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Some Physicochemical Properties of Jackfruit (*Artocarpus heterophyllus* Lam) Seed Flour and Starch

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ABSTRACT Some physicochemical and rheological properties of jackfruit seed flour and starch, isolated from the flour were investigated. The flour had good capacities for water absorption (205%) and oil absorption (93%). Substitution of wheat flour with the seed flour, at the level of 5, 10 and 20% markedly reduced the gluten strength of the mixed dough. The Brabender amylogram (6% concentration, *db*) of seed starch showed that its pasting temperature was 81 °C and its viscosity was moderate, remained constant during a heating cycle and retrograded slightly on cooling. The starch showed an *A*-typed X-ray powder diffraction pattern.

KEYWORDS: Jackfruit Flour, Jackfruit Starch, physicochemical and rheological properties.

INTRODUCTION

Jackfruit (*Artocarpus heterophyllus* Lam) is popular fruit crop that is widely grown in Thailand and other tropical areas. The ripe fruit contains well flavored yellow sweet bulbs and seeds (embedded in the bulb). The edible bulbs of ripe jackfruit are consumed fresh or processed into canned products. Seeds make-up around 10 to 15% of the total fruit weight and have high carbohydrate and protein contents (Bobbio et al 1978 and Kumar et al 1988). Seeds are normally discarded or steamed and eaten as a snack or used in some local dishes. As fresh seeds cannot kept for a long time, seed flour can be an alternative product, which be used in some food products.

There have been few studies on jackfruit seeds. Bobbio et al (1978) reported some physicochemical properties, such as pasting characteristics of jackfruit seed starch. Kumar et al (1988) studied the proximate compositions of two varieties of jackfruit seeds and reported considerable biochemical difference between the two varieties. The starch content of the seed increases with maturity (Rahman et al 1999). Different locations give different seed contents. Some functional properties of jackfruit seed flour and its protein digestibility was reported by Singh et al (1991).

This work investigated some physicochemical and rheological properties of the flour and the isolated starch from a local jackfruit variety called *Thong – Sud – Jai*. This variety is of local origin in Prachinburi Province. It is widely grown in Thailand and gives a high fruit yield (Yospunya, 1999). The type of starch analyzed by the X-ray powder diffraction technique, the first reported use of this technique to study jackfruit starch. Additionally, bread dough substitution with jackfruit seed flour was also investigated.

MATERIAL AND METHODS

Sample preparation

Jackfruit (*Artocarpus heterophyllus* Lam) variety Thong Sud Jai seeds from a local market in Bangkok, Thailand was used for this study. The seeds (3 kgs) were cleaned and the white aril (seed coats) were peeled off. Seeds were then devided into two parts. One part was lye-peeled with 5% NaOH for 2 min to remove the thin brown spermoderm covers the fleshy white cotyledons. The seeds were sliced into thin chips and tray dried at 50° - 60 °C until their moisture content was less than 13%. The chips were ground in a Pin mill FFC-23 to a 70 - mesh flour, packed in plastic pouches and stored in a refrigerator (<5 °C) until use. The yield of the flour was 36.4%

Starch isolation

Starch isolation from flour was carried out following the basic procedure washing steps suggested by Bobbio et al (1978). The flour was mixed with 3 parts of distilled water and made into slurry. The slurry was filtered through a 70 µm sieve to eliminate seed fibers. The starch suspension was allowed to settle and the liquid was decanted at < 10 °C. This step was repeated several times until the supernatant was clean and clear. The starch was dried in a convection oven at 40 ° to 60 °C until the moisture content was less than 13%, then ground with a mortar and pestle and passed through a 70 µm sieve.

Sample was stored in air tight containers at room temperature until use.

Chemical analyses.

Representative samples of flour were analyzed in triplicate for moisture, crude protein (conversion factor N x 5.7), crude lipid, and crude fiber ash contents using standard methods of the Association of Official Analytical Chemists (AOAC) (1990). Total starch was measured following the polarimetric procedure of Meloan and Pomeranz (1973).

The Specific rotation, $[\alpha] = 203$, which is arbitrarily taken as value for all starch was used for calculation (AOAC 1990). The pH of the flour was measured by the potentiometric method following the standard procedure in AOAC 1990.

Nitrogen content of jackfruit seed starch was analyzed by a macro-Kjeldahl method (AOAC, 1990). Four grams of the starch was used for the analysis. Protein content was calculated by multiplying the nitrogen content by 5.7.

Amylose contents of jackfruit seed starch was determined in triplicate using the spectrophotometric method described by Javis and Walker (1993). Standard potato amylose and amylopectin (Sigma Chemical) were used as references.

Physical and functional properties

Granular morphology of the isolated starch granules was identified in a light microscope. Scanning Electron Microscopy analysis of the isolated starch was performed in an SEM (JOEL Tokyo, Japan) with magnification of 1100X.

X-ray diffraction: step-scanned X-ray powder diffraction patterns for jackfruit starch were collected on the finely ground samples on a Shimadzu 610 diffractometer (Shimadzu, Tokyo, Japan). The X-ray source operated at 30 kV and 40 mA with a Cu target and graphite – monochromator radiation K_α radiation ($\lambda = 1.5406$). Data were collected by step-scanned method between 2 ° to 60 ° in 2θ with a step size of 0.02° 2θ and a counting time of 2 sec/step.

Water and oil absorption capacities of the flour were measured in triplicates by the method of Sosulski et al (1987), using 0.5 g flour (dry weight basis, *dwb*) in 15 ml centrifuge tubes.

Brabender viscosity curves of flour and starch at 8% concentration (*dwb*) were determined according to the procedure described by Mazur et al (1957). Standard procedures using the Brabender farinograph (Brabender OHG Duisburg, model 82575000) and extensograph (Brabender OHG Duisburg, model 850000) were employed to determine the rheological properties of the doughs.

White breads were prepared by a straight dough method using the standard procedure in AACC (1983). All purpose wheat flour (protein 10-11%) were supplemented with three different levels (5,10, 20%) of jackfruit seed flour. Specific volume (cm^3/100gm) of the breads was determined by the seed dis-placement method.

RESULT AND DISCUSSION

Flour

The flour composition of this study, compared with Singh et al (1991) were shown in Table l. The major components of the flours were carbohydrates (78.0%). The proximate analysis showed that protein (11.2%, *dwb*) and lipid (0.99%, *dwb*) contents of the flour were lower than those reported by Singh et al (1991). The difference can be contributed by variety difference, maturation of the seeds and environmental conditions. These effects were already reported by Rahman et al (1999).

Composition of flour depends on nature of the seeds. Bobbio et al (1978) reported protein, crude lipids and carbohydrates contents of jackfruit seeds as 31.9%, 1.3% and 66.2% (*dwb*), respectively. The protein content reported by Bobbio et al was very high; however, the seeds were reported to have been collected from fruits of various trees and no variety was reported. Kumar et al (1988) also reported composition of seeds from two varieties of jackfruit. Protein, crude lipids and carbohydrates content were 17.8-18.3%, 2.1-2.5% and 76.1% (*dwb*), respectively.

If the flour was prepared from seeds without removing the thin brown spermodesm, the crude fiber content was 2.36% (Table 1), close to that reported by Singh et al (1991). However, the flour used in this study was prepared only from lye-peeled seeds to remove the brown coating.

Water absorption capacity and oil absorption capacity of the flour were reported in Table l. These indicated good ability of the flour to bind water and lipid. The water absorption in this study was higher than that reported by Singh et al (1991). Milling equipment and flour preparation methods, such as a milling time can effect some properties of the flour; for example, starch damage, which will result in high water absorption because water can penetrate into granules more easily than intact granules.

Since the seed flour had high protein content (11%), the possibility of substitution of wheat flour with the seed flour for bread making was investigated. Table 2 showed the rheological tests of jackfruit seed flour mixed with wheat flour. With increasing level of supplementation, the water absorption capacity increased. High water absorption capacity is a characteristic of the wheat flour which is employed for bread making (Kent, 1975). The bread dough peak time and dough stability time were reduced as supplementation increased. This confirmed the reduction of protein gluten strength in the wheat/ seed flour. The mixed dough also showed a poor mixing tolerance index (viscosity difference after 5 min of peak viscosity). With more supplementation, the mixing tolerance index increased. Extensograph also indicated that the dough had poor extensibility and resistance to extensibility as compared to normal wheat dough. As the results, the specific baking volume of the bread was reduced by 51% at 5% supplementation level of wheat flour with jackfruit seed flour (Table 2).

Starch properties

Scanning electron microscopy (SEM) and optical microscopy under normal light showed round and bell-shaped granules predominate (Figure 1). Optical microscopy with polarized light showed sharp dark maltese cross in all starch granules. The hilum is central (Figure 2). The birefringence is different from that of the faint polarization cross reported by Bobbio et al.

Pasting properties of 8% jack-fruit seed starch was studied by means of the Brabender viscoamylograph (Table 3). Tapioca and corn starches, which are commonly used in food industry, are also shown

Table 1. Composition and some physicochemical characteristics of jackfruit flour (% dry weight basis, except moisture).

Determination	% (*dwb*)		
	With brown spermoderm	**Without brown spermoderm**	**Singh *et al* (1991)**
Moisture	7.70 ±0.20	8.57±0.25	5.1
Crude protein (%Nx5.7)	11.02±0.46	11.17±0.21	17.2
Crude lipid	1.01±0.12	0.99±0.08	2.2
Crude fiber	2.36±0.04	1.67±0.11	3.06
Ash	3.97±0.04	3.92±0.03	3.6
Total Carbohydrate [(a)]	81.64	82.25	74
Total starch		77.76±0.96	-
Amylose content of starch		32.05±1.20	-
Protein content of starch		1.84	-
pH		5.68	-
Water absorption capacity(%)		205	141
Oil absorption capacity (%)		92.6	90.2

[(a)] determined by difference

Table 2. Rheological tests of flours and specific volumes of white bread.

Parameter	WF	JF 5% WF 95%	JF 10% WF 90%	JF 20% WF 80%
% Water absorption	66.6	66.0	66.3	66.9
Arrival time (min)	1.7	1.7	2.0	1.7
Peak time (min)	8.6	4.9	4.7	3.4
Stability time (min)	11.4	6.8	5.3	4.1
Mixing tolerance index (BU)	51	100	118	178
Extensibility (cm)	9	11.1	9.9	13.3
Resistance extensibility (BU)	1000	740	523	185
Specific volume of bread cm3/100 gm	8.64	4.21	3.51	3.21

WF, wheat flour, JF, jackfruit seed flour ; BU, Brabender unit for comparison. The lower breakdown of viscosity (P/F value) during heating cycle for jackfruit seed starch as compared to that of tapioca starch indicated good stability of the starch paste and good bonding forces within the starch granules (Zobel et al, 1984). The starch paste also showed lower retrogradation as compared with tapioca and corn starch pastes. Amylose content of jackfruit seed starch was 32%, (Table 1), higher than the mean value found in tapioca starch (17%) and corn starch (26%). However, the starch paste showed relatively low retrogradation. This is probably due to differences in amylose molecular weight and its ability to leach out of the starch granules (Zobel, 1984).

The jackfruit starch is in an amorphous state as seen from the broad XRD peak pattern presented in Figure 3. The XRD pattern of jackfruit is different to the patterns of potato and water chestnut starch, especially in position and relative peak intensity in the range of $2\theta = 5°\text{-}6°$, but it is similar to the pattern of waxy rice (Hizukuri, 1988). The absence of the peak of $2\theta = 5°\text{-}6°$ is characteristic of type-*A* starch, Therefore, the jackfruit seed starch belongs to A-type starch as do cereal starches in general belong to the A-type pattern (Zobel, 1964). Cheetham and Tao (1998) also reported waxy maize starch (amylose 0%) and maize starch (amylose 28%) showed a typical A-type pattern. Transition from A-type to B-type pattern occurrs at amylose about 40%.

Conclusion

Flour from jackfruit seed was prepared by dry milling. It is high in protein and carbohydrate contents. The flour has good water and oil absorption abilities. However, less than 5% of wheat-flour can be replaced with jackfruit seed flour for making white bread. Further studies are required to improve the seed flour quality for usage.

Starch was also isolated from the flour. Its amylose content was high. The starch showed good paste stability during heating and gave the A-type X-ray diffraction pattern.

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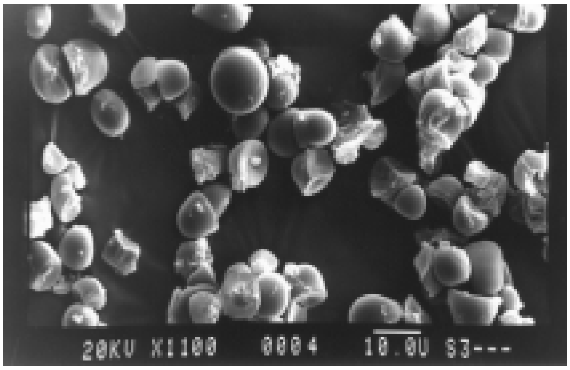

Fig 1. Scanning electron micrograph (1100x) of jackfruit seed (*Artocarpus heterophyluss* L) starch.

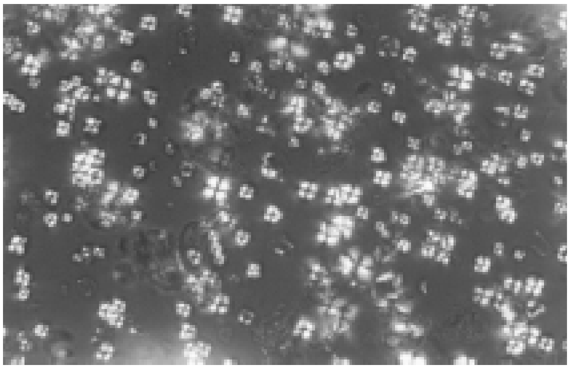

Fig 2. Photomicrograph of jackfruit seed starch under polarized light.

Table 3. Pasting properties of jackfruit – seed tapioca and corn starches.

Pasting properties	% (*db*)		
	Jackfruit Starch 8%	Tapioca 8%	Corn 8%
Pasting temperature (°C)	81	61	73
Peak viscosity (BU)[(a)] (P)	798	1590	750
Final viscosity @ 95 °C 20 min (BU) (F)	680	400	700
Cooled to 50 °C (BU) (C)	820	690	1350
Breakdown (P / F)	1.17	3.98	1.07
Retrogradation (C / F)	1.21	1.73	1.93

(*a*) (BU) = Brabender Unit

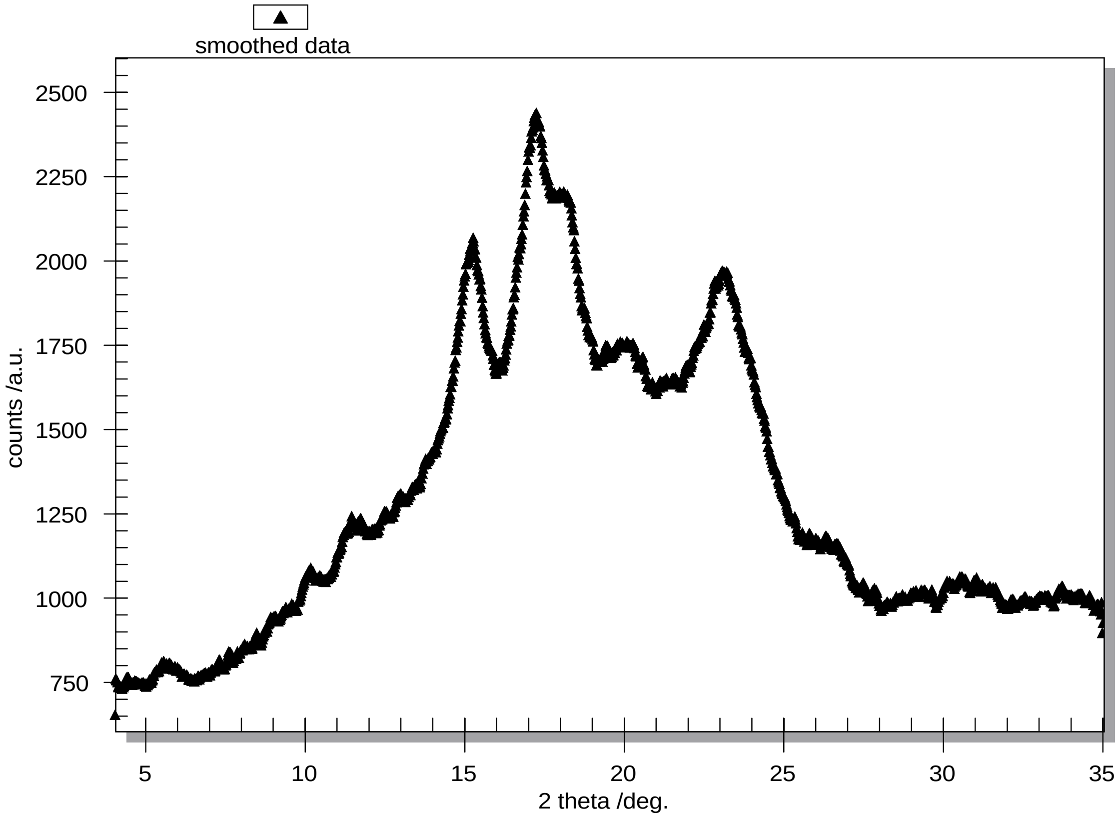

Fig 3. X-ray powder diffraction pattern of jackfruit seed starch.

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