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Changes in the Composition and Content of Sugars in the Pith during the Growth of Sago Palm

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樹齢に伴うサゴヤシ髄部の糖の種類と含有率の変化

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Introduction

Sago palm is a crop that grows well in Southeast Asia and the South Pacific in deep peat soil with low pH values and a year-round high water table. The starch accumulated in the trunk of sago palms has been utilized as a food source for the people in the regions where it is grown and will be used as raw material for the starch industries. The great potential of the sago palm starch has been expected as a solution to future food shortages (Yamamoto 1998).

The produced sugars in leaves of sago palms are transported to the pith and stored in the form of starch. Studies on the productivity of starch in sago palms cover a wide range of tropics; for example, they have examined the starch accumulation process in the pith (Jong 1995, Yamamoto et al. 2003a) and the growth performance in different soil types (Yamamoto et al. 2003b, Watanabe et al. 2005, Jong et al. 2006) However, there have been few surveys on the composition and content of sugars in sago palms (Wina et al. 1986). In this report, changes of the composition and content of sugars in sago palm pith in relation to the growth stages after trunk formation were studied on sago palms in a Malaysian sago garden.

Materials and Methods

Ten sago palm trees 2~10 years after trunk formation were selected in Mukah, Sarawak, Malaysia. The site was classified as a mature sago garden, and the soil in the area was classified as peat. Trunks were cut into sections about 0.9 m long (log). Disks of pith were taken from the central part of the logs from the basal, middle, and top of the trunks. The pith samples (50~100 g) were dried at 80°C for 2 days, and the contents of sugar and starch were analyzed. Sugars were extracted from the ground sample (0.2 g) using 80% ethanol in a centrifuge tube at 80 to 85°C for 20 min.; after the alcohol had evaporated from the extracted supernatant, the soluble sugars were analyzed. Starch was extracted using ice cold 4.6 *N* $HClO_4$ for 15 min. from the sugar-extracted residue according to the method of Murayama et al. (1955). The analysis of sugar and

Table 1. Sugar and starch contents in sago palm pith

Palm age*) (years)	Trunk length (m)	No. of logs	Pith position	High-performance liquid chromatography method**) Fructose (g kg^{-1})	Glucose	Sucrose	Total	Somogyi method Starch (g kg^{-1})
2	1.3	1	middle	87.9 (23)	265.5 (71)	21.1 (6)	374.5	49
2	1.7	1	middle	91.9 (21)	281.8 (65)	58.6 (14)	432.3	34
4.5	2.7	3	basal	9.8 (9)	15.3 (14)	82.3 (77)	107.4	504
			middle	69.7 (19)	212.1 (57)	90.9 (24)	372.7	81
			top	89.1 (31)	201.6 (69)	0.4 (0)	291.1	100
4.5	2.7	3	basal	5.3 (6)	19.4 (23)	59.0 (71)	83.7	526
			middle	62.2 (20)	250.0 (80)	0.7 (0)	312.9	95
			top	65.6 (18)	210.5 (58)	86.9 (24)	363.0	107
6.5	4.5	5	basal	ND	ND	51.4 (100)	51.4	812
			middle	1.9 (5)	ND	34.4 (95)	36.3	757
			top	26.4 (11)	99.3 (42)	112.5 (47)	238.2	398
7.5	5.6	6	basal	1.7 (3)	ND	51.6 (97)	53.3	682
			middle	ND	ND	40.7 (100)	40.7	752
			top	8.3 (15)	1.8 (3)	46.1 (82)	56.2	682
8.5	7.2	8	basal	0.9 (3)	ND	26.2 (97)	27.1	872
			middle	0.5 (2)	ND	27.9 (98)	28.4	860
			top	8.9 (12)	21.5 (30)	42.6 (58)	73.0	657
10	8.0	9	basal	ND	ND	3.0 (100)	3.0	686
			middle	1.0 (53)	ND	0.9 (47)	1.9	841
			top	0.4 (2)	ND	24.4 (98)	24.8	871
10	8.3	9	basal	ND	ND	30.2 (100)	30.2	791
			middle	ND	ND	24.0 (100)	24.0	662
			top	ND	ND	6.0 (100)	6.0	773
10	8.6	9	basal	ND	ND	26.0 (100)	26.0	781
			middle	ND	ND	13.5 (100)	13.5	744
			top	0.7 (23)	ND	2.3 (77)	3.0	868

*): Estimated years after trunk formation.

**): The numbers in parentheses are the percentages of the total sugar values.

ND: Below the minimum value of the respective measured sugar contents.

starch as glucose was performed using the Somogyi method (1945), and the content of starch was calculated by multiplying 0.9 times the content of glucose. The composition of sugar in the pith was measured by high-performance liquid chromatography (HPLC) (Robertson et al. 1996). For the analysis of the sugar composition, an 80% acetonitrile solution (1 ml) was added to the freeze-dried sample of the sugar extract solution (2 ml). The acetonitrile sample solution was passed through a membrane filter (pore size, 0.45 μm) and analyzed with HPLC using the 80% acetonitrile solution as the mobile phase (detector, RID-6A; pump, LC-4A; Shimadzu Co., column, Wakosil 5NH2; Wako Pure Chemical Industries, Ltd.). The authentic sugar solution (fructose, glucose, and sucrose; 0.2~0.02 g kg^{-1}) was analyzed for the calibration line. In a case in which the peak area of the sample was smaller than the minimum value of the calibration line, the content of sugar (fructose, ≦0.4; glucose, ≦1.8 g kg^{-1}) was regarded as a non-detectable amount (ND).

Results and Discussion

The contents of sugar by the HPLC method and starch by the Somogyi methods are shown in Table 1. A significant negative correlation was observed between the starch and total sugar contents ($r=-0.968$, $p<0.001$). This negative correlation was observed between the starch and glucose, fructose, or sucrose contents. Most of the sugars in the sago pith were glucose, fructose, and sucrose, and other sugars were not detected beyond the retention time of glucose, fructose, and sucrose. As reported in Wina et al. (1986), in swamp sago, the sugars identified were sucrose, glucose, and fructose, and maltose was not detected.

The total sugar contents in the pith showed 80~430 g kg^{-1} in relatively young sago palms (2~4.5 years after trunk formation), and the contents were larger in the middle and top parts of the trunk. As the sago

palms grew, the starch content increased, and the sugar content diminished. In the middle and top pith samples of the young palms, the glucose contents were 200~280 g kg^{-1}, and the starch contents were less than 110 g kg^{-1}. However, the starch contents in the basal pith were more than 500 g kg^{-1}. The total sugar content in the basal pith of the young palms was relatively smaller than that from the middle and top pith, and the accumulation of starch might start from the basal pith at approximately 4~5 years after trunk formation (Jong 1995).

The fructose contents were 60~90 g kg^{-1} in the middle and top pith of palms at 2~4.5 years after trunk formation and smaller in the older palms, as was the case with glucose contents. The sucrose content in the young palms was similar to those of fructose; however, approximately 8 years after trunk formation, the sucrose content gradually decreased.

The starch content in the palms 7~8 years after trunk formation was larger than 650 g kg^{-1}, and the sugar content diminished. In addition, the starch was at the maximum level in the pith of all older palms examined. These accumulation patterns were similar to those reported by Yamamoto et al. (2003a). Ten years after trunk formation, the sugar contents of the palms were very low (2~30 g kg^{-1}), and most sugars were in the sucrose form.

Based on the findings of this report, we can conclude that most of the sugars in the sago palm pith were glucose, fructose, and sucrose. The composition of sugar in the pith changed with the growth stage and varied according to the part of the trunk examined. The proportion of glucose in the total sugar was large in the young palm pith and gradually decreased with growth. In older palms, most of the sugars were sucrose.

References

Jong, F. S. 1995 Research for the development of sago palm (*Metroxylon sagu* Rottb.) cultivation in Sarawak, Malaysia. (Ph. D. Thesis). Wageningen Agricultural University, pp.139.

Jong, F. S., A. Watanabe, D. Hirabayasi, S. Matsuda, B. H. Purwanto, K. Kakuda and H. Ando 2006 Sago Palm 14: 59-64.

Murayama, N., M. Yoshino, M. Oshima, S. Tukahara and Y. Kawarazaki 1955 Bulletin of the National Institute of Agricultural Sciences. Ser. (B4) 123-166. (in Japanese with English summary)

Robertson, M. J., R. C. Muchow, A. W. Wood and J. A. Campbell 1996 Field Crops Research 49: 39-50.

Somogyi, M. 1945 Journal of Biological Chemistry 160: 61-68.

Watanabe, A., K. Kakuda and H. Ando 2005 Sago Palm 13: 12-15.

Wina, E., A. J. Evans and J. B. Lowry 1986 Journal of the Science of Food and Agriculture 37: 352-358.

Yamamoto, Y. 1998 *Sagoyashi, Kokusainoringyo-kyoryoku-kyokai*. pp.109. (in Japanese)

Yamamoto, Y., T. Yoshida, Y. Gotoh, F. S. Jong and L. B. Hilary 2003a Japanese Journal of Tropical Agriculture 47: 124-131. (in Japanese with English summary)

Yamamoto, Y., T. Yoshida, Y. Goto, Y. Nitta, K. Kakuda, F. S. Jong, L. B. Hilary and H. Hassan 2003b Japanese Journal of Tropical Agriculture 47: 250-259.