is also said to limit noodle elution into the broth. However, there are no existing studies on these effects. On the other hand, there have been previous reports on the benefits of using native sago starch in Chinese noodles, including on its usage as an ingredient in noodles and its usage as dusting flour¹. Results of these reports showed that, boiled Chinese noodle dough showed a tendency to become softer when sago starch was used as a substitute for wheat flour. Furthermore, the amount of solid elution in the broth decreased, meaning that the restriction of noodle dissolution into the broth was determined. The benefits of using native sago starch as dusting flour were not confirmed, as it was found to have similar effects to using potato starch. Sensory evaluation showed that, when 10% or 20% of wheat flour was substituted with native sago starch the noodle had more transparency, less stickiness and was significantly preferred compared to the control (0% substituted starch).

The aim of this report was to examine the characteristics of oxidized sago starch, which is currently often used as dusting flour, and the benefits of its utilization as dusting flour for Chinese noodles. The effects of adding oxidized sago starch to Chinese noodles as an ingredient were also investigated.

【Materials】

Sago starch and oxidized sago starch were used as test samples (Joetsu starch Co.,Ltd.). As a comparison to the basic properties of sago starch, acetylated sago starch was also used (Nihon Shokuhin Kako Co.,Ltd.). Weak flour (Nisshin Flour Milling Inc.), strong flour (Nisshin Flour Milling Inc.), lye water (potassium carbonate 2.4%, sodium bicarbonate 0.4% (Wako Pure Chemical Industries, Ltd.)) and Chinese noodle broth (Meiji Co., Ltd.) were used as ingredients for the Chinese noodles.

【Sample Preparation Method】

The preparation of Chinese noodles was conducted as follows. 50 g of strong flour and 50 g of weak flour were added together and sieved. Next, 45 ml of lye water was mixed with the flour,

subsequently it was kneaded for 10 min, and then kept aside for 30 min. Noodles were then made with 5% of the wheat flour replaced with native sago starch. The same was done but with oxidized sago starch. This process was then repeated for 10% and 15% replacement rates with both sago starch types. The same preparation method was used for each noodle type. For physical property measurement, dough was inserted into a noodle production machine and shaped into roughly 1.8 mm thick disks 38 mm in diameter. Noodles with a diameter of 1.5 mm and a length of 30 cm were made in order to conduct sensory evaluation and measurements on the eluted amount of noodle in the broth. The disk-shaped noodles were put in 1 L of boiling distilled water for 7 min, the long noodles were inserted for 2 min.

Tests on dusting flour were conducted with 5 g of strong flour, native or oxidized sago starch being used for every 100 g of wheat flour noodles.

【Methods】

I. Basic Properties of Oxidized Sago Starch

- 1) Amylose contents: Using an amperometric titration system (Hirama Laboratories Co., Ltd. ART-3) amylose content measurements were performed. Starch samples were degreased beforehand using 85% methanol extraction method.
- 2) Transmittance during gelatinization : Using photopastography (Hirama Laboratories Co., Ltd. ART-3pp-1), measurements on transmittance when heating were conducted. Starch concentration was set at 0.3%.
- 3) Viscosity when heating & chilling: Measurements on viscosity were carried out using a Rapid Visco Analyzer (Newport Scientific Pty. Ltd. RVA-3D). Starch concentration was set at 10%. Heating was conducted as follows. The initial temperature was set at 50°C, after maintaining this heat for 1 min, the temperature was raised by 5.6°C per min until reaching a final temperature of 95°C. After keeping the temperature at 95°C for 2 min, the temperature was lowered by the same rate it was raised, taking a total of 19 min, until 50°C was reached.
- 4) Properties of starch gels: Gel, made so that starch concentration would be 10%, was chilled at 5°C for 2 h. After that physical property measurement was administered using a RHEONER (Yamaden Co., Ltd. RE-3305). The samples were pressurized twice at a rate of 66.7%. The curves gained were used to read and compare firmness, adhesiveness and cohesiveness.

II. Benefits of Utilizing Oxidized Sago Starch in Dusting Flour and as an Ingredient in Chinese Noodles

- 1) Noodle elution amount in broth: Boiled broth containing 100 g of noodles was put in a Homogenizer for 5 min. After that, 20 g of broth was put into 5 beakers and microwaved (National NE-TZ15A) at 170W for 20 min, then the eluted noodle amount was measured.

- 2) Broth transmittance: Boiled broth containing 100 g of noodles was diluted 10 times with water, then transmittance at 660_{nm} was measured using a Spectrophotometer (General Electric Company, Gene Quant100).
- 3) Broth viscosity: The viscosity boiled broth containing 100 g of noodles was measured using a Rapid Visco Analyzer (Newport Scientific Pty. Ltd. RVA-3D). The temperature was set at 27°C and the measurement time was 10 min.
- 4) Noodle dough physical properties measurement : After cutting out the dough into 38 mm diameter disks the rupture properties of the dough were determined using a RHEONER (Yamaden Co., Ltd. RE-3305) with a 5 mm diameter spherical plunger attached. The measurement speed was set at 1mm per sec. In order to take the measurement the dough sample was placed in the middle of the sample table with a 12 mm diameter hole in its center. Then, the spherical plunger was used to compress the dough. From the stress-strain curves obtained statistics on maximum stress, firmness, breaking strain and stretchiness were obtained. The same method was conducted on boiled dough after the moisture had been removed from its surface.
- 5) Sensory Evaluation: The evaluation was conducted on property evaluation and preference in 7 stages using the scoring method. The evaluators were students and 8 cooking researchers from Kyoritsu Women's University.

【Results and Discussion】

I . Basic Properties of Oxidized Sago Starch

- 1) Amylose Content: In contrast to the 24.5% showed for native sago starch, oxidized sago starch showed 17.9%. Acetylated sago starch had 24.0% amylose content.
- 2) Transmittance during gelatinization: The temperature at which transmittance began to rise can be shown in the following order: acetylated sago starch < native sago starch < oxidized sago starch. At 85°C the transmittance of oxidized sago starch was highest at 87%, native and acetylated starches showed low figures of 33% and 35% respectively.
- 3) Viscosity when heating & chilling: At 71.5°C, acetylated sago starch showed the lowest temperature at which viscosity began to rise. This was followed by native sago starch at 73.6°C. Oxidized sago starch showed the highest at 75.9°C. In terms of maximum viscosity, native sago starch had the highest ratings at 617RVU, oxidized sago starch showed the lowest at 24RVU and acetylated sago starch was between the two with a rating of 342RVU. As shown by the distance between their maximum and minimum viscosities, the breakdown of native and acetylated sago starch was large. In contrast, that of oxidized sago starch was small and it was proved that when oxidized sago starch was heated or chilled it had a low viscosity.
- 4) Properties of starch gels: Oxidized sago starch gel was very soft with roughly one quarter of the hardness of native sago starch gel. It also had low adhesiveness and showed non-sticky

physical properties. In terms of cohesiveness, oxidized sago starch was less cohesive than the other two starch types and showed brittle properties. The hardness of acetylated sago starch gel came out at about the same as that of oxidized sago starch gel. It was also adhesive and had similar high figures to native sago starch gel in terms of cohesiveness.

II. Benefits of Utilizing Oxidized Sago Starch as Dusting Flour

- 1) The noodle elution amount in broth when, strong flour, native sago starch and oxidized sago starch were used as dusting flours was compared. As a result of this comparison, it was found that not using dusting flour produces more elution, however no significant difference was found between the three types.
- 2) In terms of broth transmittance comparison, after native sago broth, oxidized sago starch had the highest value. The viscosity of broth results showed that oxidized sago starch was the lowest and after boiling, its noodles had the least stickiness. When compared to other dusting flours, oxidized sago starch produced noodles with the least stickiness.

III. Benefits of Utilizing Oxidized Sago Starch as an ingredient in Chinese noodles

- 1) When partly replacing wheat flour with native or oxidized sago starch, softer and more stretchable boiled noodles tended to be obtained.
- 2) Sensory evaluation results showed that Chinese noodles with substituted oxidized sago starch decreased in hardness and elasticity, and had low biting quality as the substituted amount was increased. In the taste parameter of the overall evaluation 10% and 15% were not favored. However, noodles with a 5% substituted rate had the same results as the control in the taste parameter.
- 3) Results on the elution amount in broth showed that when the substituted amount of oxidized sago starch was set at 5%, a significant difference between native sago starch noodles was not found. When 15% was replaced the eluted amount greatly increased.

【Conclusion】

When investigating the benefits of utilizing oxidized sago starch in Chinese noodles, the following things were found:

- 1) As dusting flour, the noodle elution into broth was previously reported to be low, but under the test conditions in this research it was clear that oxidized sago starch did not limit elution in broth. However, in terms of the characteristics of the end product, clear and positive benefits were proven from the usage of oxidized sago starch as dusting flour. That is, the broth was found to be less turbid and viscous, and the boiled noodles were relatively non-sticky.

- 2) In terms of its utilization as an ingredient, when oxidized sago starch was substituted at a rate of 10% or more, soft noodles with unfavorable smoothness when biting were obtained. Furthermore, oxidized sago starch showed no effect in limiting noodle elution in broth. The preference rating of 5% substitution was similar to that of the control.
- 3) In this study, the usage of acetylated sago starch in Chinese noodles was not examined, however it was considered to be a promising subject of future research, due to it being viewed as having many similar basic properties to native sago starch and having potential in improving palatability, reducing noodle elution into broth and restraining noodle retrograding. Also, the subject of this study was Chinese noodles, however oxidized sago starch dusting flour may be used across a wide range of foods including Japanese wheat noodle, and coating dough for *gyoza* style minced pork and vegetable stuffing Chinese dumplings or steamed meat dumplings. The utilization and comparison of oxidized sago starch in these products has been set as a future subject of investigation.

【Reference】

- 1) Tomoko Kondo, Kazuko Hirao and Setsuko Takahashi: Effect on Chinese Noodles of Using Sago Starch. *Journal of Cookery Science of Japan*, 46, 93-99 (2013)

Farmers' Adoption Behaviour to Plant Sago Palm in South Sulawesi, Indonesia

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Abstract

The role of sago palm is considered highly important in providing income and food for the local community of Luwu Utara. This study examines farmers' willingness to plant sago palm. The result indicated that majority of respondents want to plant sago palm (75%). The data also revealed the majority of the "unwilling" respondents do not want to plant sago palm because they do not have a planting area (96%), whereas the "willing" respondents possess a sago plantation area (70.7%). The farmer's age, work experiences, sago area, and employee ownership show a significant relationship with behaviour to plant sago palm.

Introduction

Numerous attempts have been made to develop cultivation of sago palm at the industrial level, but to date there has been no significant development even though sago has been recognized as a valuable resource since the early 1970s (Regional Research and Development Agency, 2008). One critical aspect of developing the sago palm industry is the requirement to adopt practicable technology for production and management systems (Laufa, 2004) especially for smallholders. Sago farmers, especially in Indonesia, are still using conventional practices in sago processing and do not know how to cultivate sago palm. Osozawa (2016) argued cultivation at the farmer level is difficult because sago plants are large, much bigger than a human body. The farmers are familiar with cultivating cereals, tubers, and vegetables, which are small. In addition, at the national level, there is no long-term comprehensive strategy that includes developing or promoting sago palm (Trisia *et al.*, 2016).

Methods

This research was conducted in July- August 2016 at Luwu Utara Regency, South Sulawesi Province, Indonesia. 100 respondents were surveyed. Descriptive analysis was used to analyse the data. The survey was conducted throughout Luwu Utara, which was divided into three areas: Pengkajoang, Waelawi, and Tappong. These areas were selected for their high concentration of sago farmers. The questionnaire covered respondents' characteristics which are age, sago area, work experience and total labour.

Results and Discussion

Sago farmers, especially in South Sulawesi, are still using conventional practices in sago processing and do not know how to cultivate sago palm efficiently. The transformation of sago starch extraction by smallholders started before the 1970s. At that time, local people extracted sago for their self-consumption using manual tools. By the end of the 1970s, a rasping machine with diesel power had been introduced to extract sago. Between 1980s-1990s, water pumping was adopted for the washing process to get better starch. In 2012, a locally developed rasping machine using a washing process with a better pump and mechanical squeezing had been introduced improving the efficiency of starch extraction. Nowadays, sago smallholders are categorized into 3 types based on technology adoption: (1) technology transition between traditional to small-scale, (2) small-scale technology and (3) semi-mechanized technology.

The respondents can be divided into two groups: (a) willing (75%) and (b) unwilling (25%) to plant sago (Figure 1). The majority of the “unwilling” respondents (88%) tended to have less work experience (1–10 years), whereas 51.4% of the “willing” respondents had more than 10 years’ work experience. The majority of the “unwilling” respondents do not have a planting area (96%), whereas the “willing” respondents possess a sago plantation area of 0.25–1.5 ha and more than 3 ha (70.7%). Furthermore, the results showed the “unwilling” respondents have no employees (72%), whereas most of the “willing” respondents have employees (53.3%).

The mean of the driving variables is presented in table 1. Chi-squared tests showed there is a significant difference between the two groups in terms of age ($\chi^2 = 7.0603$, $p\text{-value} < 0.10$), work experience ($\chi^2 = 14.172$, $p\text{-value} < 0.01$), sago area ($\chi^2 = 33.573$, $p\text{-value} < 0.01$), and employee ownership ($\chi^2 = 4.831$, $p\text{-value} < 0.05$).

Table 1. Driving variables vs willingness to plant sago

Variable	Mean	Chi-squared	Significance
Age	2.13	7.603	0.055*
Work Experiences	1.78	14.172	0.003***
Sago Area	0.67	33.573	0.000***
Employee ownership	0.59	4.831	0.028**

*Significant at 10%, **Significant at 5%, ***Significant at 1%

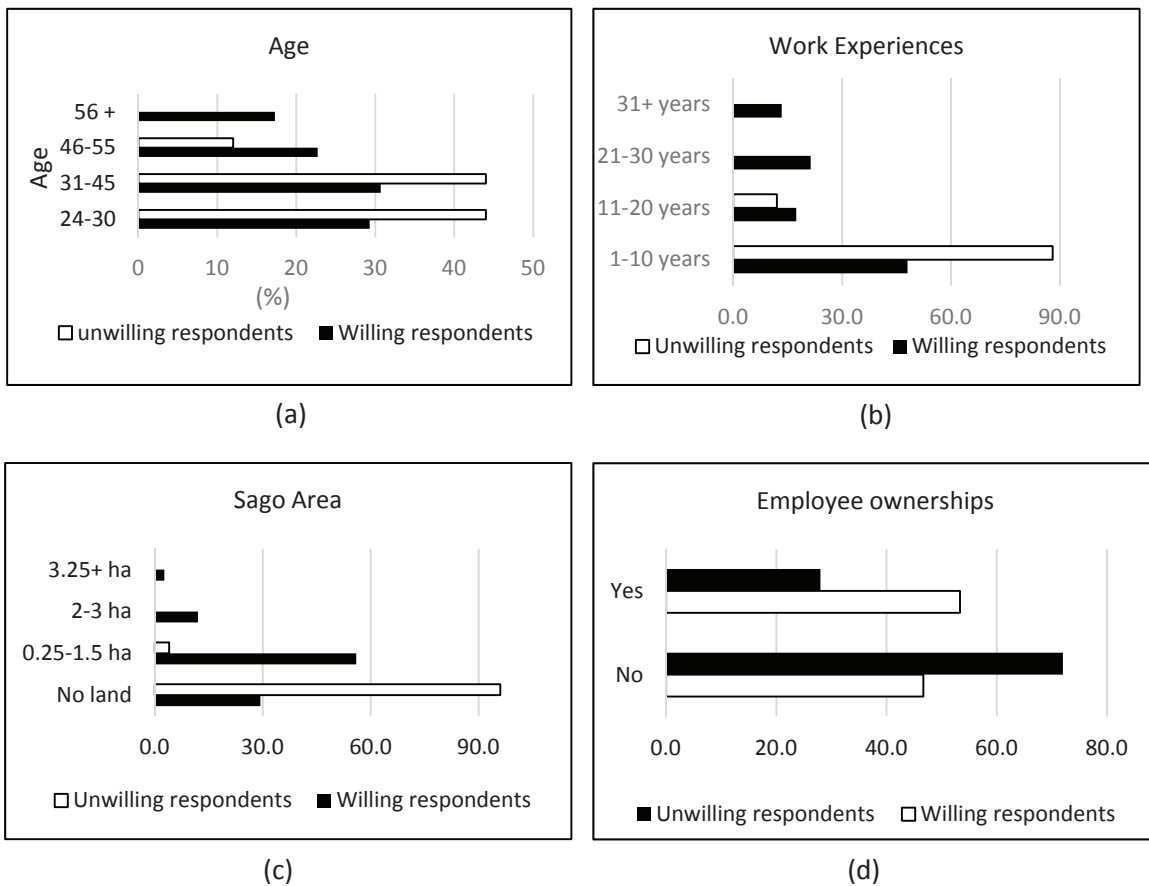


Figure 1. (a) Willing and unwilling respondent and age; (b) Willing and unwilling respondent and work experiences; (c) Willing and unwilling respondent and sago area; (d) Willing and unwilling respondent and employee ownerships

Conclusion

The cultivation of sago palm cannot be accomplished by one person alone. Success requires active participation by the government, industry, academia, and farmers. Therefore, recommendations can be derived from the findings in this study. It is important for smallholders to increase sago production in both quantity and quality. To achieve this, assistance should be provided by a mix of industry, government, and academia, i.e., sago palm restoration project removes technological barriers to the desirability of the product, finds the best sago variety, and increases institutional support. Educational services for practical applications such as a seedling training program, sago cultivation, and a management system as well as an internship program can be provided to build high quality small enterprises by local farmers.

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