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Studies on functional properties of borassus starch from fresh germinating nuts of giginya (*Borassus aethiopum*) palm

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Abstract

Starch, an agricultural biodegradable biopolymer is increasingly being demanded recently for use in versatile industrial products. This has equally increased the search for new sources of this plant product. The young fresh germinating nuts of giginya (*Borassus aethiopum*) palm, locally called 'muruchi' in some rural communities of Northern Nigeria, contain starch which is eaten when cooked. A new starch was isolated from these germinating nuts which yielded 24.73% of starch on dry weight basis. The chemical composition, swelling power, solubility, water-binding capacity, gelation, effect of storage on gel strength, thermal and pasting characteristics were studied. The chemical composition data were 0.08% ash, 0.18% crude protein, 0.26% crude fiber, 0.09% total lipids, and 26.18% amylose contents. The starch exhibited low water-binding capacity, and limited swelling power and solubility behaviors which were dependent on temperature. DSC measurement showed that the starch has low enthalpy of gelatinization (8.12 J/g) and transition temperatures (T_0, T_p, and T_c), and high gelatinization temperature range (13.1 °C). The gelatinization temperature was 64.5 °C and a low breakdown (BD) viscosity value of 192 Brabender units (BU) is suggestive of high paste stability of borassus starch during heating. Based on the high viscosity, BD viscosity, setback viscosity, final viscosity, and ability of the starch to be easily cooked and form gels, the starch may be a potential hydrocolloid for application in sauces, baby food, and a variety of new food products.

Keywords: *Borassus aethiopum* Starch; Gelatinization; Swelling power; Setback viscosity; Enthalpy of gelatinization; Pasting properties

1. Introduction

Giginya (*Borassus aethiopum*) palm is a tall tree with leathery, gray green, and fan-shaped leaves. The plant is found in the wild in Northern Nigeria and commonly cultivated in other tropical countries (Bokhari & Ahmed, 1978). It is an important source of food for the rural people of Northern Nigeria. The female tree bears a number of coconut-like fruits having a juicy fibrous orange or yellow pulp surrounding a hard nut. The mature nut contains a solid white kernel producing a sap which is used as a refreshing drink and good source of vitamin B complex (Bokhari & Ahmed, 1978; Morton, 1988). The sap is usually boiled immediately after extraction to make sugar or fermented to produce an alcoholic beverage. Also, the mature hard nuts are ground and used in porridge (Bokhari & Ahmed, 1978).

The genus *Borassus*, with *Borassus aethiopum* and *Borassus flabellifer* as the major species, has many traditional medicinal uses. They have been used in treating gonorrhea, dysentery, and respiratory diseases. The young plants are valued as diuretic and anthelmintic agents. Sap from the flower stalk is prized as a tonic, diuretic, stimulant, laxative, anti-phlegmatic, and amebicide. Sugar from the sap is a typical agent used to counteract poisoning and prescribed in treating liver disorders, and the pulp of the mature fruit is known to relieve dermatitis (Morton, 1988).

The soft kernel of the young fruit is edible and the germinating nuts of *B. aethiopum* have an enlarged starchy

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fleshy radical locally called 'muruchi' in Hausa in Nigeria. These germinating nuts are fibrous underground tubers which serve as storage organs for the seedlings and for the development of the growing palm. The tubers are regarded as common foodstuffs which provide a good source of starch for the local community where the plant grows. These tubers are eaten when boiled and could be a substitute for many starch sources. No scientific information is currently available on the starch.

A closely related species which equally contains starch is palmyra palm (*B. flabellifer*) (Morton, 1988). The carbohydrates of the tender kernel of palmyra palm were studied and found to be composed of polysaccharides characterized as a galactomannan (Subrahmanyan, Bains, Natarajan, & Bhatia, 1956). The induction of sister-chromatid exchange in human blood lymphocytes and mutagenicity of palmyra palm flour has been investigated by Anderson and Poulsen (1985) and Kangwanpong, Maratana, and Temcharoen (1989).

The objective of this work was to study the chemical characteristics, swelling, and water-binding behaviors, thermal and pasting properties of borassus starch from fresh geminating nuts of giginya (*B. aethiopum*) palm which will form the basis of its use, and modification for specific industrial applications.

2. Experiment

2.1. Starch isolation

Giginya (*B. aethiopum*) palm is the genotype available in the area of study (Bokhari & Ahmed, 1978) and only tubers from such trees are studied. Fresh tubers from germinating nuts of giginya palm were purchased from local farmers in Hong, Adamawa state Nigeria. The tubers (weighing 400 g) were washed thoroughly with tap water and grated into a pulp. The pulp was suspended in excess distilled water (1:25 w/v) and homogenized in a blender (Waring blender, Model 38BL40, Christison Particles Technology) at medium speed for 5 min at room temperature (30 °C). The homogenized slurry was strained and filtered through a muslin bag. The waste residue in the bag was washed four times with 20 ml of distilled water until clear. The resulting milky filtrate was centrifuged at 1500*g* for 10 min and the clear supernatant decanted. The whole starch sediment was washed with 10 ml of distilled water to remove adhering protein layer. The starch was dried at 40 °C in a convection oven for 48 h. Finally the isolated starch was ground in a mortar, sieved through a 100-mesh sieve, and stored at room temperature in plastic bags.

2.2. Chemical composition

Quantitative evaluations of moisture, ash crude fiber, and lipid were performed by standard methods of AOAC (2000). The nitrogen content was determined by the micro-Kjeldahl equipped with Kjeltec digester and distilling system. The protein of the starch was estimated by multiplying the nitrogen content by 6.25. The lipid was extracted with petroleum ether (b.p. 40–60 °C) for 12 h in a soxhlet extractor. The pH of a suspension containing starch slurry in distilled water (1:5 w/v) was determined using a Jenway model 3015 digital pH meter.

Amylose content of the starch was determined by the colometric procedure of Chrastil (1987) at 620 nm. For determination of phosphorus, the sample treatment method outlined by Chaisawang and Suphantharika (2006) was followed, and the phosphorus content was then determined by the molybdenum blue method using spectrophotometer (Smith & Caruso, 1964). All determinations were in triplicates.

2.3. Swelling power, solubility, water-binding capacity, and leached amylose (LAM)

Swelling behavior, solubility, and water-binding capacity at 50, 60, 70, 80, and 90 °C were determined in triplicate by the method of Waliszewski, Aparicio, Bello, and Monroy (2003). LAM in the dissolved material (Srichuwong, Sunarti, Isono, Mishima, & Hisamatsu, 2005) was determined by the colometric method reported by Chrastil (1987) in triplicate.

2.4. Differential scanning calorimetry

Differential scanning calorimetry was carried out in a Perkin-Elmer DSC-7 (Norwalk, CT, USA) at a heating rate of 10 °C/min to evaluate the thermal transition of starch gelatinization. Melting points of indium (m.p. 156.6 °C, $\Delta H = 28.55$ J/g) and *n*-dodecane (m.p. 96.5 °C, $\Delta H = 218.73$ J/g) were used for temperature and heat quality capacity calibration. Distilled water (6.0 μl) was added to 2.0 mg of starch in DSC pans. It was sealed, reweighed, and kept at 30 ± 2 °C for 24 h for equilibrium of the starch sample and water. An empty pan was used as a reference to balance the heat capacity of the sample pan. The analysis was started at 30 °C and continued to 130 °C. The characteristics onset (T_0), peak maximum (T_p), and conclusion (T_c) temperatures were determined. The enthalpy of gelatinization (ΔH) was estimated by integrating the area between the thermogram and the baseline under the peak and expressed in J/g of dry starch. Native maize, potato, and cassava starches, kindly provided by Northern Scientific Co., Ltd. Nigeria were included for comparison.

2.5. Gelation properties

Starch suspensions (2–14% w/v) were prepared in distilled water with constant stirring. These samples (200 ml) were taken in weighed beakers and immersed in a boiling water bath for 30 min and stirred with a glass stirring rod. The beakers were weighed again and the volume of suspension corrected for any evaporation loss on heating using hot distilled water. A volume of 30 ml of the viscous solution