ISOLATION AND CHARACTERIZATION OF THE PHYSICOCHEMICAL PROPERTIES OF THE STARCH OF JACKFRUIT SEEDS (*ARTOCARPUS HETEROPHYLLUS*)

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ABSTRACT

Starch was isolated from jackfruit seeds (*Artocarpus heterophyllus* Lam) and purified (starch yield 25–40% of total solids). The starch was characterized by rounded or bell-shaped granules ranging in size from 7 to 11 μ, with an amylose content of 28.1% and a D-glucose composition of more than 99%. The starch formed a highly rigid gel. The initial pasting temperature was 74.5°C, with a peak viscosity of 94°C; the granules were not susceptible to breakdown by thermal or mechanical sheer.

The jackfruit tree (*Artocarpus heterophyllus* Lam) grows wild in northern and central Brazil. The fruits, which are borne on the main trunk or branches of the tree, are extremely large, averaging from 2.5 to 5 kg and sometimes attaining a weight of 20 kg each. An average-sized jackfruit is shown in Fig. 1. Fruit yield per tree varies considerably, depending on various agricultural and environmental factors, although estimates indicate that a tree can produce several hundred kilograms of fruit per year.

The jackfruit is a multiple fruit (cross section illustrated in Fig. 2); Winton and Winton (1) have outlined the details of its botanical structure. From 8 to 15% of the total weight of the fruit is seeds, which are enclosed in a white aril (Fig. 3A) encircling a thin brown spermoderm (Fig. 3B). This membrane covers the fleshy white cotyledons (Fig. 3C), which are fairly rich in starch (1,2). Since the physicochemical properties of jackfruit starch have not been reported previously in the literature, the starch was isolated and some of its physicochemical properties were examined with a view to possible industrial use.

MATERIALS AND METHODS

The fruits of various jackfruit trees were used in this study; no attempt was made, however, to determine the variety.

Isolation of Starch

The fruits were thoroughly washed with water and were cut into halves lengthwise. The seeds were manually separated from the mucilage, and the aril and spermoderm were peeled off. The peeled seeds were slurried with an equal weight of a 0.5% solution of $NaHSO_3$ in a Waring Blendor for approximately 2 min. The slurry was pressed through cheesecloth to eliminate seed fibers. The resulting milky suspension was allowed to decant at 4–5°C and rewashed with distilled water to eliminate soluble sugars. It was then washed with 80% ethanol and dried at 30°C for 48 hr until attaining a humidity of 13%. The procedure was repeated several times, with an average starch yield of 10–15% of the fresh seeds (25–40% of total solids); maximum protein and ash contents were 0.32 and 0.22%, respectively.

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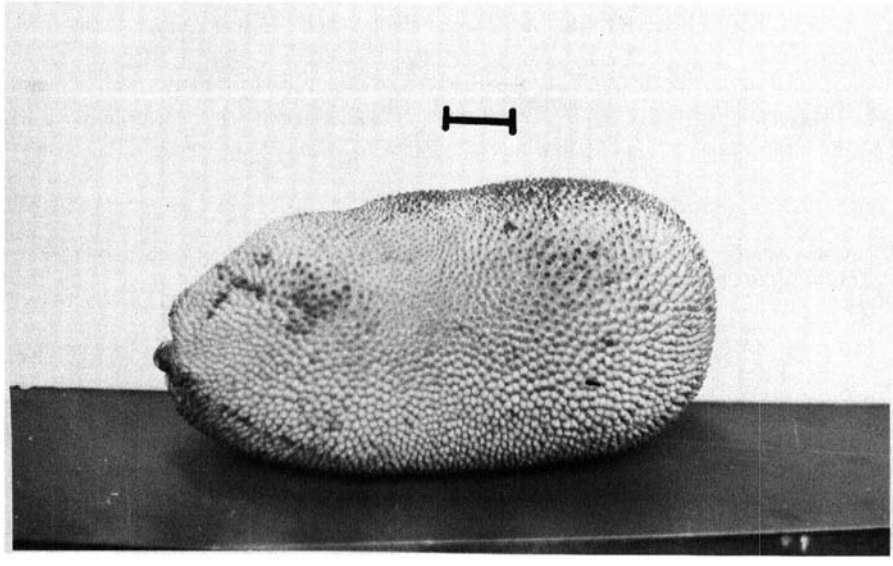

Fig. 1. Average-sized jackfruit (scale distance represents 5 cm).

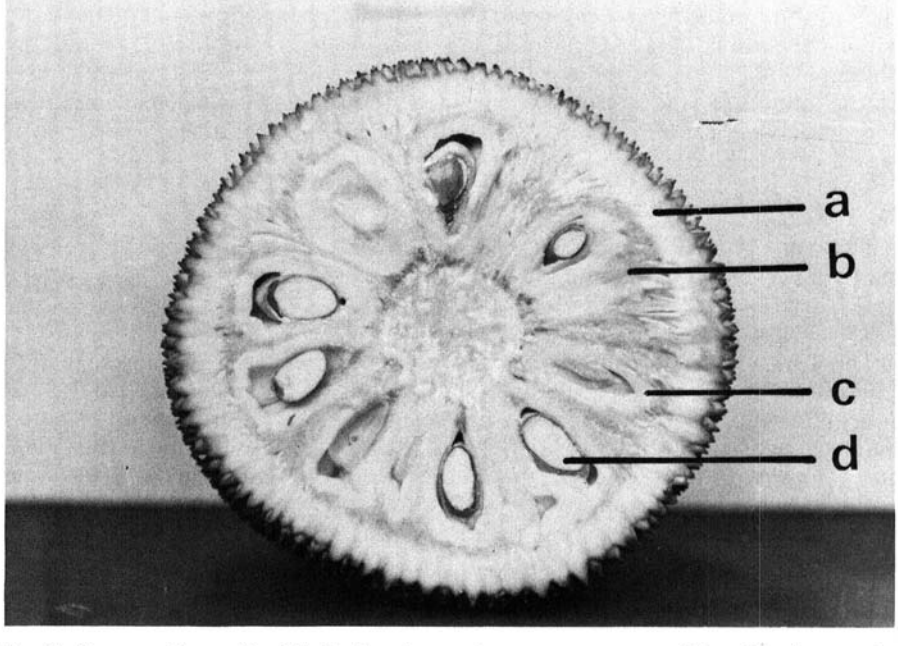

Fig. 2. Cross section of jackfruit showing various parts. a, consolidated perigones; b, inner portion consisting of abortive perigones; c, inner portion of a developed perigone; d, seed.

Chemical Analysis of Starch

Determination of protein (N × 5.7), ash, and moisture contents was made according to AOAC methods (3), while determination of fat was made by extracting 10 g of sample with ethyl ether (followed by extraction with methanol to determine the fat content of the purified starch). The amylose content was

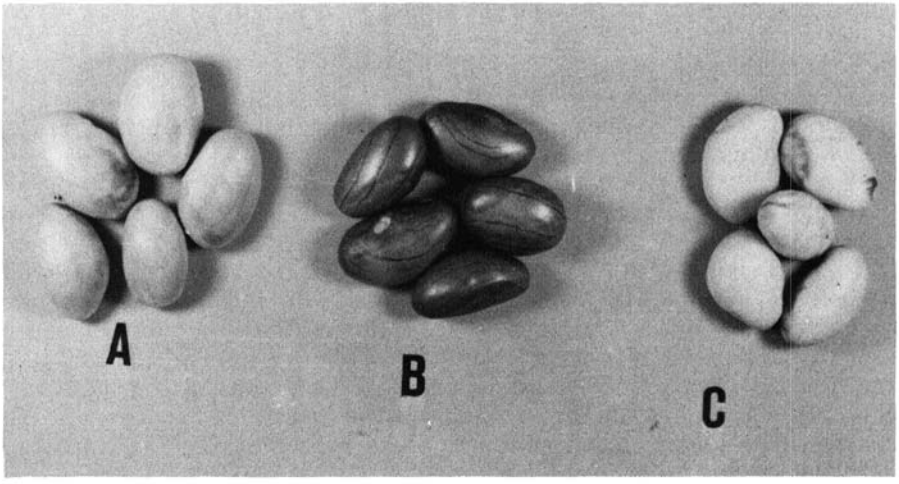

Fig. 3. Seeds of jackfruit: A) aril, B) spermoderm, C) cotyledons.

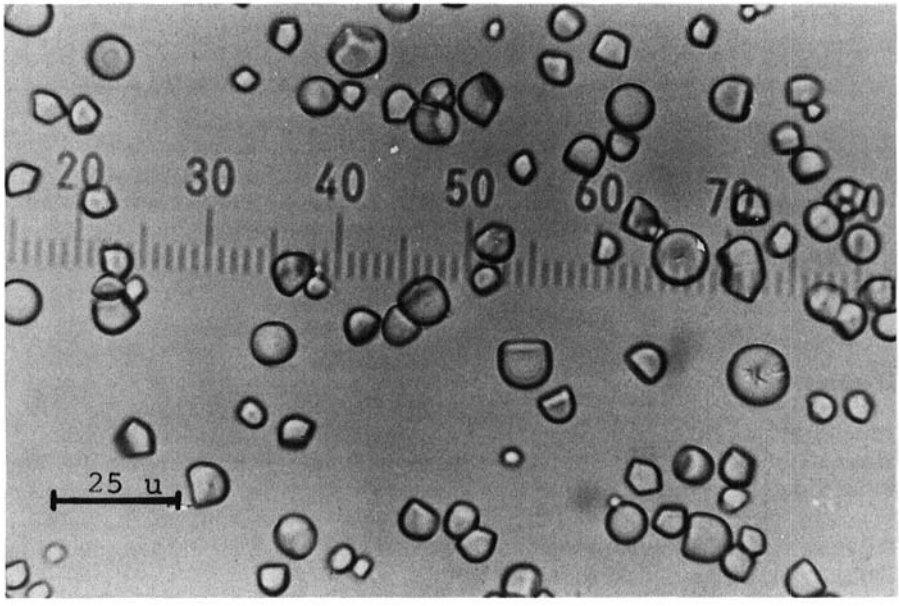

Fig. 4. Photomicrograph of jackfruit starch granules.

determined according to the method of McCready and Hassid (4) using purified corn amylose as a standard of reference. All analyses were performed at least twice.

Hydrolysis products of starch were obtained by heating a starch suspension of 2% H_2SO_4 under reflux for 4 hr. Hydrolysis products were examined by paper chromatography (5) using ethyl acetate/pyridine/water (80:20:10) as a developing solvent. The glucose content of the hydrolysis products was determined using the methods of Somogyi (6) and Nelson (7).

Physical Analysis of Starch

Microscopic Examination. A microscopic examination of jackfruit starch granules suspended in water was made; the starch granules were photographed with a magnification of ×400.

Gel Rigidity Determination. The gel rigidity was determined using an Exchange Ridgelimeter (F. C. Henson Co., Pasadena, CA) with a modification of the manufacturer's procedure. A suspension of 8% starch was made (24 g on 14% mb) by mixing with 300 ml of distilled water and heating to 93°C with continuous stirring. To avoid formation of air bubbles, the mixture was poured carefully into the standardized molds until it rose several millimeters above the tops. After 24 hr at room temperature, the tops were cut off with a wire knife to ensure a smooth, even surface, and the gel was removed from the molds. After 1 min of equilibrium time, the sag value was measured (t, 0 min); after 10 min the test was repeated (t, 10 min). The apparent rigidity (A_R) was then calculated with the following formula:

$$A_R = \frac{\text{Sag}_{t_{10}}}{(\text{Sag}_{t_{10}} - \text{Sag}_{t_0}) \times 100}$$

The results obtained for jackfruit starch were compared with those obtained for potato, arrowroot, rice, and tapioca starches.

Evaluation of Pasting Characteristics. The pasting characteristics of jackfruit starch were evaluated at 5, 8, and 10% using the Brabender Visco/amylo/Graph equipped with a 700-cm g sensitivity cartridge. The sample was weighed (14% mb) and suspended in 450 ml of distilled water. The temperature was raised 1.5°C/min to 95°C, where it was maintained for 20 min and then dropped at a constant rate of 1.5°C/min. The speed of rotation was maintained at 75 rpm.

RESULTS AND DISCUSSION

The chemical analysis of the peeled seeds (cotyledons) is presented in Table I. Starch and protein are the main components of the seed. The chemical composition of the purified starch portion is presented in Table II. The noncarbohydrate matter was 1.18%; 99.1% of the hydrolyzed starch was D-glucose. Paper chromatography revealed no other monosaccharides or oligosaccharides. The linear fraction amylose of the starch was determined in two separate samples and found to be 28.1%.

Jackfruit starch granules are rounded or bell-shaped, ranging in size from 7 to 11 μ (Fig. 4). Under polarized light, only faint polarization crosses were detected.

Jackfruit starch produced a gel that had no particular odor and was extremely firm, with practically no sag value (Table III). In comparison with other starches, the gel was highly rigid as indicated by the extremely high apparent rigidity value shown in Table III and did not develop syneresis during storage at 4°C for five days.

Characteristics of paste made from jackfruit starch at 8 and 10% levels are presented in Table IV. The initial pasting temperature was 74.5°C; it showed no

TABLE I
Chemical Analysis of Peeled Seeds (Cotyledons) of Jackfruit on As-Is Basis

Determination	Percentage
Moisture	61.5
Protein (N × 5.7)	12.3
Carbohydrates	25.1
Crude lipids	0.5

TABLE II
Chemical Analysis of Jackfruit Starch

Determination	Percentage
Moisture	13.0
Fat $_{Et_2O}$[a]	0.21
Fat$_{MeOH}$[a]	0.43
Protein	0.32
Ash	0.22
Amylose	28.1
Glucose (hydrolysis)	99.1

[a]Determined on the same sample; therefore, total fat content = 0.64%.

TABLE III
Sag and Apparent Rigidity Values of Jackfruit Starch as Compared With Other Starches (8% Concentration)

Starch[a]	Temperature of Maximum Viscosity[a] (°C)	Sag Value		Apparent Rigidity
		t = 0 min	t = 10 min	
Jackfruit	95.0	0.0	0.0	...[b]
Rice	92.5	9.7	9.8	0.98
Potato	67.0	13.7	13.9	0.69
Arrowroot	79.5	15.3	15.7	0.39
Tapioca	70.0	25.5	26.2	0.37

[a]Determined by Brabender Visco/amylo/Graph.
[b]Beyond maximum limits of apparatus.

change with increased concentration of the paste. At the 8% level, the viscosity continued to increase even after the maximum temperature of 95°C was reached. When the test was performed using a slightly higher concentration (10%), however, the viscosity increased to reach a peak at 94°C, undergoing only a limited drop during the constant heating cycle (Fig. 5). The starch granules were apparently not susceptible to breakdown by thermal or mechanical sheer, indicating that the bonding forces within the starch granule remained strong even though the granules underwent gelatinization and swelled to a high degree.

These results indicate that jackfruit starch should swell readily while withstanding severe processing conditions. It should thus be useful in the food industry where stable paste and rigid gel properties are desirable (e.g., pie fillings, canned soups, and baby foods) as well as in the production of many nonfood materials (e.g., textiles and paper sizing). Modification of gel and paste properties of other starches by mixing with jackfruit starch also should be feasible.

TABLE IV
Characteristics of Paste Viscosity of Jackfruit Starch at 8 and 10% Concentrations

Characteristic	Concentration	
	8%	10%
Initial pasting temperature (°C)	74.5	74.5
Temperature of peak viscosity (°C)	95[a]	94
Peak viscosity (AU)[b]	420[c]	860
Viscosity (AU) at constant temperature (95°C)	450	840
Viscosity (AU) at 50°C (cooling cycle)	640	1,000

[a]After 5 min of continuous heating.
[b]AU = amylograph units.
[c]Viscosity at 94°C was 330 AU.

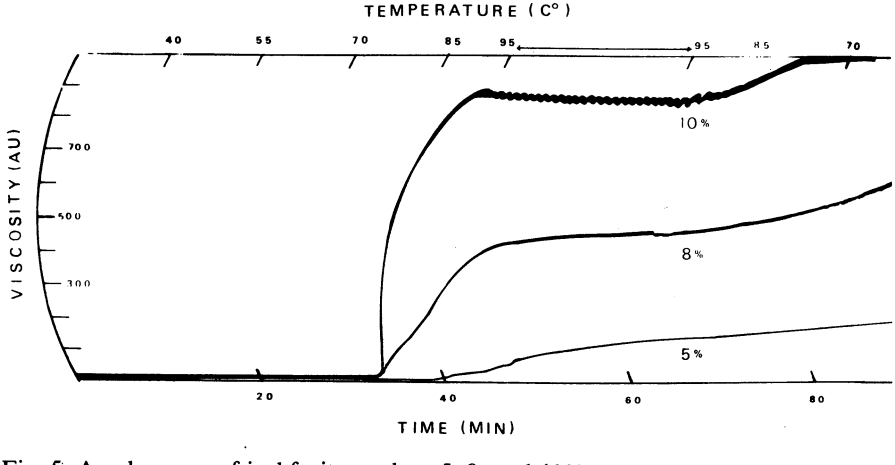

Fig. 5. Amylograms of jackfruit starch at 5, 8, and 10% concentrations.

Acknowledgments

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