

SAGO BARUK PALM (*Arenga microcarpha* Becc) AS A SUPERIOR LOCAL FOOD SOURCE AND SOIL CONSERVATION PLANT AT SANGIHE ISLAND REGENCY

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ABSTRACT

The aim of this study was to analyze the production of sago, to analyze its chemical composition and nutrient content, and to analyze the rainfall infiltration capacity of sago baruk palm grown at different altitudes. The research was conducted from October 2010 to June 2011 in Gunung Village, Tabukan Tengah, district of Sangihe. The village is laid from the coast to the top of the hill with an altitude of ± 600 m above sea level. The data analysis techniques used in this research were descriptive analyses and F test ANOVA. The results showed that sago stem weight and pith weight were significantly influenced by the altitudes. The heaviest stem weight was obtained at the bottom position, while the heaviest pith weight was obtained at the top position, and for the largest ratio of sago flour to palm stem was obtained at the top position. The chemical compositions were significantly different in the levels of protein, calcium, iron, magnesium, and pH at the three altitudes. The infiltration capacity near the cluster was higher than that of the outside cluster, both in dry and rainy seasons.

Keywords: superior local food source, production, infiltration and sago baruk palm

INTRODUCTION

Sago Baruk Palm is a kind of sago plant that grows on dry land of Sangihe District Island which is spread out in all fifteen districts with total area of 398.5 ha, and with the total

production of 713.14 t/year (Department of Agriculture, Plantation, Animal Husbandry and Forestry, Regency of Kepulauan Sangihe, 2009). Sago palm can grow in land from 1 m of the seashore up to 600 m above sea level. The stem may reach a diameter of 14-25 cm and between 6-16 m in height (at mature stage). Barri and Allorerung (2001) proposed that this plant belonged to the Palmae family and the genus of *Metroxylon* since it contained starch and was able to form a cluster. However, because the flower structure is similar to *Arenga palmga pinnata* Merr (Nurmayulis *et al.*, 2011), sago baruk palm is classified into the genus of *Arenga* (Indonesian Center for Estate Crops Research and Development, Bogor, 2005). Sago baruk palm has root systems which can withstand the layer of soil, so the palm can suppress soil erosion and minimize surface runoff. Sago baruk palm that can grow and reproduce on steep land (60° - 70°), has a number of sago leaflets on each leaf that ranges between 50-60 with varying sizes of 42-72 cm long and 4-7.2 cm wide (Barri and Allorerung, 2001). According to the ownership status, sago baruk palm is considered as local natural resource which is only found in the Sangihe Island as an endemic plant. Hence, its existence needs to be maintained or conserved (Mogea, 2002). Act no. 32, year 2009 Chapter 1 Article 18 (State Secretary of the Republic of Indonesia, 2009) explained that natural resources conservation was the management of natural resources to ensure the wise utilization and the continuing availability by keeping maintaining and improving both quality and diversity.

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Sago baruk palm is the source of staple food for 88.33% population in Sangihe Island (Department of Agriculture, Plantation, Animal Husbandry and Forestry, Regency of Kepulauan Sangihe, 1980). According to Barri and Allorerung (2001), the production of sago baruk palm stem was around 13-15 kg/stem, while according to Department of Smallholder Agriculture, Province of Regional level 1, North Sulawesi 1980, it may reach 25-30kg/stem. Sago flour can be used either directly as food or processed in industry for the ingredient of cakes and noodles (Rostiwati, 1988), and artificial syrup (Research Centre and Industry Standardisation, Manado, 2006). Moreover, sago flour can also be used as raw material for manufacturing biodegradable plastic, ethanol and other biofuel industries (Samad, 2002). Sago baruk stems are strong enough to be used as construction material (concrete reinforcement material) and potential to be developed as furniture. Sago waste residue can be used as animal feed and is potential for cultivating mushrooms. When the pulp is recycled in the soil, it can be used as fertilizer.

The ability of plant roots to distribute rain water causes other crops to survive during the dry season. Infiltration capacity correlated with soil physical character is positively correlated to the porosity of the soil and organic matter content, while the content of clay and weight content of the soil is negatively correlated (Gliessman, 2000). Rainfall and water content affect infiltration capacity. Raindrops tend to damage the structure of the soil surface, and the fine materials from the surface can be washed into the cavities of the soil which then clog the pores, thereby reducing the rate of infiltration. Vegetated lands generally absorb more water due to organic matter and micro-organisms, and plant roots tend to increase soil porosity and stabilize soil structure (Garg, 1979).

Sago baruk palm is not only used as a source of carbohydrates but it is also valuable for reforestation program (Mahmud and Amrisal, 1991; Samad, 2002). Sago plant shows high resistance to the drought. In long dry season, the palm can still grow be productive. Sago baruk palm can grow naturally to form 5 to 6

seedlings every month (personal Communication with sago baruk farmers, 2010). In cultivating the plant, farmers do not particularly apply a special treatment but cleaning the leaf sheath when they cut down sago trees from the cluster. Its economic value is one of the advantages of sago baruk palm. Its ability which holds and distributes water into the soil as well as the ability to grow on dry land is highly reliable potential for utilizing sago palms as superior carbohydrate plants.

The purposes of this study were (1) to analyze the production and yield of sago baruk palm, (2) to analyze the chemical composition and nutrient content of sago flour, and (3) to analyze the infiltration capacity around sago baruk palm.

MATERIALS AND METHODS

The research was conducted from October 2010 to June 2011 in Gunung Village, Tabukan Tengah, Sangihe Island District. The materials of the experiments were obtained from mixed farm land with an altitude of \pm 600 m above sea level. The tools used for this experiment were GPS, clinometers, set of sago processing devices, set of double ring infiltrometer and a stopwatch. The altitude in this research was divided into 3 levels, namely high altitude (400-600 m), medium altitude (200-400 m), and low altitude (0-200 m) based on the type and soil physical properties. At each altitude three of sago baruk palms were taken to be processed into sago flour. The method of this research was a survey with a purposive sampling method. Data analysis techniques included descriptive analysis, T test and F test (ANOVA) using SPSS 16.00.

The observed parameters were stem length, diameter, weight, pith weight, flour weight and ratio of sago flour to palm stem. Meanwhile, the chemical observed were proteins (Ghosh and Dill, 2009), fats (Sanders and Mittendorf, 2011), carbohydrates (Ferrier, 2002), water, calcium, iron, magnesium, acidity, ash and energy (Wolmarans *et al.*, 2008). The observation processes are shown in Figures 1 to 10.



Figure 1. The Sago Baruk palm



Figure 2. Measuring the diameter & length



Figure 3. Weighing the stem



Figure 4. Peeling and splitting the stem



Figure 5. Stem grating



Figure 6. Weighing the pith



Figure 7. Pith extortion



Figure 8. Sago Baruk flour precipitation



Figure 9. Wet Sago Flour



Figure 10. Flour Packaging Ready For Sale

The Infiltration rates near the cluster (<0.5 m) and outside the cluster (2.5 m) were calculated using Horton equation model of $f_t = f_c + (f_0 - f_c) e^{-kt}$ with f_t = infiltration capacity at time t , f_c = infiltration capacity when the price reaches a constant value; f_0 = the value of the initial infiltration capacity (at $t = 0$); k = a constant that varies according to soil conditions and the factors that determine the infiltration; t = time; and $e = 2.71828$ (Seyhan, 1977; Garg, 1979).

The rate of infiltration and infiltration constant were obtained using descriptive analysis which shows the average value of the infiltration rate and infiltration constant based on

season and altitude position (Table 3). T test at Sig $t < 0.05$ (level of error 5%) was performed to compare values observed in the rainy and dry seasons. Differences in infiltration rates and infiltration constants of the three altitudes (508 m, 330 m and 44 m) were tested using F test or ANOVA at Sig $F < 0.05$ (level of error 5%).

RESULTS AND DISCUSSION

The Sago Palm Production

The results of the experiment from three different locations are presented in Table 1. Stem length, diameter, flour weight and the sago

flour to palm stem ratio from the three altitudes were not significantly different. However, the stem weight and pith weight showed a significant difference. This is probably due to differences in soil fertility level and harvest time (Lay *et al.*, 1998; Mahmud and Amrizal, 1991). The stem weight of the low altitude sago was the highest among those of the other altitudes but this did not relate to the flour weight variable. This indicates that the yields of plant as shown by the flour was the most important component although they were taken from three different altitudes. Based on the data presented in Table 1, it is apparent that palm productions from the three locations were not significantly different. The production from the plants between stem weight and pith weight would not show significant difference. It is concluded that the sago baruk can be grown from seashore and land reaching the altitude of 600 m.

Chemical Contents

The contents of protein, carbohydrates, water, ash and energy content of the sago baruk palm flour from three different altitudes were not significantly different (Table 2). However, fat, calcium, iron, magnesium contents and the pH value were significantly different. The differences of the chemical contents from three different locations are due to the process of photosynthesis which finally produces carbohydrates and other components (Ferrier, 2002). The raw materials are inorganic component with the aid of sun light.

The sago baruk palm is probably classified as C-3 plants with high photosynthesis rates between 10–35 mg/dm²/hour with high compensation points ranging from 30 to 70 ppm. The plant which grows from the coastal area to the mountain area produces similar results in the

carbohydrates, proteins, water, ash, and energy contents. It is apparent that the sago baruk palm has high tolerance to temperatures (Lay *et al.*, 1998). The temperature factors in relation to height will give an effect because the higher altitude has low temperature, but to the process of photosynthesis at low temperatures, the energy used for respiration is also low. Therefore, the carbohydrates, protein, water, ash and energy as the results of photosynthesis activity were similar due to the different altitudes. In association with metabolic processes, total proteins, fats and carbohydrates are the primary metabolic outcome, while terpenoids, steroids, flavonoids and alkaloids are the result of secondary metabolism. In the process of secondary metabolic, primary metabolism changed into metal ions and other products. The content of calcium, magnesium and iron can be affected by the topography of Sangihe Regency that is mostly composed of volcanic tuff, agglomerate, andesite, diorit resulting from molten magma. Acidity of soil from the same kind of rock may be different due to the weathering process of litter at the site where the mixed farms were used. The result of chemical contents of sago baruk flour is shown in the Table 2.

The fat content from the three different altitudes was significant. The low altitude sago yielded the highest fat content (1.57%) followed by those from high and medium altitudes. Fats, proteins and carbohydrates are the primary metabolic outcome, and the process of fats formation in palms in general depends on the age of the plants (Mahmud and Amrizal, 1991). The age of sample palms used in the experiment was not known precisely. However, the palms population in the medium altitude showed younger performances than those from the other altitudes.

Table 1. Comparison of sago baruk palm production of the different altitudes

Variables	Altitudes		
	High	Medium	Low
Stem length (m)	11.0 a	9.7 a	11.0 a
Stem diameter (cm)	14.3 a	15.7 a	15.0 a
Stem weight (kg)	199.0 b	196.7 a	205.0 c
Pith weight (kg)	132.7 b	121.7 a	122.7 a
Flour weight (kg)	44.3 a	42.0 a	44.0 a
sago flour to palm stem ratio (%)	22.3 a	21.3 a	21.5 a

Remarks: Numbers followed by the same letter at the same line are not significantly different at p = 0.05

Table 2. Chemical contents of sago baruk flour of the different altitudes

Variables	Altitudes		
	High	Medium	Low
Protein (%)	1.79 a	1.63 a	1.70 a
Fat (%)	1.39 a	1.24 ab	1.57 c
Carbohydrates (%)	55.43 a	55.83 a	55.18 a
Water (%)	40.62 a	41.48 a	40.04 a
Calcium (ppm)	67.13 a	90.36 b	127.07 c
Iron (ppm)	0.33 b	0.42 b	0.16 a
Magnesium (ppm)	11.88 b	9.34 a	11.58 b
pH	6.41 c	4.12 a	6.23 b
Ash (%)	0.18 a	0.18 a	0.21 a
Energy (cal)	241.39 a	241.00 a	253.11 a

Remarks: Numbers followed by the same letter at the same line are not significantly different at $p = 0.05$

The calcium content of the sago trunk resulting from the low altitude was the highest (127.07 ppm), while the lowest calcium content (67.13 ppm) was observed at the high location. This difference is probably due to the leaching process from the top part of land and flowing down to the lower land.

As for the calcium parameter, the contents of iron in the sago trunk resulted from three different planting areas were also significantly different. The content of iron of the high altitude sago was the highest (0.42 ppm), while the low altitude sago yielded the lowest iron content of 0.16 ppm. The differences in iron contents were perhaps affected by the environmental conditions (kind of rocks, the presence of soil surface) and also due to the root interception and competition of this element entering the plant tissue (Hartemink, 2003).

Three locations of growing sago baruk palm also affected the content of magnesium in the sago trunk. The data listed in Table 2 show that the high altitude sago had the highest magnesium content (11.88 ppm) followed by the low altitude sago (11.58 ppm) and the medium altitude sago (9.34 ppm). This condition was probably due to uneven rock compositions (agglomerate, lava, tuff volcanic, andesite), the balance of nutrients, and the different mineral concentrations entering the plant tissue (Uchida, 2000). The pH values of sago baruk palm from the three locations were also significantly different. The soil of the high altitude resulted the highest pH value compared to that of the soil of the medium and the low altitudes. The

pH value of the soil of the high altitude was 6.41, while the pH values of the low and medium altitude were 6.23 and 4.12, respectively. The differences in pH values were probably caused by the environmental situation (accumulation of litter, leaching, etc.)

In relation to the chemical content of the sago flour, especially the energy, the possibility of using the sago flour for food supply is very likely. The energy content of every 100 g of sago flour contains 253 calories which is comparable with 100 g of rice that produces 360 calories. Therefore, the comparison of the calorie content of rice and sago baruk is 1:1.42. This means that consuming 100 g of rice would be equivalent to 142 g of sago baruk flour. Based on the result of this experiment, the consumption of sago baruk flour as a food substitution for rice would be very beneficial. If the people of Sangihe Island consume rice three times daily, one third of this meal can be replaced by consuming processed sago baruk flour.

Infiltration Rate

In the dry season, there were no significant differences in the initial infiltrations rates of outside the cluster, the final infiltration rates of outside the cluster, and the final infiltration rates of near and outside the clusters at three altitudes. However, the initial infiltration rate of near the cluster and the infiltration constant of near the cluster at the low altitude were significantly greater than those observed at the high and medium altitudes (Table 3).

Table 3. Comparison on the positions of the infiltration rate in the dry and rainy seasons

Variables	Dry season			Rainy season		
	Altitude			Altitude		
	High	Medium	Low	High	Medium	Low
fo near cluster	130.51 a	130.52 a	131.02 b	6.15 b	6.13 a	6.35 c
fo outside cluster	12.27 a	12.36 a	12.26 a	1.74 c	1.71 a	1.73 b
fc near cluster	2.20 a	2.24 b	2.24 b	0.0100 c	0.0042 a	0.0043 b
fc outside cluster	1.24 a	1.24 a	1.24 a	0.0077 a	0.0080 a	0.0077 a
f near cluster	102.57 a	103.49 a	102.63 a	55.21 c	49.54 b	48.83 a
f out cluster	11.96 a	11.91 a	12.03 a	7.08 c	6.72 b	5.52 a
k near cluster	0.245 a	0.245 a	0.264 b	0.2827 a	0.2832 b	0.8233 c
k outside cluster	0.168 b	0.165 b	0.164 a	0.1975 c	0.1970 b	0.1963 a

Remarks: fo: initial infiltration rate (mm/minute), fc: the final infiltration rate (mm/minute), f: the average infiltration rate (mm/minute), K: infiltration constant. Numbers followed by the same letter at the same line are not significantly different at $p = 0.05$

In rainy season there were differences in all infiltration rate parameters between three altitudes, except for the final infiltration rate outside the cluster (Table 3). Those differences can be attributed to the difference land covers and soil texture classes as reported by previous researchers (Araghi *et al.*, 2010; Seyhan, 1977). Results of a preliminary survey conducted prior to this study indicated that land covers of the high, medium and low altitudes were *Abelmoschus moscatatus*, sweet potato, and maize, respectively. Soil texture classes of the study area are sandy clay loam, silty loam, and sandy loam for high, medium and low altitudes, respectively. The lower infiltration rate parameters in the rainy season than those observed in the dry season were merely due to the wetness of soil.

CONCLUSIONS AND SUGGESTIONS

CONCLUSIONS

The production of sago baruk palm from three different altitudes were quite similar, this plant can grow from low to high land areas. The average production of sago baruk starch at three different altitudes was 44.4 kg, 42.0 kg, and 44.0 kg at high altitude (508 m), medium altitude (330 m) and low altitude (33 m), respectively. Sago baruk flour was possibly used as rice substitution for local people of Sangihe region, especially for staple food. There were significant differences in the infiltration rates near the cluster at the three altitudes in the dry and rainy seasons. The infiltration capacity near the cluster was higher than that far from the cluster

in the dry and rainy seasons. The initial infiltration rate and the infiltration constant near the cluster at the low altitude were significantly greater than those observed at the high and medium altitudes. In the rainy season, there were differences in infiltration rate parameters between three altitudes.

SUGGESTIONS

For the Government in Sangihe District that Sago Baruk Palm needs to be developed and preserved within the framework of the availability for local food sources, and protecting the land from soil erosion.

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REFERENCES

- Araghi P.F., S.M. Mirlatifi, G.Sh. Dashtaki and M.H. Mahdian. 2010. Evaluating some infiltration models under different soil texture classes and land uses. *Iranian Journal of Irrigation and Drainage*, 4(2):193-205.
- Balai Riset dan Standarisasi Industri Manado. 2006. Enzymatic processes of glucose syrup from Sago Baruk. *Bulletin Palma* 93: 10-15. (*in Indonesian*).
- Barri, N. and D. Allorerung. 2001. A survey on plant diversity and habitat ecosystems

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- of Sago Baruk at Sangihe Talaud Regency. Final Research Report, Indonesian Coconut and Palmae Research Institute. 115 pages (*in Indonesian*).
- Dinas Pertanian Rakyat Propinsi Dati I Sulut. 1980. Various research reports on Sago Baruk at Pulau Sangihe Besar of Sangihe Talaud Regency. Bulletin Palma 26:21-22. (*in Indonesian*).
- Dinas Pertanian, Perkebunan, Peternakan and Kehutanan Kabupaten Kepulauan Sangihe. 2009. Annual Report. pp. 25-30. (*in Indonesian*).
- Ferrier, R.J. 2002. The Carbohydrate Chemistry: Vol. 33. Royal Society of Chemistry
- Garg, S.K. 1979. Water Resources and Hydrology. 3rd edition. Dehli Khanna Publisher, 486 p.
- Ghosh, K. and K.A. Dill. 2009. Computing protein stabilities from their chain lengths. Proceedings of the National Academic of Science, USA. Jun 30, 2009;106(26):10649-106454. Epub 2009 June 17.
- Gliessman. S.R. 2000. Agroecology: Ecological processes in sustainable agriculture. Lewis Publishers, Boca Raton-London, New York, Washington, D.C. 357 p.
- Hartemink. A.E. 2003. Soil Fertility Decline in the Tropics: With Case Studies on Plantations. CAB International, London. 360 p
- Indonesian Center for Estate Crops Research and Development, Bogor. 2005. Cultivation and benefit of Sago Baruk. Bulletin Palma 29:73-74. (*in Indonesian*).
- Lay, A., D. Allorerung, Amrizal and M. Djafar, M. 1998. Sustainable processing of Sago. Research reports on Coconut and Other Palms. Bulletin Balitka 29: 73-75. (*in Indonesian*).
- Mahmud, Z. and Amrizal. 1991. Palmae for food, feed and conservation. Bulletin Balitka 14:112-114. (*in Indonesian*).
- Mogea, J.P. 2002. Preliminary study on the palm flora of the Lore Lindu National Park, Central Sulawesi, Indonesia. Biotropia 18: 1 -20.
- Nurmayulis, Susiyanti and Kartina. 2011. Growth of arenga palm (*Arenga palmga pinnata* (Wurmb) Merr) explant with Benzil Amino Purine (BAP) application. Agrivita, Journal of Agricultural Science vol 33 (2): 142-145.
- Rostiwati, T. 1988. Planting techniques of Sago, Centre for Plantation Forest Research and Development, Bogor. Bulletin Palma.235:13-18. (*in Indonesian*).
- Samad, M.Y. 2002. Improving small scale sago industry through application of semi mechanical extraction. Indonesian Journal of Science and Technology Vol.4, No.5, hal. 11-17. (*in Indonesian*).
- Sanders, C.R. and K.F. Mittendorf. 2011. tolerance to changes in membrane lipid composition as a selected trait of membrane proteins. Biochemistry 50 (37): 7858–7867. DOI: 10.1021/bi2011527
- Seyhan, E. 1977. Fundamental Hydrology. Geografisch Institute der Rijks Universitet, Utrecht. The Netherlands.
- State Secretary of the Republic of Indonesia. 2009. Act no 32, 2009. Regarding Environmental Protection and Management. 39 p. (*in Indonesian*).
- Uchida, R.S. 2000. Recommended plant tissue nutrient levels for some vegetable, fruit, and ornamental foliage and flowering plants in Hawaii. In: *Plant nutrient management in Hawaii's soils*. College of Tropical Agriculture and Human Resources. Silva, J.A. and Uchida, R.S. (eds),, University of Hawaii at Manoa. pp. 57- 65.
- Wolmarans, D.N. P., C.S. Buitendag and A. De Jager. 2008. Energy and nutrient composition of South African wheat, wheat flour and bread. *Technical report to The Winter Cereal Trust of South Africa*. ISBN: 978-1-920014-54- Medical Research Council of South Africa