AGRONOMIC PRACTICES ON SAGO PALM; THE SARAWAK EXPERIENCE

ABDUL HALIM HASSAN, Dato' Dr
CRAUN Research Sdn. Bhd. (CRAUN), Jalan Sultan Tengah, 93055 Kuching, Sarawak. Malaysia

Abstract

Sago flour, extracted from the trunk of mature sago palm, has been reported being traded in South East Asia as early as 1200 AD. The sago starch is found in the maturing sago palm, during its vegetative phase, with maximum content at flowering time. Of the several species of starch producing palm, *Metroxylon sagu Rottb.* is the most important palm being commercially exploited for its starch content.

Sago palm is a hydrophilic, hapaxanthic (once flowering) and soboliferous (producing suckers) plant. It is found growing along the coastal flood plains and along the riverine for about one to two kilometers inland from the waterways. It occupies the mixed swampy land forest of the hot humid topics of South East Asian regions (as far as Bangladesh) and the Oceania. Sago palm reaches maturity in 8 – 15 years depending on the environment that it is growing in and produces an average sago yield of about 150 kg – 175 kg of dry starch per tree. A yield of more than 20 tonnes per ha of sago flour is possible under a very good growing condition in the rich alluvial plains of Malaysia.

Recognizing the great potential of sago palm as a carbohydrate source, both for food and other applications, the Sarawak State Government embarked on a programme to increase productivity of sago palms. To spearhead this project, Land Custody and Development Authority (PELITA) was entrusted with the development of sago plantation, and Crop Research and Application Unit (CRAUN) was set up in 1994 to undertake research and development both for upstream and downstream activities of sago rumbia.

Sarawak supports a diverse vegetation, occupying the peat swamps along the coastline and over the mountainous regions of Sarawak interior to the Indonesian border. Apart from having large areas of infertile mineral soils, the fresh water peat swamps of the coastal region support peat soils of various depths with about 40% of the total of peat areas consisting of very deep peat (Anderson 3). Since sago planting areas are found in the low-lying areas along the rivers of Batang Mukah, Batang Oya and Batang Igan, it was assumed that sago palm prefers the water-logged, fresh water basins of the peat regions. However, majority of these areas are infertile with serious limitation to most crop growth, and are generally considered unsuitable or at best marginally suitable for agricultural development purposes. Since large scale development has taken place in Sarawak and all suitable land has been utilized agriculturally, these marginal land are being exploited. Thus, ways to improve these organic soils by appropriate land improvements and soil amelioration must be developed. Methods to conserve the moisture or water regimes of the peat areas as well as development of management practices for efficient utilization of these soils are discussed with special reference to the development of sago cultivation in peat soils of Sarawak.

Starch Utilization - Sago and Starch Produced in the Tropical Area

Montri Chulavatnatol

Department of Biochemistry, Faculty of Science, Mahidol University, Rama 6 Road, Bangkok 10400, Thailand

(in preparation)

Socio-economic, Anthropological Studies regarding Sago Palm Growing Areas

Yukio TOYODA
College of Arts, Rikkyo University, Nishi-ikebukuro, Toshima-ku, Tokyo

Key words: anthropology, vegeculture, multi-species growing, personification, myth

Abstract

The areas people grow sago palm cover a part of South East Asia, south Asia, and Melanesia. This paper deals with the outline of socio-economic and anthropological studies that have been conducted so far in these areas.

In order to describe the agriculture of these areas, the concept of vegeculture, or vegetative planting culture, has turned to be useful. It was proposed by Karl Sauer and other scholars, and has been developed by Japanese botanist, Sasuke Nakao. He suggested that vegeculture is a very basic category of farming culture in human world history. This concept, vegeculture, is contrasted with seed-planting culture which grows cereal grains, such as wheat, maize and rice. In the system of vegeculture, there are several groups of crops as major components, which are bananas, yams, and aroids, sugarcane, sago and breadfruit. According to Nakao, people used to cook bananas and root crops on hot stones in earth ovens, which is still observed in some Pacific areas. In the case of poisonous root crops, people mashed the raw starchy material, and then leached it in water. From these methods, Nakao argued, people developed the techniques now used to extract sago starch.

Those people who grow sago as their crops basically practice vegeculture, and they have some common characteristics when we look at the social aspects of their agriculture. First, vegeculture grows a lot of species as its crops, while seed-crop agriculture grows very few kinds of species. Even when we find few species in the garden, people distinguish many types of varieties, and they give different local names to each. Although the vegeculture is less productive compared with seed-planting agriculture, it is more stable than seed-crop. This could be related with the fact that the system of vegeculture has a lot of species as its products.

Secondly, the accumulation of wealth has not developed very much in these areas. Since it was hard to keep root crops for a long time, people could not store these crops as their wealth, while seed plant, such as rice and wheat, is easily stored and can be accumulated as wealth. The technique of storage in the vegeculture area has not developed much, and this could be a major reason, together with the lack of transporting technique, why the people there have not developed accumulation of wealth. This could be one of the main reasons why large political organization did not develop in the vegeculture areas.

Crops play a lot of social roles in these areas. A typical case is yam. People often give special meanings to yams, especially in Melanesia. Yams are considered not only as "food", but also as "gifts" in rituals. They are often treated as special crops and many rituals are performed in relation with yams. Some species of taros, bananas and also sago are also used as gifts when they have to pay bride wealth, or to compensate for the troubles between communities.

The next feature is that crops in these areas are often personified. They are treated as if they are living human beings. When yams do not grow well, people sometimes rub them in order to let them grow well. We have examples from Papua New Guinea that people decorate yams as if they are human, and display them in the center of village when they harvest yams. Other crops are also treated as if they are human. Relating with this, these areas often have gender classification in some crops. Some crops are treated as male, and others as female.

Among the people in sago growing area, we find similar myths that explain the origin of planting crops. The stories begin by killing someone, usually a girl. The body of the dead was cut into pieces, and they were buried in the ground. Later, from each piece of the body, crops began to grow, and the people found that they were edible, and they began to grow them. These stories tell how people began cultivating root crops, such as taro and yam, and also sago. The distribution of these myths shows the similarity of their culture and it is possible that it might explain the ways of diffusion how people began to grow crops, including sago.

Sago starch production in Asia and the Pacific - problems and prospects

Christopher Oates[1], Alastair Hicks[2]

[1]Agro Food Resources (Thailand), Bangkok, Thailand
[2]FAO Regional Office for Asia and the Pacific (RAP), Bangkok, Thailand

Abstract

Sago palm is experiencing, in some countries, a resurgence of interest that stems from its value in food security and potential for income generation in sustainable livelihood systems. Managed correctly, sago palm can provide benefits to farmers and processors, yet offer an ecologically sound alternative for increased land use. Technological advancement in this sector must be balanced between removing the drudgery of manual starch extraction for household processors (mainly the women) and not providing a means of over-exploiting the natural environment. Processing technology must also be appropriate and posses an inherent limitation such that excessive felling will not become an issue.

These issues are discussed by reviewing the processing of sago palm for starch. Issues relating to production of sago palm and starch utilization are discussed in the perspective of starch extraction. The main issues examined include sago processing for starch and the properties of this starch. Within the region four different levels of technology sophistication co-exist, these are described in detail. Problems and benefits of structural changes in the sago industry are also discussed, with the view of developing guidelines for the sustainable and socially acceptable production of sago starch, at an industrial scale. The paper also provides background on sago starch functionality, emphasizing quality aspects and how they are influenced by processing. Finally, issues on sustainability of this natural resource are mentioned, highlighting some of the past, non-sustainable, practices as examples.

This review paper is based on available literature and field study in the sago processing countries of ASEAN and Papua New Guinea.

THE CURRENT SATUS AND FUTURE PROSPECTS OF SAGO PALMS IN JAVA

Haryadi

Faculty of Agricultural Technology, GMU, Bulaksumur 55281Yogyakarta, Indonesia

Key words: *Arenga, Metroxylon*, starch production, utilization, future prospect

Abstract

Arenga and *Metroxylon* sago palms grow naturally in Java. The palms are harvested by the villagers to get cut logs. Usually it takes a long way to carry the logs to the starch extraction site. The logs are processed traditionally by small industries to produce starch. The main utilization of the starch is to make starch noodle.

The sago starch demand in Java can not be met by the local production, thereby sago starch must be brought from other islands. The consumption of sago starch tends to increase due to, among others, the population growth.

Since there is almost no effort at all to replant especially *Arenga* sago palm, sustainability of sago starch production in Java is in danger. On the other hand, the lands potential for both *Arenga* and *Metroxylon* sago palms are probably abundant; there are particularly at river bank at which commonly the palms are found. The predominant tree that grows at river bank is bamboo which is considered suitable for land conservation. *Metroxylon* sago palm may replace the bamboo position, in addition to supply logs containing starch. Though *Metroxylon* sago palm potentials are superior over *Arenga* one in terms of starch productivity and sustainability, the latter should not be omitted.

SAGO CULTIVATION IN NORTHERN MINDANAO PHILIPPINES

A. R. Josue and M. Okazaki[1]

Central Mindanao University, College of Agriculture, Musuan, Bukidnon 8710, Philippines
[1]Tokyo University of Agriculture and Technology, Graduate School of Bio-Applications and Systems Engineering, Koganei, Tokyo 184-8588, Japan

Key Words: Sago palm, Northern Mindanao, sago forest, thatch roofing

Abstract

A survey of sago cultivation in the coastal areas of Northern Mindanao was conducted by mapping and documenting sago palm stands in various stages of growth including its utilization practices. Observations on the growth and density of the sago palm was established in permanent grids of 20 x 20 meters with three replications.

Sago growth in Northern Mindanao, Philippines that were mainly observed along the coastal areas of the island is sporadic in distribution, characterized by presence of clusters containing 3 to 5 leader palms and several young palms at various stages of growth. Sago palms were observed growing in degraded mangrove and marshland areas. The largest and most dense sago growth area was estimated to be about 30,000 square meters and the least dense were in clusters of 3-5 m^2 having 2 to 3 leader palms with several young suckers.

Sago is mainly grown for thatch roofing materials and as a source of fuel wood which the farmers sell to supplement their income. Starch extraction is done rarely and only in extreme cases of food shortages in the farm. Starch extraction is crudely done and the starch produced is not of good quality.

Sago growth and density study in permanent plots is currently being conducted in Alubijid, Mindanao. Data on palm density growth characteristics such as height, girth, number of fronds and leaves are collected annually.

Growth and Starch Production of Sago Palm in South-East Sulawesi: Effect of Soil Water Regimes.

Y.B. Pasolon[1 2], Subair[2], M.Udin[2], F.S. Rembon[2], M. Hamundu[2] and Y. Yamamoto[3].

[1]Dry Land Research Center, [2]Faculty of Agriculture Haluoleo University, Kendari 93232, Sulawesi Tenggara Indonesia.[3]Faculty of Agriculture, Kochi University, Nankoku-shi, Kochi-Ken, 783-8502 Japan.

Keywords: Soil water regimes, starch production, vegetative growth .

Abstract

Sago palm (*Metroxylon sp*) has a cultural values in indigenous people of Tolakinese since a couple hundred years ago. However, due to the changing of rice to become a staple food, sago plantation gradually reduced. It was reported that in 1980 total area of sago palm in Southeast Sulawesi was 33,000 ha. Recently, the rest of sago fields in this province were less than 13,706 ha. The destruction of sago fields was mainly due to the increase of non-sago staple food culture migration. Naturally most of the sago fields were growing in a swampy area and riverbanks of mineral soils without agro-chemical fertilizer input and lack of management. Sago starch extraction (*sumaku*), was traditionally conducted inside of sago field without quality control. Leaf cutting was more seriously in a several local sago plantation. Tolakinese classified the natural sago palm into four different types, namely: a). *Roe* refer to *M. sagus* Rottb., b). *Runggumanu* refer to *M. rumphii* Mart, c). *Rui* refer to *M. microcantum* Mart. and d). *Baruwila* means white sago.

The objectives of this paper were focussing on an analysis of vegetative growth and starch production of *M. sagus* Rottb and *M. rumphii* Mart. which naturally growing on three different types of soil water regimes: dry soil, riverbank and swampy area. The experiment was conducted in 1996 and 1998. Plant population, number of leaf and leaf scars, trunk length, trunk diameter and weight, starch content, yield of dry starch and soil chemical properties were observed.

Naturally dry soil was never flooding in along year, riverbank was flooded in a short period of overflowed and swampy area was naturally flooded in a long period. Soil textures were dominated by silt to silty loam, soil pH = 4.4 to 4.8, organic-C = 2.27 to 2.91 %, total N = 0.19 to 0.28 %, available P = 15 to 20.67 mg/kg and exchangeable K= 0.15 to 0.17 cmol/kg. Plant population, number of sucker, trunk diameter, trunk length and leaf number was lower in the dry soil than in the riverbank or swampy area. The same phenomenal was observed on starch density, starch concentration and dry starch production. There was an indication that continuously flooding of the rhizosphere in swampy area was delayed the harvesting from 2 to 3 years. In the case of root density and maximum root depth, dry soil produced higher root density and deeper root depth compared with riverbank and swampy area.

Based on the above results we concluded that sago palm was grown more better in a swampy area than in a riverbank or dry soil, however, vegetative growth of sago palm in the swampy area was longer than in the riverbank or dry soil. There was also an indication that sago palm could grown well in an upland soil as far as the water table not less than 50 to 70 cm depth respectively.

Shortcut to Sago Palm Plantations: Rehabilitation of Natural Sago Forests into Sustainable Sago Plantations

Foh Shoon JONG

PT. National Timber & Forest Products, No. 105-109, Jalan Jen. A. Yani, Selatpanjang, 28753, Riau, Indonesia

Key words: Metroxylon sagu, sago palm, sago forests, rehabilitation, plantation.

Abstract

Of the 2.6 million hectares of sago palms (*Metroxylon sagu* Rottb.) found worldwide, about 2.4 million hectares are found as wild or natural sago palm forests in Irian Jaya and Papua New Guinea. These natural resources are only exploited commercially to a small extent. To benefit mankind more adequately, they should be increasingly tapped through selective harvesting and rehabilitation.

In undertaking such a project, the social and political stability in the area needs to be studied. The procedures of sago forest acquisition and the practice of native customary land rights in some localities are other issues to be tackled. After addressing these issues, aerial and on site survey can be carried out to identify the palm density, variety or species composition as well as the starch contents of the sago palms. A sound infrastructure and transportation system needs to be built and the soil water table needs to be appropriately regulated. To enable the choice and design of the desired agronomic practices, infrastructure and transportation systems, a soil and topography survey has to be carried out.

Only mature and high yielding palms are to be harvested for processing in the rehabilitation process, with an estimated starch yield of about two to five tons per hectare. Undesirable sago palms as well as unwanted vegetation should be felled to reduce competition with the desired palms. Empty gaps should be filled with high yielding suckers to maintain the density of desired sago palms at about 100 – 150 rather evenly spaced palm clusters per hectare. Regular field maintenance like weeding and fertilizer application needs to be carried out to ensure sustainable palm growth and starch yield.

As compared to the ten years required to reap harvest from new sago palm plantations, a properly designed and executed rehabilitation programme can transform sago forests into productive sago plantations in a much shorter time. After a lapse of about 3 to 5 years from the initial rehabilitation, annual harvest of mature palms can commence. The estimated starch yield is expected to increase gradually from a few tons to plateau off at about 10 to 15 tons per hectare per year.

The First Trial of Import and Transplanting Sago Palm in Tanzania[1]

A.J.P. Tarimo[1], H. Runkulatile[1], Y. Takamura[2] and K. Osozawa[3]

[1]Sokoine University of Agriculture, P.O. Box 3035, Morogoro, Tanzania
[2] 1-165, Shinmonjyo-cho 17-1, Fukakusa. Fusimi-ku, Kyoto, Japan
[3]Ehime University, Japan

Keywords: importation, sago palm, transplanting, tropical area, Tanzania

ABSTRACT

Sago palm (*Metroxylon sagu* L.) was first grown in the Tanzanian soil on April 1, 2000. This occurred after long discussions between Scientists at Sokoine University of Agriculture in Tanzania and their counterparts in Japan (The Kyoto University Sago Palm Research Fund) under the leadership of Prof. Yasuo Takamura regarding introduction of the crop to Africa.

Suckers of sago palm were imported from Indonesia with the assistance of Scientists at Hasanudin University. On arrival in Dar-es-Salaam, Dr. Osozawa and Dr. H. Runkulatile received them from the custom officers at the airport. The suckers were taken to Morogoro (200 km west of Dar-es-Salaam), by a pick-up truck where they were immediately transplanted. To the best of our knowledge, this was the first time that the plant was grown in the African soil. Two sites were earmarked for establishing the seedlings, i.e. at Sokoine University of Agriculture Horticultural Unit and Mkindo Farmers Training Centre (MFTC) in Turian (about 75 km North of Morogoro). In all, 20 suckers were planted at the Horticultural Unit and 30 were transplanted at Mkindo FTC. These sites differed slightly, i.e. Morogoro being rather drier with kraznozem type of soils and Mkindo being hot and humid with mostly clayey type soils. Our first impression was that Mkindo would have been more suitable for the crop than Morogoro due to the good climatic and soil characteristics.

Preliminary results have shown, however, that neither site was more favourable for growth of the crop. At both locations, for example, the rate of deterioration of the transplanted suckers with time was similar. By August 2000 only one sucker was surviving at each location. The surviving suckers had shown all the characteristics of rooted plants as described in the main paper. To date, however, only a single plant is still surviving at the Horticultural Unit. Wild fires set out by the Maasai herdsmen damaged the survived plant at MFTC.

Plans are under way to import more suckers from Indonesia. We are convinced that if new seedlings were available, we would maximise the experience gained to ensure survival of greater numbers of suckers than it has been during the first introduction exercise.

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Silvicultural Techniques in Sago Palm Seedling Selection and Transportation

Dorthea Agnes Rampisela

Kampus tamalanrea, Jalan Perintis Kemerdekaan, Makassar(Ujung Pandang), Indonesia

(in preparation)

Plant Regeneration via Somatic Embryogenesis from Immature Leaf Tissues of Sago Palm (*Metroxylon sagu* Rottb.)

J.S. Tahardi and Nesti F. Sianipar

Biotechnology Research Unit for Estate Crops, Jl. Taman Kencana 1,
Bogor 16151, Indonesia

Key words: Sago palm, somatic embryos, plant propagules, cloning

Abstract

The sago palm (*Metroxylon sagu* Rottb.), a monocot tree native to the tropical swamplands, is fast becoming an important source of industrial starch. Sago palm is generally propagated by suckers or seeds. As sago palm cultivation is expanding on a plantation scale, it has become increasingly difficult to meet the demand for superior planting materials through conventional propagation. An alternative technology through tissue culture must be developed to enable production of elite clonal planting materials *en masse*. In this paper we report a procedure for rapid regeneration of sago palm via somatic embryogenesis. Shoot apical tissues and unemerged leaves from young suckers were cultured in a modified Murashige-Skoog (MS) medium containing a combination of auxin and cytokinin, with 0.15% activated charcoal, 3% sucrose and 2 g/L Gelrite. Dichlorophenoxyacetic acid (2,4-D) was used at 25-200 mg/L in combination with kinetin at 0.1-1.0 mg/L. After 1 month in culture in the dark, the explants expanded and began callusing. After another 2-3 months in the light, nodular structures appeared. The nodules were friable and highly proliferative upon subculturing. Transfer of these nodules to media with reduced levels of 2,4-D (5- 10 mg/L) led to the development of somatic embryos similar to those reported in oil palm. Germination of the somatic embryos and subsequent plantlet regeneration were achieved in the same MS medium without phytohormones. Further research is underway to optimize and scale-up the procedure for efficient production of sago palm somatic embryos and propagules.

SMART OPTIONS FOR SUSTAINABLE SAGO PROCESSING

K. B. Bujang

Molecular Biology and Biotechnology, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia

Keywords: sago processing, starch extraction, liquid effluent, solid waste. waste utilisation.

Abstract

Sago is one of the main agricultural products of Sarawak, which gained national recognition as being the key crop to be established in the swampy regions, which occupies 70% of the state. Being able to flourish with minimum care and having little known pest, the success of large-scale sago planting rests largely on suitability of the soil, efficient starch extraction methods, process diversification and significant participation of related government agencies for such ventures to be viable. Sago processing is a potentially polluting industry in terms of solid and liquid waste production. Discarded fronds and cuttings may create a fire hazard and pest problems in the plantation. Barks from the sago trunk are fairly resistance to degradation and may take years to decompose. Although some research works have suggested this for use as construction and flooring material, these suggestions are yet to be perceived seriously by this industry. Solid waste consisting of fibrous vascular bundle from rasping of the pith currently free-flows into the waterways without any significant treatment. The average consumption for a medium size sago mill is between 600 – 800 logs per day. At about 20% the weight of each log and at an estimated 20 litres for every kilogram of starch extracted, these wastes represents a formidable amount of pollution generated daily from the bark and liquid effluent, respectively. Several prominent reports have envisaged the use of treated sago effluent in fermentation for the production of solvents such as acetone and buthanol. Others have separated the solid pith residue from the effluent and successfully composted this largely cellulosic waste for use as a soil conditioner. In the event of shortage in supply of sago logs, increasing cost in starch production or decline in demand for sago starch, conversion of sago starch into high fructose syrup, lactate or ethanol may prove to be highly profitable compared to export of pure starch. An appropriate waste management option will convert these problems into a possible cost-effective venture for the sustainability of this industry.

The Development of Technology For The Extraction of Sago

J. E. Cecil

No affiliation.
9 School Place, Oxford, OX1 4RG, UK

Key words: Sago starch, processing, traditional technologies, technology development, industrial pollution.

Abstract

This paper describes the author's experiences in monitoring the development of technology for the extraction of sago starch from *Mauritia* in Venezuela, *Arenga* in Java and *Metroxylon* in Malaysia, Indonesia and PNG in many diverse situations over the course of many years. He describes different technologies people have used to make sago and reviews how sago extraction technology developed from primitive hand tools to modern starch factories.

The paper begins by reviewing non-mechanical extraction technologies used in the forest and in cottage industries. It describes a very efficient non-mechanical technology used in Malaysia until the 1970s for extracting starch from *Metroxylon Sagu*. It then follows the introduction of mechanisation into this process and discusses the types of primitive machines used at this stage.

Before going further into the next stage of mechanisation – that of mechanising several steps of the process at a single site or factory, the paper looks at pollution problems resulting from large quantities of pollutants being discharged into the environment at a single place. The two main pollutants, soluble solids and fibre are quantified and their effects are discussed.

The paper then reviews the development of factory operations in Indonesia and Malaysia, but with particular emphasis on what happened in Eastern Malaysia. It discusses the construction by a government agency of a refinery at Sibu to try to improve the quality of starch produced in Sarawak and the reasons why this refinery was less successful than had been hoped. It describes the efforts of individual entrepreneurs to capture a greater share of the market by extending the mechanisation of the process in their own factories and the techniques they used to improve the quality of the starch they made. It describes efforts people made to improve efficiency and reduce labour costs – some of which were successful and some spectacularly unsuccessful.

Finally the paper reviews the difficulties that can be faced by a large factory and the impact a large factory can have on the local community, both in obtaining and cornering supplies of raw material and in sweeping away existing low technology operations that would otherwise employ large numbers of local people.

Genetic Variation of Sago Palm (*Metroxylon sagu* Rottb.) in the Malay Archipelago

H. Ehara [1], S. Kosaka [1], N. Shimura [1], D. Matoyama [1], O. Morita [1], C. Mizota [2], H. Naito [3], S. Susanto [4], M. H. Bintoro [4] and Y. Yamamoto [5]

[1] Faculty of Bioresources, Mie University, 1515 Kamihama-cho, Tsu 514-8507, Japan, [2] Iwate University, [3] Kurashiki University of Science and The Arts, [4] IPB, [5] Kochi University

Keywords: Genetic distance, *Metroxylon sagu*, Microsatellite, RAPD, The Malay Archipelago.

Abstract

The true sago palm belongs to the genus *Metroxylon* and has often been classified into two species, *M. sagu* Rottb. and *M. rumphii* Mart., based on morphological characteristics – the absence or presence of spines on the petiole and rachis (Beccari 1918). Rauwerdink (1986) proposed recently that *M. rumphii* (the spiny type) should be synonymous with *M. sagu* (the spineless type). On the other hand, sago palms are classified in more detail in folk classifications used by native people who have subsisted on sago, and then it is considered that many varieties may be existences. Previously we reported that sago palm production would be closely related with soil fertility in the eastern archipelago of Indonesia (Ehara et al. 1995). However, to determine the factors relating the starch production, the genetic diversity of sago palm should be investigated. In this study, random amplified polymorphic DNA (RAPD) analysis was performed to estimate geographical and genetic relationship among local varieties growing at different sites in the Malay Archipelago.

The plant material contained 39 populations, which included 38 populations of sago palm (*M. sagu*) collected from 22 sites in the Malay Archipelago and 1 site in PNG: 16 spineless and 22 spiny populations, and 1 population of *M. salomonense* Becc. originated in the Solomons. Newly expanded leaflet of young palm was cut into small pieces and silica-dried or freeze-dried. Total genomic DNA was extracted using either the CTAB protocol or ISOPALNT (Nippon Gene). The PCR was performed as has been described by Ehara et al. (1997), using five 10-mer primers (P01, P02, P04, P06, P17). Total DNA of every population was amplified twice, and the reproducible products were rated as the population's own products. Each population's product was considered to be a unit character, with which the populations were scored for the presence (1) or absence (0) of a product. Genetic similarity (S) between all pairs of populations were calculated and converted into dissimilarity D (= – ln (S)). A cluster analysis by using the neighbor-joining (NJ) method (Saitou and Nei 1987) was conducted.

A total of 40 PCR products were detected from all the populations. Of 40, five products were shared by all of the populations, and 35 products were polymorphic among 39 populations. The cluster analysis showed that all the tested populations were divided into at least three main clusters consisting of the local varieties in the eastern area and the western area of the Malay Archipelago, and Melanesia. It was also suggested that the local varieties in the eastern area of the Malay Archipelago might have larger genetic variation than the local varieties in the western area. Moreover, we have got a result that chloroplast microsatellite will be of considerable help to estimate genetic relationship among sago palm varieties.

Genetic and morphological variation of the sago palm (*Metroxylon sagu*) in Papua New Guinea using AFLP

A. Kjær

Dept. of Systematic Botany, Aarhus University, Denmark, andkjaer@hotmail.com

Keywords: *Metroxylon sagu*, AFLP, Morphological variation, Papua New Guinea

Abstract

New Guinea is a center of morphological variability of *Metroxylon sagu*. The morphological variation includes presence/absence of spines, height, number and size of leaves etc. Based on these characters local villagers distinguish a number of types. Morphological variability is apparently linked to features such as sago-quality, fiber density and hardness of trunk, which are determinants of the utilitarian value of the individual types. The purpose of the present study is to describe the morphological variation of sago palms within and between populations and to relate this to genetic distances. In this way we will be able to address a number of pertinent questions relating to phylogeny and biogeography. Recently Rauwerdink joined the two former species, *M. sagu* (non-spined) and *M. rumphii* (spined) into *M. Sagu*. Hopefully the results of our work will allow us to test his basic assumption that presence and absence of spines is controlled by a two-allele genetic system. Fieldwork was conducted in Papua New Guinea during a three month period in 2000. One hundred and thirty two palms were sampled at seven different localities in the Western, Milne Bay, Morobe, East Sepik and Sandaun Provinces of Papua New Guinea. A sampling method was devised based on experiences gained during a pilot project conducted Nov.-Dec. in 1999. Information on local naming and use was recorded. From each palm ramet the following morphological variables were measured: height, dbh., length of petiole, length of rachis, number of pinnae, width of pinnae, length of pinnae and height and width of petiole at first pinnae. DNA material was sampled from the young leaves and analyzed using Amplified Fragment Length Polymorphism (AFLP).

Genetic Diversity Identification of *Metroxylon sagu* in Alubijid by Random Amplified Polymorphic DNA Assay

L. L. Celiz[1], K.Toyota[1], M. Okazaki[1] and A. R. Josue[2]

[1]Graduate School of Bio-Applications and Systems Engineering, Tokyo University of Agriculture and Technology, 2-24-16 Nakacho, Koganei, 184-8588 Tokyo, Japan
[2]College of Agriculture, Central Mindanao Unviersity, Musuan, Bukidnon 8710 Philippines

Key words: sago leaflets, RAPD, PCR, electrophoresis, Alubijid

Abstract

The RAPD (randomly amplified polymorphic DNA) method uses a synthetic, ten-base long chain which are subjected in a polymerase chain reaction (PCR) to amplify genomic DNA which are useful for distinguishing variations in DNA. This experiment was carried out using 3 different primers (Primer 2, Primer 4 and Primer 17) and different sago leaflet samples to distinguish genetic variation of sago palms and to compare genomic "fingerprints" of spiny and non-spiny type sago palms in the experimental site in Alubijid, Philippines.

PCR was performed at 94°C for 1 min followed by 45 s of 93°C for 1 min, 42°C for 2 min and 72°C for 2 min. Final elongation was conducted at 72°C for 7 min. PCR reaction volumes were 50 μ l, each containing 5 μ l of 10 x reaction buffer, 5 μ l of (2.5 mM each) dNTP, 10 pM of Primer, 2.5 μ l dimethyl sulfoxide, 0.25 μ l Taq polymerase (TaKaRa Ex Taq) and 1 ng DNA extract. 5 μ l of the amplified volume was electrophoresed at 1.5-2% agarose gel containing 1 x TAE buffer stained with ethidium bromide at 50 volts for 60 minutes and visualized using a UV transillumintaor.

All primers used gave amplified products in all samples extracted at 100^{th} dilution. However, banding pattern varies with the primer. RAPD analysis followed by PCR showed genetic variation between and within populations of sago palm in the experimental site and between spiny and non-spiny types. The PCR efficiency depends on the purity of DNA, amplification reaction factors and conditions. The use of RAPD analysis in the identification of genetic variation of sago palms needs further studies.

Phylogenetic and Biogeographical Analysis of Metroxylon Section Coelococcus in the Western and South Pacific.

Will C. McClatchey

Department of Botany, University of Hawaii at Manoa, Honolulu, Hawaii, 96822-2279, U.S.A.

Key Words: Metroxylon, thatch, phylogenetic, Coelococcus, Pacific Islands, biogeography.

Abstract

The genus Metroxylon has been shown to consist of two sections, Metroxylon and Coelococcus. Section Metroxylon questionably circumscribes more than one species that spread from New Guinea to the Philippines and Peninsular Malaysia. Section Coelococcus extends from the Solomon Islands to Vanuatu, Samoa, Fiji and Pohnpei. Morphological phylogenetic studies of section Coelococcus demonstrate that it consists of two clades, each of which is supported by several synapomorphies. Within each clade, the distinction of species is much less clear. The biogeographical distribution of the species with each of the clades of section Coelococcus will be discussed within the light of phylogenetic analysis. It is hypothesized that recent evolution within section Coelococcus leading to the species currently recognized may be due in part to human selection pressures on small wild and semi-domesticated populations as well as founder effects from anthropogenic or natural distribution events.

Sago Waste Residue as Herbicide Alternative at Pepper Field

H.M.H. Bintoro [1] Anis Tatik Maryani [2] Nobuo Sugiyama [3] and Kuniyuki Saito [4]

1) Bogor Agricultural University, Kampus IPB Darmaga, Bogor 16680, Indonesia
2) University of Riau, Kampus Bina Widya, Pekan Baru 28193, Indonesia
3) University of Tokyo, Graduate School of Agricultural and Life Sciences, Yayoi, Bunkyo-ku, Tokyo 113, Japan
4) Okayama University, Faculty of Agriculture Tsushima Naka-1-1-1, Okayama 700, Japan

Abstract

The aim of this experiment is to evaluate the effect of some mulches, especially sago pith residue on weeds and pepper (*pepper nigrum* L) growth. The experiment was conducted at Darmaga Research Station, from January to May 2001. The treatments were control (without mulch) as M0, plastic mulch as M1, weeds cutting mulch as M2, sago pith residue as M3 and wooden dust as M4. Every treatment was replicated four times. The result showed that all treatments decreased weeds growth at pepper field. Plastic mulch was the best treatment for decreasing weeds growth. However sago pith residue could decrease weeds growth four times (fresh weight) and nine times (dry weight).

The effect of some mulch on number of pepper primary branch was not significantly different, but the best treatment for number of primary and secondary branch were M2 (weeds cutting mulch). Sago pith residue treatment caused the least number of pepper leaves and pepper height.

On Utilization of Fibrous Residue of Sago Palm as Media for Cultivation of Edible Mushroom

Nadirman HASKA

Agency for the Assessment and Application of Technology
(BPP Teknologi, Indonesia)

Abstract

Oyster mushroom or abalone mushroom (*Pleurotus ostreatus*) in Japanese called "shimeji", while in Indonesian called "jamur tiram" is once popular mushroom in Indonesia since ten years ago. Product of this mushroom is consumed as food in its fresh condition. The processed kind of oyster mushroom like crispy or chips (tiram crispy or tiram chips) can be obtained in the super market, this products has been exported to Singapore and Hong Kong.

Substrate or media for cultivation of the mushroom contained such saw-dust, rice siftings, gibs/lime, starch (tapioca/sago/aren) and water. Not all kinds of saw-dust can be used for media cultivation of mushroom, the best saw dust for media is from the *Albizia falcataria* L. wood, this wood can be found easily in Indonesia, especially in Java Island.

The mixing of saw-dust with fibrous sago residue showed positive influence. Giving 20 to 50% of the fibrous sago residue have shown positive impact on the mushroom's growth. The first harvest can be accelerated from 32 days to 27 or even 25 days. Addition of fibrous sago residue more than 30% can reduce the use of starch on the substrate. The level of productivity has not showed significant increase, but it effect very much on the mushroom's production cycle, from an average of 60 days/cycle to an average 50 days /cycle. Adding more than 50% of fibrous sago residue does not give any benefit to the mushroom productivity.

Effect of Sago on Methane Emission and Carbon Dynamics in Tropical Peat Soil

K. Inubushi [1], M. Okazaki [2] and K. Yonebayashi [3]

1) Faculty of Horticulture, Chiba University, Matsudo, Chiba 271-8510 Japan
2) BASE, Tokyo University of Agriculture and Technology, Koganei, 184-8588 Japan
3) Faculty of Agriculture, Kyoto Prefectural University, Kyoto 606-8522, Japan

Key words: global warming, land-use change, sago plantation, tropical peat, wetland

Abstract

Methane is one of the most important greenhouse gases, with rapid increase in its atmospheric concentration, relative rate being almost at 1.0 % annually. Methane has strong infrared absorbing potentials as 20-30 times of CO_2 at a molecule basis. Since methane is terminal product of anaerobic decomposition process of organic matter, major sources of methane are natural wetland, paddy fields, ruminant animals and termites. Although total area of tropical peatland (30 million ha) is about 6% of world natural wetland, its two thirds are distributed in Southeast Asia and potentially important for agriculture and aquaculture. Nevertheless there are few knowledge about methane emission from tropical peatlands. This paper will deal with production and emission of methane in tropical peat soil as affected by land use changes from secondary wetland forest to sago palm (Metroxylon sagu) plantation and further possibile influences on methane production after changing to paddy fields, in Sarawak, Malaysia. Carbon storage in soil and plant biomass as well as losses through dissolved organic carbon in ground water and soil respiration were summarized in these ecosystems. The effect of land-use change from wetland forest to sago palm plantation on methane gas flux and organic carbon dynamics in tropical peat land was studied at field and in laboratory using tropical peat soil of SG. Talau Dalat Peat Research Station, Sarawak, Malaysia. Small amount of methane was released from soil surface of both forest and plantation field and no significant difference between two forests (1.1-2.2 mg CH_4 m^{-2} hr^{-1} or 0.96-1.93 mg ha^{-1} yr^{-1}); thus, the amount of methane emission from total area of tropical peat soil was estimated as 2.14-2.72 Tg yr^{-1}, contributing only 0.5 % of total global methane emission. Sago palm contained much less carbon as biomass but lose more through dissolved form in ground water.

Summary

The positive impact of forecast climate changes on the productivity, range, and sustainability of Sago Palm (*Metroxylon sagu*) as a renewable resource.

Edward Allen and Roland Hornung
Plant Biotechnology Laboratories (PBL), Department of Agricultural Sciences, Faculty of Life Sciences, Imperial College at Wye, University of London, Wye, Ashford, Kent, TN25 5AH, UK.

The latest IPCC report forecasts that in the coming 50 years there will be highly significant changes in the global temperature regime, concentration of CO_2, and precipitation regimes over all areas of the world, with the most significant changes occurring over mid and high latitudes. However tropical areas are likely to change, warming slightly and have an altered rainfall distribution.

This is consistent with recent bioecological modelling, which is briefly reviewed. The paper will highlight potential sago growing areas for future generations based on current and projected environmental changes. The greatest challenge with the advent of climate change will be responding to the impact of new environmental regimes emerging world wide, especially the forecast increase in variability of rainfall for tropical areas. Sago appears to be pre-adapted to growing in new areas including a variety of soil types. However, investigations need to be carried out on the identification of suitable elite palms for the new environments.

Mutation breeding has been identified as an efficient way of creating new cultivars, but it is suggested that this should be done in tandem with work on clonal propagation of sago *in vitro*.

Three new ecological niches are identified as having most promise for exploitation by sago: newly inundated tropical areas due to sea-level rise, tropical areas wetter than before caused by changes in precipitation pattern, and existing wet tropical areas warmer than before due to the effect of global warming.

The nature and quality of the starch formed in the sago bole may also be improved by applying modern biotechnological techniques such as genetic modification. Applying these technologies will make it possible to respond efficiently with the provision of planting material for new niches both in existing and non-traditional production areas, arising from forecast changes in climate.

This approach appears to be especially applicable to gearing sago production towards production of long chain organic polymers for the plastics industry, as a more sustainable and lower risk alternative to traditional crude oil sources. Plastics produced from starch have already been shown to be biodegradable.

Finally it is concluded that sago will benefit from forecast climate changes, that these changes offer great opportunities for increasing sago production areas, and further improve the already promising outlook for sago production in the 21st century. However, the greatest benefits will be derived if this is coupled with an intensive breeding program.

ABSTRACT

SAGO COMMERCIALIZATION IN PAPUA NEW GUINEA: PNG - World Leader in Sago in the 21st Century!

A.P.Power[1]

Papua New Guinea is in the process of developing a National Plan for Sago Commercialization. This paper discusses the elements of this plan and the basis of PNG's aspiration to become world leader in sago in the 21st Century. The paper begins by noting the extent of the existing resource located in commercial quantities in several provinces in Papua New Guinea. Detailed assessment of the Malalaua District of the Gulf Province is reported. Of the more than 1 million hectares under sago 90% is concentrated in two provinces. Innovative joint venture agreements with local landowners have been developed to provide long term security of access to the resource. Papua New Guinea sago development is positioned to capitalize on the commercial and technical sago harvesting and manufacturing knowhow of Malaysia by an alliance between Sago Industries Limited and Songiing Holdings Sdn Bhd, the largest and most efficient sago manufacturer from Sarawak, Malaysia. Sago Industries Limited initiatives have resulted in various Memoranda of Agreements with National and Provincial Governments. Desktop study by Songiing Holdings Sdn Bhd estimates that to realise the potential of a commercial sago industry in Papua New Guinea an investment of US$770 million over eight to ten years can result in production of 4 million tonnes high quality organically grown sago starch valued at US$680 million annually.

[1] A.P.Power, Managing Director, Sago Industries Limited, PO Box 1907 Port Moresby, powcrap@daltron.com.pg

QUALITY IMPROVEMENT OF SAGO (METROXYLON SAGU) STARCH PROCESSING.

M.Z. Abdullah, Y.P. Ean, . A.R. Shariza ., D.M.A. Manan and B.M. N. Mohd Azemi

School of Industrial Technology, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia

Key words: sago starch, starch utilization, tropical areas, biotechnology, waste residue

Abstract

Traditional practices of extracting sago starch suffer from low extraction rate and inferior quality in term of purity, and colour. Colour being one of the contributing factors of quality sago starch was chemically controlled during post extraction stage and monitored manually prior packing. This paper describes an attempt to improve the extraction rate through enzymatic treatments and automatic machine vision inspection of the quality features of sago starch at post extraction stage. The features considered were colour and granules sizes. The conditions of physical and mechanical extraction processes of sago starch currently employed allowed only about 50% extraction rate with the remaining discharged together with fibrous substances as wastes. Often some impureties were also presence in the extracted starch. Using a mixture of cell wall degrading enzymes, starch extraction was enhanced by almost 30% and the characteristics somehow differ from commercially extracted starch. Particle size distribution favouring granules of smaller sizes, whiter in appearance and the presence of resistant starch were the unique characteristics of enzyme extracted sago starch. Evidently the rheological behaviours of the enzyme extracted starch were also differ from the commercially produced sago starch. The appearance of commercially processed sago starch often discoloured due to the presence of phenolic compounds may contribute towards acceptability. The image analysis system was developed in order to inspect and grade the starch automatically. This allowed inspection for quality control which otherwise done manually and subjected to human error.

Paste texture of sago starch in comparison with other commercial starches

W. S. Choi, S. Y. Lee and S.-T. Lim
Graduate School of Biotechnology, Korea University, Seoul 136-701, Korea

Paste texture (flowing property) of commercial starches of difference origins (sago, potato, cowpea, tapioca, sweet potato, normal corn, waxy corn, and rice starches) were compared using a texture analyzer (TA-XT2, UK), and their relations to the paste viscosity profile were measured. The long or short texture of starch paste could be determined by the slope from the minimum force peak in the force-distance curve obtained by a compression test, and also by the slope from maximum force peak in an adhesion test. These values were highly correlated with the setback in rapid viscogram ($r=0.81$, $p<0.01$), indicating that the paste texture is highly related to the intermolecular association. From the texture analysis with freshly prepared starch pastes, sago starch produced the longest paste whereas normal corn starch did the shortest paste. Also the sago starch paste displayed non-linear change in the adhesion force (the slope) while the analysis probe retrieved whereas other starch pastes showed relatively linear change. During a storage (25oC for 30 min), sago and sweet potato starch pastes tended to become longer whereas other starch pastes became shorter by retrogradation. These results indicate that the chain conformation and association behavior of sago starch are unique and different from those of other starches. More research is reserved in this respect.

Structural and Morphological Changes of Sago 'Raw Starch' during Storage at Room Temperature –A scanning electron microscopic study-

Y. Nitta, M. Honda, T. Matsuda, A. Miyazaki*, T. Yoshida*, Y. Yamamoto*, Y. B. Pasolon** and R. S. Gusti**

School of Agric., Ibaraki Univ., Ami, Ibaraki 300-0393, Japan; *Fac. of Agric., Kochi Univ., Nankoku, Kochi 783-8502, Japan; **Haluoleo Univ., Kendari 93232, Indonesia

Keywords: bacilli, decomposition, electron microscope, raw starch, storage

Abstract

Sago 'raw starch' extracted by the most convenient and traditional method is thought to allow storage up to three weeks or a month at room temperature in Southeast Asian sago growing areas. This study reports observations from scanning electron microscopic investigation of time course changes during 60 days storage at room temperature of amyloplasts derived from three 'raw starch' samples bought in the market of Kendari, Indonesia.

Various amyloplast sizes, and ellipsoidal or spindle shapes with uneven surfaces were observed in all samples. Cell wall fragments or cells containing some amyloplasts were also observed in some samples. Cell walls appear to decrease palatability when cooking.

Amyloplast decomposition commenced with appearance of small surface holes after 25 to 34 days' storage. This storage period closely coincides with local room temperature storage habits. With the advent of amyloplast decomposition, bacilli and saccharide-like substances appear and adjacent amyloplasts agglomerate. Times of amyloplast decomposition commencement differed among amyloplasts and samples; the portion and percentage area of decomposition were recognized to be partial in each sample or amyloplast (Fig. 1). These results indicate that amyloplast decomposition was mainly due to action and propagation of bacilli rather than enzyme activities while adhered to the amyloplast envelopes. Moreover, some inhibitors that suppress bacilli action and propagation seem to be involved in 'raw starch' during such one-month storage.

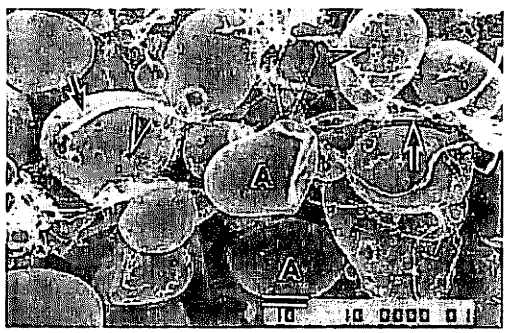

Fig. 1 Decomposition of amyloplasts after 60 days' storage. A, amyloplast; ↑, bacillus; ▲, small hole. Bar: 10 μm.

Production and Utilization of Value-added Starch Hydrolysis Products

Teruo Nakakuki and Hideyuki Sumiyoshi

Research Institute, Nihon Shokuhin Kako Co., Ltd., 30 Tajima, Fuji, Shizuoka 417-8530, Japan

Keywords; starch hydrolysis product, oligosaccharide, functional saccharide, maltooligosaccharide, cyclodextrin

Abstract

The starch sweetener industry has been advanced by the discovery and application of new enzymes. Advances have been influenced by both domestic and international economic factors and various changes in market needs. Since 1970, several novel microbial enzymes producing specific oligosaccharides have been discovered. Using these new enzymes, it is now possible to produce on an industrial scale various new sweeteners such as maltotriose- and maltotetraose-containing syrups. These syrups are products having low sweetness. Also, they give resistance to the retrogradation of starch gel and prevent the crystallization of sucrose. Their reduced browning tendency results in improving heat stability. They have begun to be used as property enhancers for various foods, powdering materials, saccharides for dry milk, liquid diets for patients, and viscosity-increasing agents for refreshing drinks. On the other hand, cyclodextrins are produced by the action of cyclodextrin glucanotransferase (CGTase) from various bacterial origins. Recently, cyclodextrin derivatives such as branched cyclodextrins including glucosyl or maltosyl cyclodextrin and 2-hydroxypropyl β-cyclodextrin (HP-β-CD) have been developed. These CDs are capable of forming inclusion complex with various organic compounds by incorporating them into the cavity of their cyclical structure. This can lead to desirable changes in the physical and chemical properties of the incorporated compounds. HP-β-CD has been especially used as a moisture-retaining saccharide for various kinds of cosmetics. Also, new markets of β-CD applied to the effects of the prevention of cream down in ice tea and the improvement of taste are developing. Furthermore recent developments in industrial enzymology have made possible the large production of various new starch oligosaccharides such as a branched-oligosaccharide composed of isomaltose and panose, β-1,6 linked gentiooligosaccharide, α,α-1,1 linked trehalose and α-1,3 linked nigerooligosaccharide.

We will review the recent progress for the development of starch hydrolysis products and also discuss the future of functional starch sweeteners.

The Effect of Pro-oxidant on Natural Weathering of Sago Starch filled Linear Low Density Polyethylene (LLDPE)

U. S. Ishiaku, N. Sharma, H. Ismail and Z. A. M. Ishak

School of Industrial Technology, Universiti Sains Malaysia 11800 Minden Penang

Keywords: LLDPE, sago starch, pro-oxidants, EAA, weathering test

Abstract

The degradation of linear low density polyethylene (LLDPE) formulated with sago starch, elastomers, viz. Styrene butadiene rubber and epoxidised natural rubber, a metal salt and ethylene acrylic acid (EAA) was studied to evaluate the effect of these components on the degradation process of LLDPE. The composites were subjected to natural weathering in a hot and humid tropical climate (27 $\pm$ 3^{0}C, 80 $\pm$ 7%), conducted at an open space without the disturbance of any shadow falling upon the test samples for 6 months. Physical and morphological changes of the samples were used to monitor the progress of natural weathering. Techniques such as tensile test, scanning electron microscopy, FTIR, DSC and molecular weight determination were employed.

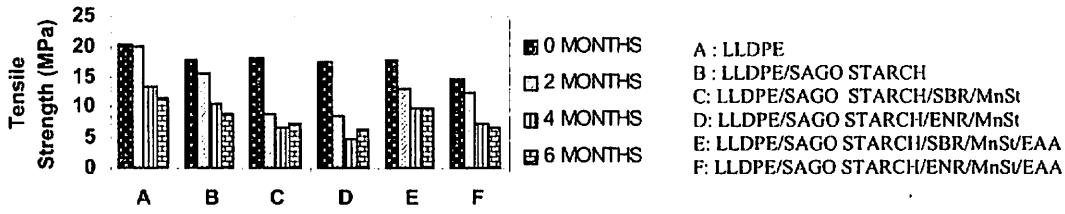

Fig 1: Effect of Natural Weathering on Tensile Strength

While decrease in tensile properties is insignificant in the control sample (A) until the 4th month, the sample containing sago starch (B) showed appreciable deterioration by second month (Figure 1). This is because the starch will induce biodegradation, with the fact that erosion of the starch by rain produces voids that will act as stress concentrating points. This consequently led to reduction in tensile properties. Degradation is enhanced with the incorporation of pro-oxidant that consists of unsaturated elastomer and metal salt (C and D), which will promote the oxidative degradation of polyethylene. The presence of EAA (E and F) is believed to facilitate further generation of hydroperoxides through oxidative effect. Similar trends are observed in other mechanical properties while analytical and morphological studies support the trends of mechanical properties. The studies show a significant decrease in mechanical properties which revealed that the combination of pro-oxidant and EAA enhanced the degradation rate of sago starch filled LLDPE composites.

A Study on the Processing Methods of Sago Starch Extraction in Asian and Pacific local regions

Yoshihiko NISHIMURA and Terence Miro Laufa

Graduate School of International Development (GSID), Nagoya University, Furo-cho, Chikusa-ku, Aichi, 464-0861 Japan

Key words: Sago starch, sago extraction methods, sago cultural zones, Asian local regions, Pacific local regions

Abstract

The present status quo shows that sago is still an important agricultural crop in the Philippines, Indonesia, Malaysia, Papua New Guinea, and Vanuatu. However, Malaysia, among these countries has established starch industries under its food industrialization schemes, especially on Borneo. Sago agriculture closely associates with root vege culture zones. As it stands, sago culture plays a leading role in the cultures of these areas concerned. Here the methods of starch extraction depend on these areas from the past till now. Extraction methods in these areas were investigated through field surveys and it was established that there were some differences. This study investigated some local areas in a Pacific Island country, Papua New Guinea as well as a local area in a Southeast Asian country, Indonesia. Data was collected and analyzed. Other information was sourced from pictures and other references. Extraction of sago palm starch in Papua New Guinea and the Indonesian case show similar processes, except that different actions and implements are used. The former has sago-growing areas in coastal regions, while the latter can be readily seen in Irian Jaya, Ambon, Sulawesi and Kalimantan. The technology used for extracting sago starch is intricately linked and adapted to suit local conditions.

Four steps are usually required for extracting sago starch: (1) harvesting mature sago palm; (2) cutting/splitting into small pieces or log; (3) pounding/crushing of sago pith; and (4) washing of sago piths. Though the processes are same, the extraction methods differ in some respects, thus three differences were noted. Firstly, the log is prepared for the Malaysian and Sulawesi cases, while for PNG, it is mostly done in unprepared state simply because it is mainly for self-consumption and does not need to be moved to other processing sites thereafter, while the Malaysian and Sulawesi cases have to be transported to processing sites and are mainly for commercial purposes, especially for Malaysia, while Sulawesi's processing could be for both self-consumption and commercial purposes. Secondly, PNG up to the border of Sulawesi use hatchets to remove sago piths. In contrast, grating is applied in Malaysia. Thirdly, in PNG washing of starch is done by hand, while in Malaysia and Sulawesi use their feet. Hence, this paper attempts to classify these sago cultural zones into three distinct types with respect to the sago processing for the Asian and Pacific local regions. In conclusion, Sulawesi Island serves as the border for PNG and Malay sago culture, showing intermediary alignment to both practices in PNG and Malaysia.

Sago: economic change and nutrition

Stanley J. Ulijaszek

Institute of Biological Anthropology, University of Oxford, Oxford OX2 6QS, UK

Keywords: palm sago, subsistence ecology, nutrition, modernization, diet

Abstract

Palm sago has been an important staple food for many tribal groups living on marginal lands. In this presentation I examine the subsistence ecology, dietary diversity and nutritional status of sago-eating populations in Papua New Guinea, and the ways in which economic modernization has changed the diet and nutritional health of these populations in the past twenty years or so. In general, palm sago is an efficient source of dietary energy, which traditionally spares time for the acquisition of food sources which are rich in protein and micronutrients. Despite this, traditional sago-eating populations have had among the poorest nutritional status in Papua New Guinea. This is because poor nutritional status is not a straightforward outcome of subsistence ecology, but is also a function of local disease ecology, human population density, economic development, education, and extent of primary health care. Mean birthweights, reflecting maternal nutritional status, are lower in taro-consuming and plantain-eating communities than in sago-eating communities in Papua New Guinea. Furthermore, poor childhood nutrition in Papua New Guinea is associated with low levels of socio-economic development, as well as with the consumption of the traditional staples taro and sago. Notably, both of these staples are consumed in greatest quantity in locations with the lowest levels of economic development.

Economic modernization has taken place in much of Papua New Guinea, including among many sago-eating communities, and this has lead to improvements in general health status, as well as nutritional status. In many places this has been accompanied by increased population density such that the extent of sago use, including the planting of sago, is greater than ever before. Dietary diversity has increased, by way of consumption of imported foodstuffs, to supplement the consumption of sago, regardless of whether sago production can meet the food demands of the growing population or not. While this has generally lead to improved nutritional status across the past twenty years, health problems associated with obesity and hypertension are beginning to emerge among traditionally sago-eating communities in Papua New Guinea.

Options of Commercializing Sago among the Abu' Alifes of the Torricelli Mountains of Papua New Guinea

Otto Nekitel

Language and Literature Department, School of Humanities, University of Papua New Guinea, P.O.Box 320, University Post Office, Papua New Guinea

(in preparation)

Metroxylon (Arecaceae) in Vanuatu and the Solomon Islands: Traditional and Current Uses

John Leslie Dowe

Tropical Plant Sciences, James Cook University, Townsville, Queensland 4811, Australia

Keywords: *Metroxylon*, Vanuatu, Solomon Islands, traditional use, current use

Abstract

Species of *Metroxylon*, *M. salomonense* (Warb.) Becc. and *M. warburgii* (Heim) Becc., the sago palms, are an emblematic feature of the islands of eastern Melanesia. Traditionally, throughout the area, sago was harvested from the stems of these plants, but presently this use is confined only to the northern Solomon Islands and then only in times of food shortages. Apart from being a food source, the palms are extensively used throughout the region as material for building houses, with the leaves producing a sought-after durable thatch, and the petioles used for supports and beams. Minor uses for many parts of the palms have also been recorded. The natural distribution of both species has been obscured by the movement of humans together with these useful plants throughout the region. It is suspected that *M. salomonense* has been wholly introduced into Vanuatu, while *M. warburgii* is indigenous but now ubiquitous, owing to human dispersal.

Sustainable Utilization of the Upper Montane Sago Species *(Eugeissona utilis & Arenga undulatifolia)* by Penan in Central Mountain Range of East Kalimantan, Indonesia.

I. Yamada and J. Akamine*

Center for Southeast Asian Studies, Kyoto University, 46 Yosida Shimoadachi-cho, Sakyo-ku, Kyoto, 606-8501, Japan
*School of Humanities and Social Sciences, Nagoya City Univ., 1 Yamanohata, Mizuho-cho, Mizuho-ku, Nagoya, 467-8501, Japan

Key words: montane sago, Penan, sustainable utilization, monitoring, eco-resources

Abstract

There are several palm species in Southeast Asia which are generally called sago. The most common one is *Metroxylon sagu* of which the habitat is lowland swamp area. Beside this species, the Penan people in Borneo have been utilizing montane species of sago for their traditional main food resources. One is Nanga (*Eugeissona utilis*) and the other Jaka (*Arenga undulatifolia*). Nanga grows gregariously on the upper ridge of the mountain while Jaka is found along the riverside sporadically. Both of the species are important sources of the main food of the Penan people.

In November 1994, we made a research on these sago utilization of the Penan people around Pujungan area, upper Mahakam river, East Kalimantan, Indonesia. The village is located at the bank of a small river and surrounded by the hilly mountain. Time to time, people go to the mountains to collect Nanga palm. The site frequently visited by the villagers is situated about one hour walk from the village at the steep ridge of mountain. As this species grows gregariously, people selected only the matured palms and leave the younger ones untouched. Some young shoots are also harvested. The amount of resources is quite sufficient for their livelihood.

On the other hand, Jaka, on the riverbank is much scarce and approaching the point of extinction because of the easier accessibility. The way of extraction of sago starch is similar to that of *Metroxylon*. Since the diameter of the palm is very small, the tools for extraction are mostly made up of simple wooden materials. The procedure to extract starchy will be described in detail and a comparative discussion with lowland sago will also be made, focusing on the sustainable utilization of eco-resources.

Sago in Indonesia

H.M.H. Bintoro

Bogor Agricultural University
Faculty of Agriculture
Darmaga Bogor, Indonesia, 16680

Key words : arable land, potential area, biodiversity, prospective.

Abstract

Indonesia has about 21 milliion hectars of arable land that potential for sago palm, but up to now only around 1-4 millions it grown at natural condition. Sago diversity is very wide. It is about 20 kinds of sago palm has been found at Sentani subdistrict in Irian Jaya. Sago has good prospective in the future. Sago starch can be used as staple food, snack raw material, and also can be used for food industry, fish and animal feeds. Sago starch also can be processed to be HFS, amino acid, sorbitol and organic acid.

Commercial Sago Palm Cultivation on Deep Peat in Riau Indonesia

Foh Shoon JONG

P.T. National Timber & Forest Products, Jln Jen. A. Yani No. 105-109, Selatpanjang, 28753, Riau, Indonesia

Keywords: commercial cultivation, deep peat, management, Metroxylon sagu, sago palm

Abstract

P.T. National Timber & Forest Products (PTNT) initiated a 20000-hectare self-financed commercial sago palm (*Metroxylon sagu* Rottb.) plantation in 1996. It is established on deep peat of about three meters in depth, at Tebing Tinggi Island in the Riau Province of Indonesia. About 8000 hectares have now been completed and continued development of the plantation is progressing steadily at about 2000 hectares per year.

The sago palms are cultivated as a non-swamp land crop. An extensive canal system divides the plantation into rectangular planting blocks of 50 hectares. Dams are built at appropriate places to regulate the soil water table to about 20 to 50 cm below the soil surface. A combination of rails, roads and canals is used for work realization, supervision, transportation of farm inputs and outputs.

Vegetative offshoots (suckers) are used for planting. They are nursed on floating rafts until the emergence of new roots and fronds before they are transplanted. A square spacing pattern of ten meters is adopted for field planting. Trimming of leaflets to reduce transpiration is carried out when suckers are planted during dry seasons. Census and replacements of dead suckers are carried out at three and six months after planting.

In the field, indigenous fern species serve as natural soil cover. Weeding along the planting rows is carried out twice a year, with fertilizers applied immediately after weeding. Sucker growths in each palm cluster are regulated stepwise, so that only one sucker is allowed to further its development in a desired interval of 18 months.

The plantation is divided into phases of 1000 hectares, each equipped with adequate infrastructure and manpower to carry out routine operations rather autonomously. In the past four years, the infrastructure system has adequately facilitated various field operations. Concurrent agronomic practices and soil water table management have enabled satisfactory growth and development of the sago palms.

Nutrient status of soils of coastal lowland area at different distance from sea in relation to leaf nutrient of sago palm

B.H. Purwanto, K. Kakuda, and H. Ando

Yamagata University, 997-8555, Tsuruoka, Yamagata, Japan

Key words: coastal lowland, distance from sea, bulk density, soil nutrients, leaf nutrients

Abstract

Sago palm has been recognized to survive in peat soils, which have chemical and physical constraints such as waterlogged condition, extremely acid, low status of macronutrients and micronutrients, and low bulk density. This palm is distributed on peat soils and mineral soils of coastal lowland area. It was reported that distance from sea influenced soil solution composition of peat soils in coastal lowland area and shorter distance from sea contributed higher content of Na and Mg. These differences might be reflected by nutrient composition in leaf of sago palm.

Objective: To clarify nutrient status of peat soils in coastal lowland area in relation to distance from sea and its contribution to nutrient in leaf of sago palm

Materials and Methods: *Location*: Mukah, Sarawak, Malaysia and Selat Panjang, Tebing Tinggi, Indonesia. *Sampling interval*: Soil and leaf samples were taken from different distance from sea at about 500 m interval along 3 km sampling transects. *Analytical procedure*: Total-N in soil (Kjeldahl method), exchangeable cations (NH_4OAc-extract), extractable Fe (DTPA-extract), Zn and Cu in soils (0.1 N HCl extract) and concentration of N (Kjeldhal method), K, Ca, Mg, Na, Fe, Zn and Cu in leaf (wet ashing by $HNO_3 + HClO_4$)

The results showed that:

- The soil bulk density greatly varied among the soils. Hence, concentration of nutrient in soils should be expressed in volume basis to get a fair comparison among the soils.
- Significant relationship between total–N in soils expressed in volume basis and distance from sea was observed, and on the contrary neither amount of exchangeable cations nor minor nutrients in soils expressed in volume basis were affected by distance from sea.
- There was no relationship between amount of exchangeable Mg and extractable Fe, Zn and Cu in soils expressed in volume basis and concentration of those nutrients in leaf. In contrast, total N in soils expressed in volume basis significantly influenced concentration of N in leaf. Significant influence of amount of exchangeable Ca, K, and Na in soils expressed in volume basis on concentration of those nutrients in leaf was also observed

This research clearly demonstrated that concentration of N, Ca, K and Na in sago leaf responded the concentration of those nutrients in soils.

The Cooking and Processing Properties of Japanese Traditional Confectionery made of Sago Starch — Effect of Addition of Trehalose and Silk Fibroin on Physical Properties—

T. Hamanishi, N. Matsunaga, K. Hirao, K. Kainuma* and S. Takahashi

Faculty of Home Economics, Kyoritsu Women's University, 2-2-1, Hitotsubashi, Chiyoda-ku, Tokyo 101-8433, Japan
*Bio-oriented Technology Research Advancement Institution, 3-18-19, Toranomon, Minato-ku, Tokyo 105-0001, Japan

Keywords : sago starch, trehalose, silk fibroin, mushiyokan, kudzumochi

Abstract

"Mushiyokan", "Kudzumochi" and "Kudzukiri"are Japanese traditional confectioneries made of kudzu starch. The main materials of these confectioneries are starch, sugar and water. In case of the Mushiyokan, sweet bean paste is added. Mushiyokan and kudzumochi are prepared for gelling by heating with steam. Kudzukiri is a confectionery made of gelatinized starch sheet. After cutting the sheet into noodle shape, it is served with brown sugar syrup. These confectioneries are concentrated starch food.

In addition to small production volume, kudzu starch is classified to an expensive starch. Therefor we examined that sago starch is suitable for these Japanese traditional confectioneries, because of relatively similar rheological properties.

Trehalose is known as an excellent oligosaccharide to protect the retrogradation of starch gels and also to prevent protein denaturation. Recently silk fibroin suspension is commercially available from the silk weaving industry. This product is called "silkmilk" because of the similar appearance to milk. The silkmilk makes food luster and smooth by addition. The effect of addition of trehalose to the Japanese confectioneries and addition of silkmilk to kudzukiri made of sago starch was studied.

Mushiyokan and kudzumochi made of sago starch became strongly resistant to retrogradation by addition of trehalose, compared with those made of kudzu starch. Kudzukiri added silkmilk increased luster.

Three Japanese confectioneries added trehalose were evaluated the sweetness was low, because the sweetness of trehalose was the about half of that of sugar. Therefor, it thought that sago starch was acceptable for Japanese traditional confectioneries with mixing trehalose and sugar.

Analysis of Leaf Area of Sago Palm (*Metroxylon sagu* Rottb.)

S. Nakamura, Y. Goto and Y. Nitta

Miyagi Agricultural College, 2-1 Hatatate 2-Chome, Taihaku-ku, Sendai, 982-0215 Japan

Keywords: Area of leaflet, leaf area, leaflet, length of leaflet, width of leaflet

Abstract

Area and shape of leaflets were measured closely in order to find how to estimate the leaf area simply from observations made on the leaf and leaflet shape. The palm we examined in Mukah, Sarawak, Malaysia was about six years stage and it had nine green leaves including a top leaf like a needle. Length of leaves and leaflets, area of leaflets and the maximum width of leaflets were measured.

Area of the second leaf (ebL-2) that consisted of 135 leaflets was estimated at 12.1 m^2, 5.82 m^2 on right, 6.28 m^2 on left (Fig.1.). Area of eight leaves from ebL-2 to ebL-9 was estimated at about 100 m^2.

From the analysis of leaflets shape, it seemed that the area of leaflets and the length × width of leaflets were related closely. The length × width of leaflet was correlated with the area of leaflet (Fig.2.). Linear regression was shown; $y = 0.766x - 15.1$, $r^2 = 0.996$.

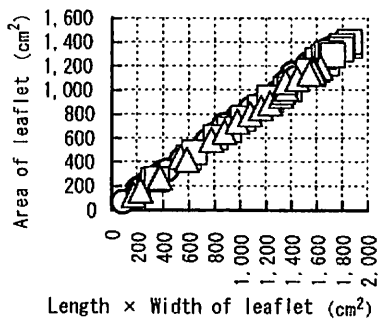

Fig. 2. Relationship between the area of leaflet and the length × Width of leaflet. ○ : ebL-2, □ : ebL-4, △ : ebL-5.

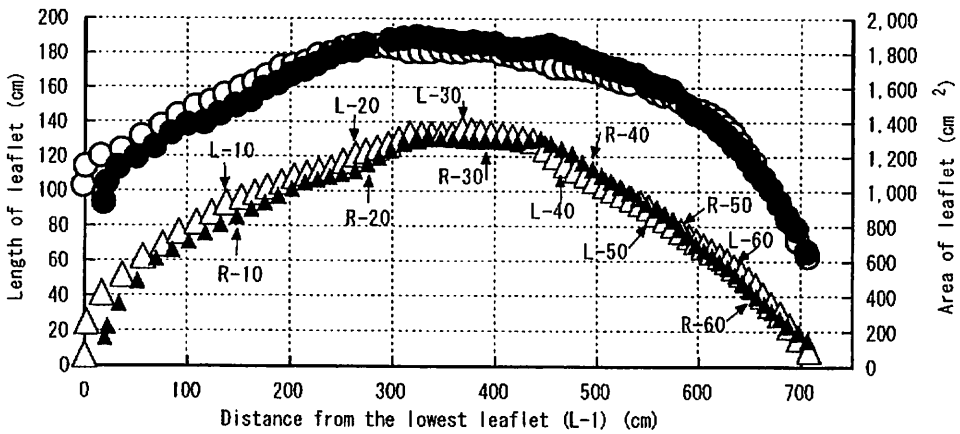

Fig. 1. Length and area of leaflets of ebL-2. ○ and ● indicates length of leaflets on left and right respevtively. △ and ▲ indicates area of leaflets on left and right respectively.

Changes in Some Characters of Sago Palm Suckers during Raising Period and Their Early Growth after Transplanting

K.Omori, Y.Yamamoto, F.S.Jong[1)],T.Wenstone[1)], A.,Miyazaki and T.Yoshida

Faculty of Agriculture, Kochi University, B-200 Monobe Nankoku, Kochi, 783-8502 Japan
[1)]PT National Timber and Forest Products, Selatpanjang , Riau, Indonesia

Key words: chemical constituent, early growth, raising period, sago palm, sucker

Abstract

Sago palms (*Metroxylon sagu* Rottb.) usually propagate by sucker, and in cultivation practice it is raised in a shallow pond or on the raft in a small river for 1-3month(s) to promote their establishment. Although the sucker establishment is the first step to develop new sago gardens and plantations, the survival rate of transplanted suckers is generally low. Very few reports on the characters of collected suckers and their growth during raising period and after transplanting are available. This study was conducted to clarify the characters of collected suckers, and their growth during raising period for 6-months period and at one year after transplanting in Tebing Tinggi Island, Riau, Indonesia , in 1998-2000.

Twenty-nine randomly collected suckers from the neighboring islands of Tebing Tinggi Is. were observed to clarify the characters. Sucker height ranged from 25 to 44cm with the mean of 33.4cm. The length, diameter, weight and cut end diameter of the sucker stems showed the mean values of 18.6cm, 13.4cm, 3.67kg and 10.0cm, respectively. The variation coefficients of sucker height (12%) is lower than the characters of sucker stems (20-30%).

Conspicuous changes were not observed in length, diameter and weight of sucker stems for 6-months raising period on the raft in a canal, although the cut end diameter decreased. Emergence of new leaves and roots started at one-month after raising, and suckers raised for 3-months, i.e., normal raising period, had 2 leaves and 18 roots. Thereafter, number of new leaves and roots increased more and attained 6 leaves and 21 roots at 6-months after the start of raising. During raising period, starch percentage in pith of sucker stem decreased rapidly from 1-month (49%) to 3-months (9%), corresponding with the emergence of new leaves and roots, but the percentage is almost constant thereafter. On the other hand, the percentages of mineral elements, such as N, P, K, Ca and Mg , tended to increase, mainly due to the decrease of starch content. These results suggested that sago palm suckers depend their growth on the reserves in stems, but change into autotrophism by their own leaves and roots after 3-months of raising.

The suckers transplanted on deep peat soils showed plant height 1.6m, number of leaves 18, weight 4kg, number of roots 83 in the mean values after 1-year. The roots penetrated into soils over 1m deep, although the root growth was better in the suckers transplanted on the area with lower groundwater level.

Major Factors Limiting Seed Germination of Sago Palm (*Metroxylon sagu* Rottb.)

H. Ehara

Faculty of Bioresources, Mie University, 1515 Kamihama-cho, Tsu 514-8507, Japan

Keywords: Endogenous inhibitor, Germination, *Metroxylon sagu*, Physical treatment, Seed coat tissue.

Abstract

Sago palm (*Metroxylon sagu* Rottb.) can be propagated from both offshoots (suckers) and seeds. Recently, the use of seedlings has increased slightly because of a shortage of planting materials in some sites in Malaysia and Indonesia, although germination of sago palm seed is generally poor. The aim of this study is to clarify major factors limiting seed germination of sago palm and to investigate the enhancement of germinability.

Fruits were collected from spineless sago palms at Batu Pahat in Johor, Malaysia. With the help of a farmer who has owned sago palms, pollinated fruits were selected and used for the following experiments. Unpollinated fruits were slim and light.

The effects of air temperature on seed germination were examined. Germination percentage of non-treated seeds (uncleaned seeds, i.e. fruits) was 10% at 25°C 40 days after sowing. Seeds without the pericarp (exocarp and mesocarp) and sarcotesta, i.e. cleaned seed, showed comparatively higher germination (40%) after 40 days when incubated in water at 30°C; water was renewed every day. Germination of cleaned seeds recorded 20% after 40 days at 35°C. The results suggest that air temperature affects germinability of sago palm seeds in the range 25°C – 35°C, and that germinability will be reduced by not only low air temperature but also by excessively high air temperature.

The effects of physical treatment and the presence of the pericarp and sarcotesta on seed germination were studied. Germination counts were made for seeds submerged completely in water at 30°C in the dark. (1) Seeds from which the pericarp and sarcotesta were removed, i.e. cleaned seeds, started to germinate from 32 days after sowing. In contrast, seeds with pericarp and/or sarcotesta still attached, i.e. uncleaned seeds, did not germinate at all within 100 days because water absorption was restricted mainly by the presence of pericarp. (2) When cleaned seeds were placed in water with the pericarp, germination was delayed. Soaking cleaned seeds with the pericarp and sarcotesta resulted in no germination in 100 days. However, germination was not hindered when the cleaned seeds were mixed together with only the sarcotesta.

We can conclude that the presence of pericarp and sarcotesta are major factors limiting germination of sago palm seeds. The causes of this response relate to a restriction of water absorption by the pericarp, the physical presence of the operculum that exits inside of pericarp, and leaching of endogenous germination inhibitors from the pericarp. The germination of sago palm seed can be improved by removing the pericarp and sarcotesta, and soaking the seed in water at around 30°C.

WATERTABLE STUDY OF SAGO PALM ON TROPICAL PEAT

Lulie Melling[1], Mitsuru Osaki[2], Kamarudin Ambak[3], Dominic Jugah[1], Jaman Osman[1], and Ahmad Husni[4]

[1]Soil Management Branch, Department of Agriculture Sarawak, Jalan Badruddin, 93400, Kuching, MALAYSIA
[2]Graduate School of Agriculture, Hokkaido University, Sapporo 060-8589, JAPAN
[3]Sessang Station, Malaysian Agriculture Research and Development Institute, MALAYSIA
[4]Department of Land Management, Universiti Putra Malaysia, MALAYSIA

Key words : Watertable, Sago Palm, Tropical Peat, Water Management, Plant Growth

Abstract

In Sarawak, sago has always been considered to be grown mostly on poorly drained mineral soils and peat soils. In the early 80's, the sago palm is though to be one of the very few crops that can grow on the natural deep peat swamps with minimal drainage. It was hoped that by the cultivation of sago palms, it is possible to convert the vast areas of peatswamps into productive agricultural land without sophisticated and expensive soil amendments. (Kueh, et. al. 1987, Jong and Flach, 1995). Since the establishment of the sago plantation, some problems that have not been realised before are now experienced in the plantation. One of them is the high mortality rate and stunted growth of the sago palm in the field.

Sago agronomy is still at its infancy. Whatever information available was gathered from farmer's experience. Thus there is a need to carry out research to quantify the requirements of the sago in a scientific manner. It is believed that the peat swamp needs to be drain for the successful growth of sago. Thus a watertable study of sago palm in the was established and the results are very encouraging. With the watertable study, it is hoped that we will be able to determine the required water table. This would then be able to assist the Department of Agriculture and Land Custody and Development Authority(LCDA) to design the drainage of their sago mini estate and plantation so as to improve the growth of the sago. Thus this is also to shorten the gestation period of the sago.

Effect of Ingredient Ratio of Sago Starch on Serum and Liver Lipid Levels and on Oxidative Status in Rats

K. Hirao and K. Igarashi

Department of Bioresource Engeneering, Faculty of Agricultue, Yamagata University, 1-23, Wakaba-machi, Tsuruoka, Yamagata 997-8555, Japan.

Keywords: sago starch, ingredient ratio, antioxidative status, TBARS value

Abstract

Effects of the ratio of sago and tapioca starches in the diet on the serum and liver lipid levels and on *in vivo* oxidative status were determined in the rats fed a cholesterol-free and - enriched diets.

Although body weight was lower in the diet group with higher level of sago starch than that in the diet group with lower level of sago starch, atherogenic index, tiobarbituric acid reactive substances (TBARS) in the serum and liver tended to be lower in the diet group with higher level of sago starch, indicating that the diet with higher level sago starch is superior in preventing atherosclerosis and in suppressing lipped peroxidation *in vivo*. Liver SOD and catalase activities were also higher in the diet group with higher level of sago starch. But, glutathione peroxidase activity and the contents of reduced and oxidized glutathiones were lower in the diet group with higher level of sago starch.

When tapioca starch was fed instead of sago starch, food intake and body weight in the diet group with higher level of tapioca starch was also lower than those in the diet group with lower level of tapioca starach. The concentrations of total cholesterol, triacylglycerol and glucose in the serum was also significantly lower in the diet group with higher level of tapioca starch as well as sago starch. Atherogenic index, and serum and liver TBARS value were significantly lower or tended to decline in the diet group with higher level of tapioca starch.

The levels of lipids in the serum and liver, liver TBARS, atherogenic index, and liver antioxidative enzyme and lipogenic enzyme activities, and further live α-tocopherol content and liver 8-OH-dG/dG ratio did not vary between the rats fed the diet with the same level of the starches.

The liver total cholesterol level was lower in the rats fed the diet with lower level of sago starch than in the rats fed the diet with lower level of tapioca starch. For a reason of this phenomenon, it was considered that sago starch, compared with tapioca starch, promoted fecal excretion of bile acid and neutral steroids.

Chemical properties of peat soils and peat soil solutions obtained from Sago palm forest

Masayuki Kawahigashi[1], Hiroaki Sumida[1], Haruo Tanaka[2], Chihiro Kumada[3]

[1] College of Bioresource Science, Nihon University, [2] Faculty of Agriculture, Tokyo University of Agriculture and Technology, [3] Research Institute of Environmental Science, Tamagawa University

Keywords: peat soil, soil solution, humification degree, nutrient, Sago growth

Abstract

Soil survey and analysis on chemical properties of peat soils and soil solutions were performed on 6 peat lands (T-1 and T-2 located at Talau peat research station in Dalat, Sarawak, Malaysia, and M-1 to 4 located in Mukah town) with differences in reclamation years (8 to 15 years), planting years (7 to 15 years), and degree of Sago growth (1 to 20 m). One peat land (T-2) was classified to shallow peat. The others were classified to deep peat. Degree of sago growth was best at T-2, where mineral soil layers have been observed under 20cm depth. Sago growth of one deep peat land (T-1), where height of Sago palms were about 10m and trunks with about 40cm diameter were observed, was better than the other deep peat land (M-1 to 4), where height of Sago palms were about 1m and no trunks were observed.

Chemical properties of deep peat soils (M-1 to 4 and T-1) changed with soil depth. Carbon content and ratio of carbon and nitrogen content (C/N ratio) increased with increasing soil depth. Nitrogen content decreased with increasing soil depth. Humification degree measured by Kaila method increased with increasing soil depth. Changes in chemical properties concerning with organic matters with soil depth indicated that fresh organic matters successively accumulated on a surface layer of peat soil. On the other hand, changes in these chemical properties in T-2 showed opposite trend to deep peat soils.

Chemical properties of soil solutions were different from those of soils. Values of pH were lower in soil solutions than in soils. Total organic carbon content decreased with increasing soil depth. Total contents of anions in soil solutions obtained from every soil layers were larger than those of cations. A proportion of sulfuric ion to total anions was highest in T-2. Mineral soils in T-2 were acid sulfate soils.

In deep peat soils, contents of nutritional cations were larger in soil solutions than in soils. These nutritional cations were not retained on cation exchangeable site because of very low pH in soils. Although nutritional cations in soil solutions were available forms for Sago palm, they were easily move away with ground water movement. Sago growth would depend on capacity of retention in organic soils.

Biomass accumulation of sago palms cultivated for roofing material in Northern Mindanao

M. Yoshikawa[1], M. Okazaki[2], L. L. Celiz[2], T. Hamanishi[3]

1) Faculty of Agriculture, Tokyo Univ. of Agr. & Tech., Fuchu, Tokyo, 183-8509 Japan.

2) Graduate School of Bio-Applications & Systems Engineering, Tokyo Univ. of Agr. & Tech., Koganei, Tokyo, 184-8588 Japan.

3) Faculty of Home Economics, Kyoritsu Women's Univ. Hitotsubashi, Chiyoda, Tokyo, 101-8433 Japan.

Keywords: biomass, Mindanao, leaf weight, sago management, thatch

Abstract

In Northern Mindanao, Philippines, sago palm has been cultivated to harvest roofing material. Local people have managed sago palms by cutting three or four leaves every three months for thatch production. This study aimed to estimate the above ground biomass and its change under the local management by monitoring permanent plots.

Three 20m×20m permanent plots were settled in Albijid, Northern Mindanao, in 1998. Population density, palm height, girth at the ground level, and number of leaves were measured from 1998 to 2000. Furthermore, 10 palms in each plot were cut down in 2000, and all leaves were weighed separating leaflets and petioles.

Mean population density was 129/plot, mean height was 8.71m, mean girth was 86.9 cm, and mean number of leaves was 5.2, respectively. Mean height was increased from 6.67m to 8.71m in two years, but mean number of leaves was decreased from 5.8 to 5.2. Mean girth and density did not show significant change with time.

The above ground biomass was estimated from mean leaf weight (6.73kg/leaf), as 4520 kg/plot. The estimated biomass in each plot was varied from 4173 to 6346 kg in 1998, however, the variation decreased from 4247 to 4798 kg in 2000. This means that the sago field has been managed to be homogeneous in biomass based on palm density and leaf number.

Comparing the weight of leaflets and petioles, petiole weighs 2.7 times more than the leaflets. Therefore, it was clear that petioles contributed to above ground biomass accumulation rather than the leaflets. The weights per length of petioles were larger in long leaves than in short leaves. This means that strong petioles are needed to support large leaves.

Economic Botany and Ethnobotany of Metroxylon in the Solomon Islands and Fiji

Will C. McClatchey

Department of Botany, University of Hawaii at Manoa, Honolulu, Hawaii, 96822-2279, U.S.A.

Key Words: Metroxylon, thatch, sago starch, Solomon Islands, Fiji.

Abstract

Selection of leaves for thatch from trees in the genus Metroxylon has likely had profound effects upon the small populations of these palms growing in Solomon Islands and Fiji. Differences in the durability of leaf material is shown from each of the species of Metroxylon. Traditional economic usage patterns are described from throughout the Western Pacific islands. Cultural beliefs and understandings of the biology, origin, and role of the palms within local societies are described for the Solomon Islands and Fiji. Linguistic data is used to demonstrate patterns of usage and/or distributions of technologies associated with the trees.

Physicochemical Properties of Sago Starch Compared with Various Commercial Starches

T. Hamanishi, K. Hirao, Y. Nishizawa, H. Sorimachi, K. Kainuma* and S. Takahashi

Faculty of Home Economics, Kyoritsu Women's University, 2-2-1,
Hitotsubashi, Chiyoda-ku, Tokyo 101-8433, Japan
*Bio-oriented Technology Research Advancement Institution, 3-18-19, Toranomon, Minato-ku, Tokyo 105-0001, Japan

Key words: physicochemical property, sago starch, amylose, viscosity

Abstract

Generally, storage starch is accumulated in seed such as corn, rice, wheat or root such as potato, sweet potato, cassava, kudzu and bracken. Few plants accumulate starch in the trunk like sago palm. In this study, we compared physicochemical properties of sago starch with those of various commercial starches, and examined the placing relationship among these starches.
In Japan, kudzu and bracken starches are used for the traditional confectionery and classified as expensive starches compared with potato, corn, rice, sweet potato, wheat, tapioca starches.

Observation by scanning electron micrograph and X ray diffraction analysis were conducted. Granular size distribution, amylose content by iodine amperometric titration, photopastegraphy, endotherms from scanning calorimetry, viscosity by rapid-visco analyzer and texture by tensipresser were determined, and following results were obtained.

Sago has large granular size starch following potato starch. Amylose content of sago starch was 24.5% and the value was close to that of wheat starch. The gelatinisation temperature was close to that of corn starch. The maximum viscosity was high in order of the potato, sago, tapioca, sweet potato, rice, bracken, kudzu, corn, wheat starch. Firmness of sago starch gel was close to that of kudzu and potato starches.

The results of this study demonstrated that sago starch was easily acceptable for various starch food. This study also showed that kudzu and bracken starch could be replaced by sago starch for making typical Japanese traditional confectionery.

Diversity of sago palm from Irian Jaya (Indonesia) based on morphological characters and RAPD markers

Barahima[1], J. Renwarin[1], L.N. Mawikere[1], and Sudarsono[2]*
[1]Department of Agronomy, Fac. of Agriculture, Cenderawasih University, Manokwari, Irian Jaya, Indonesia
[2]Plant Molecular Biology Lab, Department of Agronomy,
Bogor Agriculture University (IPB), Bogor, Indonesia
(*Contact address: pertaipb@bogor.indo.net.id)

Abstract

Sago is an important carbohydrate producing crops, especially in Irian Jaya. People of Irian Jaya harvest sago from natural forest, therefore, it will be possible that diversity of this crop will disappear unless conservation of genetic materials of this crop is not conducted. Such activity requires availability of genetic information for sago that are available in Irian so that balance of conservation and utilization can be devices.

This study was conducted to obtain preliminary data on the diversity of sago palm in Irian Jaya. The diversity of sago palm was studied by observing some morphological characters and the RAPD markers. For morphological characters, the following were recorded the presence/absence of spin (*duri* in Indonesian language), the length of spin, and starch productivity. For RAPD marker, 29 random primer (10-mer) from OPERON was utilized. The analysis was conducted against 53 sago accessions belonging to University of Papua, Irian Jaya.

Results of the study showed, sago accessions in Irian can be grouped into: without spin, short spin, and long spin. The morphology of the spin was also variable among accessions investigated. Moreover, the spin may also exist during different stage of sago growth, such as: no spin with spin in all stages of growth, or spin exists at the russet stage. The starch production among accession analyzed can be grouped into: high, medium, or low starch producing trees.

Out of 29 random primer tested, only seven were capable of producing amplified RAPD bands. The other 22 tested primer did not produce amplified product at al. The selected primers that were producing polymorphic markers were: OPP-06, OPI-14, OPE-16, OPO-4, OPG-12, OPG-13, dan OPP-03. The average amplified product obtained from RAPD analysis using those primers ranged from 7-12 amplified bands, within the size of 250-3500 bp. A total of 61 polymorphic markers were produce from these 7 primers. Phylogenetic analysis using RAPD marker indicated the existence of high diversity among sago population in Irian Jaya.

Nitrogen Dynamics in Experimental Sago Field of Dalat, Malaysia

M. Okazaki[1], C. Yamaguchi[1] and A. Halim Hassan[2]

[1]Graduate School of Bio-Applications and Systems Engineering, Tokyo University of Agriculture and Technology, 2-24-16, Nakacho, Koganei 184-8588 Japan
[2]Land Custody and Development Authority, Kuching, Sarawak, Malaysia

Keywords: dynamics, input, nitrogen, output, sago palm,

Abstract

Nitrogen dynamics study has performed in the experimental sago field of Sungai Talau Peat Research Station of Land Custody and Development Authority, Dalat, Sarawak (2º 50' N, 111º 55' E) from 1996 to 1997. Living sago palm samples were cut with a chain saw and collected to determine their nitrogen content in tissue. Dead leaves were also sampled in the large-scale litterfall trap through a year. Rain water samples were collected by the precipitation sampler for the open bulk precipitation and throughfall and the ditch water samples were taken by the polyethylene bottle sampler. Tropical peat samples were collected by a small auger and spade. Total nitrogen contents in the samples were determined by a nitrogen and carbon analyzer (Sumigraph NC-80) in Japan.

Present amount of nitrogen in tropical peat soil within 0.1 m depth and living sago biomass (population density: 204 clumps per ha) without root system amounted to 228.6 kmol ha^{-1} and 22.9 kmol ha^{-1}, respectively. Input of nitrogen through precipitation to the experimental field was 0.01 kmol ha^{-1} and litterfall (dead leaves) was 7.86 kmol ha^{-1}. The uptake of nitrogen by sago palms was estimated as 1.79 kmol ha^{-1} yr^{-1} on the base of the calculation that the harvest of sago palms at every 10 years gave the nitrogen output from the experimental sago field. The output of nitrogen from the experimental sago field by the stream flow was 2.29 kmol ha^{-1} yr^{-1}.

Based on the preliminary input and output budget study the gain of nitrogen occurred in the experimental sago field in this study. However, nitrogen fixation, denitrification and nitrogen input through stream flow from the secondary swamp forest were not determined yet.

Nutritional Ion Characteristics of Tropical Peat Soils in Sarawak, Malaysia

H. Tanaka, A. Horigome*, C. Yamaguchi-Kumada*[2], M. Ohmi, M. Kawahigashi*[3], H. Sumida*[3], S. Suzuki, K. Sakagami

Faculty of Agriculture, Tokyo Univ. of Agric. & Techn., Fuchu, Tokyo 183-8509, Japan;
Presently, Osaka Office, Fertilizer and Feed Inspection Station, Min.of Agric. Forest. & Fish.;
*[2] Research Institute, Tamagawa Univ., Machida, Tokyo 194-8610, Japan;
*[3] College of Bioresource Science, Nihon Univ., Fujisawa, Kanagawa 252-8510, Japan

Keywords: tropical peat soil, deep peat, shallow peat, nutritional ions, Sarawak

Abstract

The sago palm is exploited as a stable and cash crop in Sarawak, Malaysia. It is a perennial starch crop of some economic importance in Sarawak, and has adapted well to peat swamp area. However, it is said that sago palms glowing in deep peat soils take a longer time to reach maturity than those in shallow peat and alluvial soils. It is also reported that amounts of nutritional ions in deep peat are lower than those in shallow peat. The differences in nutritional ion content of peat soils related to the type of soils are discussed.

In this study, some deep peat soils (22 samples) and shallow peat soils (9 samples, including 4 mineral horizon samples) in Sarawak, Malaysia were used. The values of pH and pH titration volumes were measured using a glass electrode method. Water-soluble and exchangeable (extractable with salt solution) cations (Ca^{2+}, Mg^{2+}, K^+, Na^+, NH_4^+) were measured with atomic absorbance photometer or ion chromatography. Water-soluble anions (SO_4^{2-}, PO_4^{3-}, Cl^-, NO_3^-) were measured with ion chromatography.

Deep peat soils were strongly acidic nature, and the pH (H_2O) values were less than 4.1 (3.1-4.1). Those values of shallow peat soils varied from 3.5-5.2. Bulk densities of deep peat soils were light (0.08-0.17 Mgm^{-3}), and those of shallow peat soils were 0.16-0.87.

The amounts of exchangeable cations in deep peat soil differed from those of shallow peat soils (Table 1,2). Especially, Mg^{2+} and NH_4^+ were lower in deep peat soils on volume basis because of low bulk density.

Table 1. Amounts of the exchangeable cation ($cmol(+)kg^{-1}$, dry matter basis)

	Ca^{2+}	Mg^{2+}	K^+	NH_4^+
Deep peat soils	1.2-19.8	3.5-9.9	0.4-2.6	1.3-8.4
Shallow peat soils	0.5- 2.2	3.2-9.2	0.1-0.5	1.3-2.6

Table 2. Amounts of the exchangeable cation ($kmol(+)m^{-3}$, volume basis)

	Ca^{2+}	Mg^{2+}	K^+	NH_4^+
Deep peat soils	14-229	43- 98	3.9-29	12- 92
Shallow peat soils	13-113	51-800	3.2-16	26-214

From the pH titration volumes, deep peat soils had higher acidity (1.1-3.2 $mol(OH)kg^{-1}$) than shallow peat soils (0.5-2.1).

Sago, Attractive Renewable Resource for "Lactate Industry"

Ayaaki ISHIZAKI, Emeritus Professor, Kyushu University, Mailing Address:
No. 611, 1-01-1, Meinohama, Nishi-ku, Fukuoka, 819-0002 Japan
TelFax. 81-92-882-6647, ishizakia@jcom.home.ne.jp

Keywords: lactate industry, poly-lactate, L-lactic acid, continuous fermentation, bacteriocin producer,

Abstract

Date, plastics, petrochemical commodity product, is facing problems to solve in respect of environmental stand-points and saving vast use of fossil fuel. Poly-lactate rises great attention that this polymer has biodegradability and its process may be possible to use renewable resource. However, for public to accept this new product, the production cost must be competitively cheap to the petrochemical one in addition to the same quality between petrochemical polyester and biodegradable polylactate. To produce high quality polylactate with low cost, it is necessary to produce high purity L-lactic acid with very cheap cost. Since synthetic method would produce racemic form (DL-form), fermentation process must be adopted to select stereochemical pure lactic acid isomers, L-form. Production cost of fermentation process must be mainly influenced by 1. raw material, 2. microorganism, and 3. process efficiency. I developed new fermentation system to solve above three problems to produce very high purity of L-lactic acid for poly-L-lactate production. This process defines as "Lactate Industry" that produces plastics from sago starch, photosynthetic products in place of petroleum and this plastics will be decomposed into carbon dioxide by composting after use. Thus the industry is environmental friendly and stimulates carbon dioxide recycling in biosphere. This process is employing bacteriocin producing, L-lactic acid homo fermentative microorganism. Since bacteriocin accumulated in the culture system works to attack enemy foreign microorganisms which usually possess racemase which convert L-lactate into D-form, this system can maintain very high L-lactic acid purity for long time operation. At the same time, the process consisting of synchronized fresh cell bioreactor by cell recycling with turbidostat and pH-dependent continuous substrate feed. Thus, this system attained very high specific L-lactate productivity resulting very high volumetric L-lactate productivity. Using sago starch hydrolyzate, I estimate production cost of very high purity L-lactic acid for polymer synthesis as competitive price with petrochemical industry.

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Pasting and Textural Properties of Sago Starch and Wheat Flour Mixtures

I. S. Md Zaidul[1], A. Abd Karim[1], D. M. A. Manan[1], B. M. N. Mohd Azemi[1], A. K. Mohd Omar[1], A. Azlan[1], Nik Norulaini N. A[2].

[1]School of Industrial Technology, [2]School of Distant Education
University Sains Malaysia, 11800 Pulau Penang, Malaysia

Corresponding author: I. S. Md Zaidul
E-mail: zahid_e@hotmail.com

Keywords: sago-wheat mixtures, swelling power and solubility, pasting properties, texture profile analysis, asymptotic residual modulus

Abstract

The rheological properties of sago starch and wheat flour mixtures at different percentages of sago in the form of paste and gel were studied by using Brabender Amylograph and Texture Analyzer. Swelling power and solubility of high protein wheat (HPW), medium protein wheat (MPW) and low protein wheat (LPW) flours and sago starch were determined at various temperatures (55° to 95°C). Sago and wheat granules started to swell from 55°C and reached a maximum at 75°C. Solubility was found to increase with temperature for all type of wheat flours and sago. Solubility of sago was significantly higher than wheat flours but the difference in solubility among the wheat flours was not significant. Pasting properties of sago starch and wheat flour mixtures at different percentages of sago substitution of 10, 20, 30, 40 and 50% sago were studied. Gelatinization temperature (T_G) and peak viscosity (V_P) were found to increase as sago portion in HPW, MPW and LPW flour increases. The peak temperature (T_P) was found to decrease with increase in sago portion in the mixtures at 40 and 50% sago. The setback values (S_B) in sago-LPW flour mixtures were significantly higher than sago-HPW and sago-MPW flour mixtures. The setback viscosity (V_S) was not significantly different for all type of mixtures and in controls. The breakdown viscosity (V_B) was found to be affected by the sago portion in the mixtures. The breakdown value (B_D) was also found to increase with the increase in sago portion in the sago-wheat mixtures. The texture profile analysis (TPA) also was carried out for sago-wheat mixtures at different percentages (10, 20, 30, 40 and 50%) of sago substitution. The hardness for control sago gel increased gradually with the increment of concentration of gel and the value tends to be higher than control wheat flours gel at 20% concentration. The gels become too hard for control sago at 30, 40 and 50%. In TPA study, the gel did not exhibit any significant differences in hardness, adhesiveness and cohessiveness with sago portion in HPW, MPW and LPW flour mixtures at different percentages. In retrogradation study, the hardness was found to decrease in comparison to the values of fresh samples. Asymptotic residual modulus, E_A was found to increase with the increase of sago portion up to 50% for all types of wheat. Samples were kept for 4 days at 4°C and were found to be higher than the values in fresh sample of LPW and MPW mixtures but for HPW, the value was lower than the value of fresh samples at 10% and 30% however, at 50% the value was found to be high. EA value does not show uniform increasing or decreasing or consistency pattern.

Fundamental Research for Production of Feed from the Residue after Extraction of Sago Starch

T. Ozawa, T. Ueno, O. Negishi, S. Masaki* and M. Amari*

Institute of Applied Biochemistry, University of Tsukuba, Tsukuba, Ibaraki 305-8572, Japan
*National Institute of Livestock and Grassland Science, Ikenodai, Kukizaki, Ibaraki 305-0901, Japan

Keywords: sago residue, silage, ammoniation, urea-treated fermentation

Abstract

Sago starch is a useful resource for foodstuffs and industrial raw materials. With the increasing production of sago starch, very large amounts of fibrous residue have been discharged from sago mills. For the further development of sago starch production, it is necessary to find the use for the residue. In this research, we have done the fundamental research for production of feed from the fibrous residue.

1. Silage preparation: The fibrous residue was treated with 70% moisture at 25°C and 30°C for 6 weeks in a glass bottle fitted with a Bunsen gas release valve. Every one week, the reaction product was analyzed on the moisture content, pH, organic acids, residual starch content, and digestibility. It gave similar results between the treatment of 25°C and 30 °C. The pH dropped less than 4.0 by the resulting lactic acid. Although the residual starch decreased as much as 3 0%, the quality of the silage seemed to be very good.

2. Ammoniation: The fibrous residue was treated with 3% ammonia, 70% moisture at 25°C and 30°C for 6 weeks in a glass bottle fitted with a Bunsen gas release valve. Every one week, the reaction product was analyzed on the moisture content, pH, ammonia content, total nitrogen content, residual starch content, and digestibility. It gave similar results between the treatment of 25°C and 30°C. Putrefaction of residue was prevented and the total nitrogen content became 3.2% by the reaction of ammonia with fiber. The residual starch decreased as much as 15%. But digestibility was improved.

3. Urea-treated fermentation: The fibrous residue was treated with 6% urea, 70% moisture, and 0.5% rice bran or soybean plant at 30°C for 8 weeks. The urea was degraded to give ammonia by urease producing microorganism. Urea content became about 2% after two weeks. In the first stage, pH raised to 8.0 and then fell to 6.8. Though putrefaction of residue was prevented by this fermentation, digestibility was not improved.

Determination Of Free Sugars and NSP in Inner Mongolia Cereals *

Fuli TIAN, Xuping Niu
1) Department of Chemistry, Inner Mongolia University, Huhhot 010021

The original dietary fiber can be referred to collectively as non-starch polysaccharides (NSP)[1]. Increased intake of dietary fiber by humans has many beneficial effects[2]. The NSP and free sugars are accurately quantified on a one-sample basis .The samples were finely divided so that it passed through a 0.5mm screen. Duplicate samples were accurately weighted into a 30 ml screw capped culture tube and hexane was added, vortex and sonicate. Centrifuge at 2000g at 20℃ for 15 min and discard fat supernatant. Ethanol was then added and the free sugars were extracted. The ethanol was evaporated and the residue was kept for free sugar analysis. The residue was extracted in acetate buffer(PH 5.0),incubated with a thermostable α -amylase at 100℃ for 1h and with amyloglucosidase at 55℃ for 16hwith shaking. The extract was centrifuged and the supernatant was taken and adjusted to 80% ethanol to precipitate the soluble NSP and the residue was washed several times with water and dried for determination of insoluble NSP.

The free sugars and soluble NSP were hydrolyzed for 2 hours at 100℃ with 1 mol • L^{-1} sulfuric acid to release monosaccharides. The released monosaccharides were reduced with $NaBH_4$ at 40℃ and acetylated using acetic anhydride with 1-methylimidazole as catalyst. The acetylated monosaccharides were dissolved in ethyl acetate and injected in a HP5890 II GC fitted with a flame ionization detector and highly polar capillary column. The injector and detector temperature were both held at 270℃ with the column temperature raising from 180℃ to 230℃ over10 min. The levels of monosaccharides were calculated based on the peak areas of that sugars and the internal standard with corrections made for the recovery of the sugars during the analysis. The results are shown in Table 1.

Table 1 Constituent Monosaccharides of Free Sugars in Naked Oats and Buckwheat

Sample Name	Total (g/kg) Fresh weight	Sample Weight (mg)	Constituent Monosaccharides of Free Sugar				
			ara	xyl	man	gal	Gluc
Naked oats	9.72	200.0	tr.	tr.	tr.	2.68	7.04
Buckwheat	7.67	200.0	tr.	tr.	tr.	1.14	5.12

Table 2 Non-starch Polysaccharides in Naked Oats and Buckwheat

Sample Name		Total (g/kg Fresh weight)	Sample Wt (mg)	Constituent Sugars of NSP							
				Rham	Fuc	Rib	Ara	Xyl	Man	Gal	Glu
Naked Oats	SolubleNSP	10.90	99.3	0.34	0.09	0.04	1.84	1.50	0.00	1.46	5.63
	InsolubleNSP	75.75		2.64	0.00	1.25	13.75	27.86	3.93	2.47	23.84
	Total NSP	86.65									
Buckwheat	Soluble NSP	2.62	100.2	0.00	0.00	0.00	0.25	0.42	0.00	1.24	0.71
	InsolubleNSP	34.11		6.64	0.00	0.00	6.04	2.90	9.16	2.04	7.33
	Total NSP	36.73									

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Component analysis of sago waste residue after extracting starch

Sasaki S, Ohmi M, Tominaga H and Fukuda K

Tokyo university of Agriculture and Technology, Saiwaicho, Fuchuu-city, Tokyo, 183-8509 Japan

Keywords: waste residue, component analysis

Abstract

Sago starch is extracted from the pith of *Metroxylon sagu* by water, and it is industrially utilized as a food source. However, the extracted residue is only treated as a waste since it has no uses. Accordingly, it is necessary to develop a new use for the waste residue. In this study, the component (cellulose, hemicellulose and lignin etc.) of waste residue was analyzed aiming at the use of it.

The components of waste residue was analyzed by conventional method, and the content is as follows;
1) ash content, solubility in cold water, ethanol-benzene (1:2 v/v) mixture solvent and 1%-NaOH aqueous. 2) moisture content, holocellulose, cellulose, α -/ β -/ γ -cellulose, klason lignin and starch content. 3) composition of monosaccarides.

Table 1 shows the results of cellulose, starch and lignin content. These results of component analysis shows that much starch was ever included in the waste residue. Therefore, it is clearly that sago residue is polysaccaride compound of starch and cellulose.

Table 1 Cellulose, starch and lignin content (wt%)

	Klason lignin	Starch	Holocellulose	Cellulose	α-*	β-*	γ-*
Pith	1.4	54.1	27.3	14.4	4.1	2.4	93.4
	(0.1)	(14.2)	(2.0)	(0.1)	(0.1)	(0.5)	(0.4)
Waste residue	5.1	30.9	40.4	20.6	34.9	3.5	61.6
	(0.1)	(2.4)	(3.4)	(0.8)	(4.3)	(4.5)	(8.9)

All of the content was based on the dried weight before cold water extraction.

*Based on the dried weight of cellulose.

Comparative Studies on Sago Starches by Direct Analysis of Chains on Outer Layer of Amylopectin

Srichuwong Sathaporn , Titi C. Sunarti and Makoto Hisamatsu

Laboratory of Food Science and Technology, Faculty of Bioresources, Mie University, 1515 Kamihama, Tsu 514-8507 Japan

Abstract

Sago starch from Sago palm (*Metroxylon sagu*) is expected to be a potential carbohydrate as sources of biodegradable plastic and green energy in near future, however, it has been scarcely utilized and a few studies have carried out on it.

As the separation of amylose and amylopectin with n-butanol causes some problems concerning difficult certification of pure ones by an occurrence of amylopectin formed a complex with n-butanol. In order to liberate these problems, a simple analysis method has been developed (1) and chains on outer layer of amylopectin were conducted on comparative study of sago and some commercial starches.

Sago starch without separation of amylose and amylopectin was hydrolyzed partially and completely by Isoamylase at 30°C. The partial and complete hydrolysates were fractionated into three fractions (fr.1, fr.2, fr.3) by Gel permeation chromatography with a column of Toyopearl HW 50-S. The chain length distribution of fr.3 containing shortish chains, which composed in outer layer of amylopectin, is concentrated and analyzed by a high performance anion-exchange chromatography equipped with a pulsed amperometric detector (HPAEC-PAD). Physiological property obtained by using a rapid visco analyser (RVA) is also conducted to recognize a relationship with the molecular structure.

(1) J. Appl. Glycosci., 48(2) 123-130 (2001):Direct analysis of chains on outer layer of amylopectin through partial hydrolysis of normal starch by isoamylase

Characteristic of the esterificated sago residue

Sasaki S[1], Yamaguchi C[2], Tanaka H[1], Ohmi M[1], Tominaga H[1] and Fukuda K[1]

[1]Tokyo University of Agriculture and Technology, Saiwaicho, Fuchuu-city, Tokyo, 183-8509 Japan
[2]Tamagawa University Research Institue, Machida, Tokyo, 194-8610 Japan

Keywords: sago residue, esterification, thermoplasticity

Abstract

In order to utilize the sago residue after extracting starch as new woody resource, thermoplasticizaton of sago residue by esterification and preparation of plastic sheet from the esterified sago residue (ESR) were attempted in this study.

The sago residue was esterified with plant oil, and a plastic sheet was prepared from the esterified sago residue by hot-press. The reactivity, thermoplasticity, mechanical properties of the reaction products and plastic sheet as shown in Table 1 were evaluated.

Table 1 Analysis

sample	analysis
ESR	1) Examination of solvent to remove unreacted plant oil.
	2) Evaluation of reactivity.
	3) Infrared spectroscopy.
Plastic sheet	4) Evaluation of thermoplasticity.
	5) Measurement of modulus elasticity.

Figure 1 showed one of the results of infrared spectra of ESR, and the adsorption peak of ester bond (about 1750cm^{-1}) was appeared. From this results, it is suggested that esterification of sago residue is possible. Thermoplasticization of plastic sheets prepared from ESR was confirmed by visual evaluation.

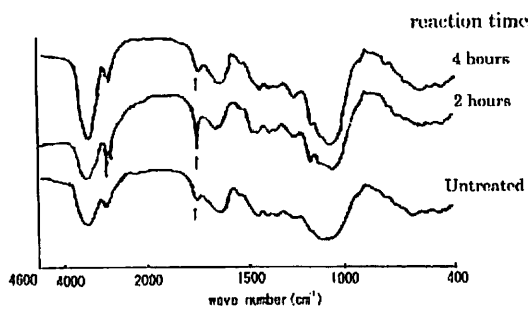

Fig. 1 Infrared spectra of reaction products (ESR) at 160℃

Application of Ozone in Sago Starch Processing

Klanarong Sriroth[1], Komzak Laoka[1], Sittichoke Wanlapatit[2], Chukiet Kijkhunasatian[2], Sunee Chotineeranat[2], Kunruedee Sangseethong[2], Kuakoon Piyachomkwan[2] and Christopher G. Oates[3]

[1]Department of Biotechnology, Kasetsart University, Bangkok, Thailand
[2]Cassava and Starch Technology Research Unit, National Center for Genetic Engineering and Biotechnology (BIOTEC), Bangkok, Thailand
[3]Agro Food Resources (Thailand), Co., Ltd., Thailand

Keywords: sago starch, ozone, bleaching, oxidation, properties

Abstract

One of the major constraints in promoting sago starch utilization is poor starch quality. For commercial purposes, properties including moisture content, crude fiber content, starch fineness and whiteness of starch are of importance. Alternatively, some chemicals such as sodium metabisulfite and calcium hypochlorite are applied during the extraction process to prevent the enzyme-catalyzed browning of phenolic compounds present in high concentration in sago pith. Chemical application is restricted to concentrations only within a level that will not leave residue in the starch. Recently, the use of ozone (O_3), a GRAS (generally regarded as safe) compound as bleaching agent has been applied in the paper industry. The advantage of ozone, which is a strong oxidizing agent, over other chemicals is the absence of chemical residue in final products, as it rapidly decomposes to diatomic of oxygen (O_2). This paper reports work aimed to evaluate potential use of ozone treatment in the sago starch industry. A preliminary study was performed by treating laboratory-extracted sago starch with ozone gas at different doses (10 to 120 mg O_3/ g dry starch). Starch properties including carboxyl and carbonyl group contents, macromolecular component, granular appearance, whiteness, paste clarity and viscosity were investigated. Ozone-treated sago starch had altered properties, the changes depending on treatment dosage. At low dose (<40 mg O_3/ g dry starch), ozone-treated sago starch became whiter (the Kett scale was 54 and 72 for native and ozone-treated starches, respectively) with a reduction in paste viscosity. When higher dose of ozone was used (120 mg O_3/ g dry starch), ozone-treated sago starch behaved like a low-viscous oxidized starch (peak viscosity was 368 and 256 RVU for native and ozone-treated starches, respectively) which is more preferably used in some application such as adhesives, paper and textile. This is presumably caused by the disruption of glycosidic linkages of high- to low-molecular weight molecules as a result of oxidizing power of ozone. The results suggest a promising future of ozone application in sago starch processing, either as bleaching agent to obtain high starch quality or as an oxidizing agent to produce modified starch.

The Uppermost Surface Structure of Sago Starch Granules

T. Hatta[1], S. Nemoto[1], T. Hamanishi[2], K. Yamamoto[3], S. Takahashi[2] and K. Kainuma[4]

1 Japan International Research Center for Agricultural Sciences, 1-1 Ohwashi, Tsukuba, Ibaraki 305-8686, Japan
2 Kyoritsu Women's University, 2-2-1, Hitotsubashi, Chiyoda-ku, Tokyo 101-8433, Japan
3 National Food Research Institute, 2-1-2, Kannonndai, Tsukuba, Ibaraki 305-8642, Japan
4 Bio-oriented Technology Research Advencement Institution, 3-18-19, Toranomon, Minato-ku, Tokyo 105-0001, Japan

Keywords: sago starch, AFM (Atomic Froce Microscopy), XPS (X-ray Photoelectron Spectroscopy)

Abstract

Up until present, a great deal remained unclarified concerning the uppermost surface of starch. In this present study, we obtained the information concerning the micro-morphology and chemical state of uppermost surface of sago starch granules[1),2)] using surface analytical techniques have been developed in many fields.

The following became clear after the investigations on the state of uppermost surface of sago starch granule. (1) The detailed structure of the sago starch surface observed by AFM is shown in Fig. 1. The surface of sago starch are never smooth. We observed the numerous rumples or folds consisting of small raised nodules are similar to the surface of potato starch granules[3),4)]. (2) Considering the electron shell in relation to the molecular structure, we analyzed the electronic state using XPS as chemical structural probe. The *C1s* orbital of starch is characterized by the presence of a chemical shift with small peak at low binding energy site[5)]. In the case of sago starch, the intensity of this photopeak is high.

Investigations of the surface structure and binding state of crystals of starch and saccharires using AFM and XPS have just been initiated. We attempt to obtain a new interpretation about the uppermost surface of various starches.

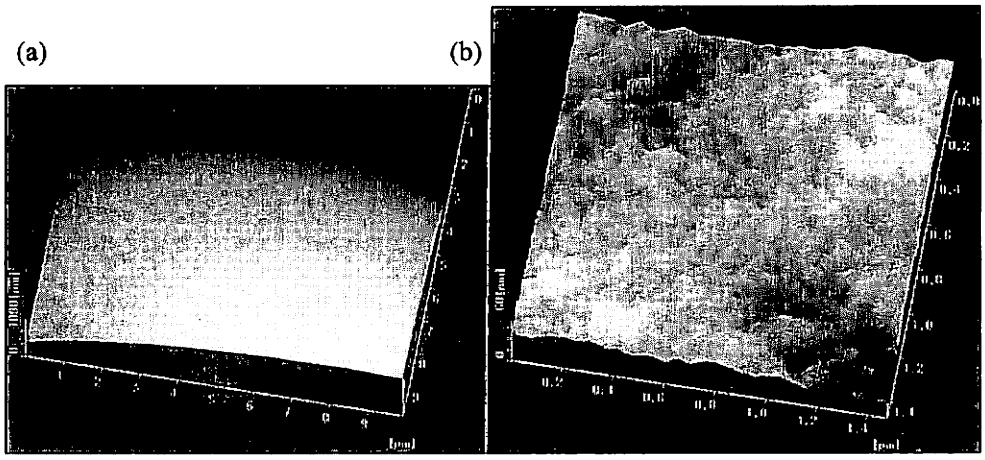

Fig. 1 AFM images of sago starch granule. (a) 10μm□ and (b)1.5μm□. The starch granules sampled from the tree aged 14.5 years and the top part of tree.

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Preparation of Granular Cold-Water Soluble Sago Starch: A Preliminary Study

K. Bhupinder, A. Abd. Karim, C.C. Seow

University Science Malaysia, 11800 Minden, Penang, Malaysia

Key words: sago starch, modification, alcoholic-alkaline treatment, cold-water solubility, paste clarity

Abstract

In light of the need to further enhance the use of sago starch in food products, development of granular cold-water swelling/soluble (GCWS) sago starch was undertaken. Currently GCWS starches are produced commercially using corn, waxy corn and tapioca starches. GCWS starches are of commercial interest for use in instant foods such as puddings and microwave-cooked foods, instant fillings, sauces and dry mixtures to be reconstituted with cold or ambient temperature liquids. In this study, GCWS sago starches were prepared using alcoholic-alkaline treatments. The native starch was treated with mixtures of aqueous solutions of ethanol and NaOH to effect swelling of the starch granules. A 2^3 factorial experiment, based on a completely randomized design, was carried out at two controlled temperatures (25 and 35°C), two ethanol concentrations (40 and 60%, w/w), and two levels of NaOH (3 and 4M). These treatments yielded GCWS starches with intact granules when viewed under a light microscope. All three factors were found to significantly ($\alpha = 0.05$) affect the cold-water solubility properties of the modified sago starch. Maximum cold-water solubility was 69.4 ± 4.0% using a combination of 35°C, 4M NaOH and 40% ethanol. Minimum cold water solubility 8.0 ± 0.8% was obtained under the following conditions: 25°C, 3M NaOH and 60% aqueous ethanol. A higher treatment temperature and concentration of NaOH enhanced starch granule swelling whereas a higher percentage of ethanol restricted swelling. High cold-water solubility can be achieved by employing a proper combination of all three factors. Paste clarity (measured as % transmittance of a 1% starch solution) appeared to be positively correlated with degree of cold-water solubility.

Cationic modification of sago starch (*Metroxylon sagu*) by an Aqueous Alkaline Process

WanRosli, W.D., Alias A.K. and Wong, S.G.

School of Industrial Technology, Universiti Sains Malaysia
11800 Pulau Pinang, MALAYSIA

Abstract

Cationic starch, an important papermaking wet end additive, was prepared via reaction of sago starch with 2-chloro-3-hydroxypropyltrimethylammonium chloride (CHPTAC) in an aqueous media. Different factors affecting these reactions, including reaction temperature, reaction time, concentration of CHPTAC (mole CHPTAC/mole starch), concentration of NaOH (mole NaOH/mole CHPTAC) and starch:water ratio (w/w) were investigated. The degree of substitution (DS) and reaction efficiency (RE) was calculated from the nitrogen content of the aminated starch. Depending on reaction conditions, DS and RE of up to 0.07 and 89% were obtained respectively. The following conditions were found to be the optimum for the preparation of cationic starch from sago: 50.0 g (dry basis) sago starch, 3.50 M NaOH (per mole CHPTAC), 82 ml distilled water, 30.9 g Na_2SO_4, reaction temperature 45.0°C (±1.0°C), reaction time 3.0 h and concentration of CHPTAC: 0.027 M (CS1), 0055 M (CS2) and 0.081 M (CS3).

ANALYSIS OF HOUSEHOLD BEHAVIOUR ON PRODUCTION AND CONSUMPTION OF SAGO IN SENTANI, JAYAPURA IRIAN JAYA

Jasper Louw[1)], Bonar M. Sinaga[2)], Basita Ginting[2)] and Nadirman Haska[3)]

1. Institute for Assessment Agricultural Technology, Jayapura, Indonesia
2. Bogor Agricultural University, Bogor, Indonesia
3. Agency for Assessment and Application of Technology, Jakarta, Indonesia

Abstract

Sago (*Metroxylon sagu* Rottb.) is an important commodity to endogenous people in Irian Jaya Indonesia. In Sentani Jayapura, for instance, it has several main functions, namely (1) staple food, (2) give income to farmer, (3) increases social status of tribal leader. Relation to the function above, households make decision to produce and consume the sago. During production activity, households always use natural resources (sago tree), human resources (labour) and technology (rasper) to find sago starch. Economically, their stock are limited so that must be wisdom in utilization. In consumption, they use sago starch as main staple food. In addition, they usually sell it to get earn. Then they spend most of their earn to get clothes, food etc. The research conduct in Sentani Jayapura during January – February, 2001. The objectives of its are (1) to analysis affected of socio-economic factors on produce and consume of sago, and (2) to analysis relationship between production, consumption and using of the labor. The result of it shown that socio-economically decision making of farmer to produce sago starch affected by income of sago, using family labor, using hired labor, and sago rasper. Beside production activity, farmers have other activity on sago, namely consumption. Decision of farmers to consume sago starch affected by total income, size of family, education investation, non sago consumption, and non food consumption.

Sago Palm in Nepal

H. K. Saiju

Department of Plant Resources, Thapathali, GPO Box 12066, Kathmandu, Nepal

Key words: alcoholic drink, clay pot, ferment, Tadi, young shoots

Abstract

Sago palms found in tropical areas of Nepal are *Caryota urens* L., *Phoenix acaulis* Roxb. ex Buch.-Ham., *Phoenix humilis* Royle ex Becc. & Hook. f. and *Phoenix sylvestris* Roxb. *Phoenix sylvestris* produce watery sap in the trunk. Local people tie clay pot near the top of the tree and make a hole above the mouth of the pot. After few hours the liquid drip in the pot. The fresh liquid is sweet in taste. If the liquid is kept over-night in the pot it ferments and produce alcoholic drink. Local people cherish the liquid, locally known as Tadi.

Phoenix acaulis Roxb. ex Buch.-Ham., *Phoenix humilis* Royle ex Becc. & Hook. f. and *Phoenix sylvestris* Roxb are found to be growing wild in Nepal. The local people eat the young shoots of Phoenix species. The Phoenix species are used as indoor plants for decoration. The long rooted plants of Phoenix species are good for soil conservation in fragile hills of Nepal.

Significant of Sago in Our Culture

Ephraim Nanto KARARA

Sago (PNG) Dev.Co. Ltd. PO Box 2734, Boroko, NCD. Papua New Guinea.

Key words: sago starch, delicious food in the tropics

Abstract

Sago is part of culture in coastal regions and islands of Papua New Guinea. Sago has also been the centre of economic activities before modern civilisation and was traded in barter system for food security. Special sago dishes are prepared on special occasions. In the Central Province the two (2) notable are *bariva* and *dia* dishes at wedding ceremonies.

Papua New Guinea every year during Independence Day celebrations in Port Moresby put on extra festivities for Motuans to remind the new generation of the value of sago when their forefathers used clay pots to trade for sago, grass skirts and mats.

This festivity is called Hiri Moale Festival and is celebrated for three days with the building of the big canoes known *"lakatoi"* using only bush materials, then sailing into the harbour onto Ela Beach with men and women singing songs and dancing. People on the shore also echo the songs and dance in welcoming them.

The *lakatois* sailed with the South East wind named in motu *Lauraba* to Gulf Province and return to Central Province with North West wind known as *Lahara*.

Sago is still regarded by Motuan as a special food. Research and studies should provide valuable information on development of sago starch into sago flour.