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To cite this article: T C Sunarti *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **557** 012073

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Effects of slurry concentration and rotational speeds of drum drier to the characteristics of pregelatinized breadfruit (*Artocarpus altilis*) flours

T C Sunarti¹, W S L Br. Sinaga², and C Pandji¹

¹Department of Agroindustrial Technology, Faculty of Agricultural Engineering and Technology, Bogor Agricultural University, Indonesia

²Program Study of Food Science, Faculty of Science and Technology, University of Pelita Harapan, Tangerang, Indonesia

Abstract. Breadfruit is one alternative carbohydrate source in Indonesia. However, breadfruit is seasonal and climacteric crops; it should be processed immediately to produce flour. Native breadfruit flour has many limitations since it is difficult to be solubilized and swollen in cold water. The flour is modified physically by pregelatinization to improve its properties. Pragelatinized breadfruit flour can be used as instant food, porridge, and baby food. This research is aimed to investigate the effect of slurry concentration (20 and 30%) of native breadfruit flour and rotational speeds (4, 6 and 8 rpm) of double drum drier to the chemical composition and physico-chemical properties of the pregelatinized flours. The results showed that pregelatinization did not influence to the chemical composition. Pregelatinization of the flour improved the water solubility and swelling power on room (30°C) and hot (70°C) solutions, reduced the freeze-thaw stability, caused partial gelatinization which is monitored by losing the birefringence of starch granule, and darkened the flour. The pregelatinization also reduced the gelatinization temperature and had low final viscosity. Low concentration of slurry and low rotation speed of drum increased the gelatinized part of the flour, which is influenced to the cold and hot water solubility.

Keywords: breadfruit flour, drum drying, physico-chemical properties, pregelatinization

1. Introduction

Breadfruit (*Artocarpus altilis*) or sukun (local name) belongs to the Moraceae a family of about 50 general and over 1000 species. The species originated in Oceania, and is grown across the Pacific region. It is now found in many countries in tropical zones across the world, including in Africa, Australia, South America, South and Southeast Asia [1]. It has long been an important staple crop and a primary component of traditional agroforestry systems in Oceania [2].

The plant *Artocarpus altilis*, seedless variety, is a fruit-producing plant. In Indonesia, breadfruit is harvested twice a year. The fruit can be eaten in all stage of maturity, since it is a good source for carbohydrate, vitamin and minerals [2]. Breadfruit is a large, round, starchy fruit borne by a tree. It is classified as climacteric fruit, which has fast respiration process [3]; therefore it has short shelf-life. In order to anticipate abundant breadfruit during the peak harvest session and to prolong its shelf life, the fruits should be processed immediately.

Breadfruit is consumed after cooking by boiling, steaming, roasting, baking and frying. Breadfruit has been processed into many forms for utilization in the food industry. It can been processed into starches [4] into flour [5,6] and other modified products [7]. Native breadfruit flour has some limitation in application as food products. It has low solubility and swellability in room temperature. Studies on the modification of breadfruit starch involving heat-moisture-treatment and annealing, as forms of physical modification collectively referred to as hydrothermal treatment which entail modification of temperature and moisture content have been carried out and reported by Adebowale et al. [8]; and Ojifolokun and Adeniran [7]reported the study explored the potential of substituting breadfruit into cassava to obtain gari analogue.

Pregelatinization is one of the physical methods used to modify starch by using drum dryer, spray dryer or extruder [9]. This modification method affects physicochemical and functional properties of



flour significantly [10]. Due to starch granule disruption, pregelatinized flour can absorb water and increase viscosity immediately even with cold water [11,12]. For powder production from fruit or root and tuber, drum drying is considered a special method for numerous materials with many benefits such as good characteristics of product and economic efficiency of the process. Pregelatinized starch is primarily used as a thickener in many instant products, such as baby food, soups and desserts, due to its ability to form pastes and dissolve in cold water. The use of pregelatinized starch is preferred in sensible foods because it does not require heating to form a paste [13]. The four variables which govern the operation of drum are steam pressure, rotational speed, and film thickness and feed material characteristics. The steam pressure or heating medium temperature will regulate the drums temperature. The rotational speed of the drum determines the all performance of dryer [14]. This research is aimed to investigate the effect of slurry concentration of native breadfruit flour and rotational speeds of double drum drier to the chemical composition and physico-chemical properties of the pregelatinized flours.

2. Methods

2.1. Materials

The breadfruit used in this study was collected from local farmer in Jawa Barat. They were on the optimum green maturity, and taken in polypropylene plastic bags to the laboratory to use and process immediately.

2.2. Processing of Breadfruit into Flour

Fresh fruits were peeled and washed with clean water, and then sliced, blanched with hot steam for one minute, and dried at 60°C for 6-8 h. Dried chips were milled into flour, and the flour was screened by 60-mesh standard sieve.

2.3. Production of Pregelatinized Flour

The slurry (A1-20% and A2-30%) was prepared by mixing the flour with distilled water, and then dried in double drum drier with different rotational speeds (R1-4 rpm, R2-6 rpm, and R3-8 rpm). The drier has two stainless steel drums with 12 in outer diameter and 8 in cylinder length, and 80±5°C surface drier plate temperature. Then the dried flour was milled and screened by 60-mesh standard sieve. Samples were kept in polyethylene bag, sealed and stored at room temperature until used.

2.4. Flour Characteristics

The flour was analyzed its proximate components (moisture, ash, crude fiber, crude protein, crude fat, and carbohydrate *by difference* contents) according to AOAC methods [15], starch content (Luff Schorl method [15], the whiteness of flour by Colortec, shape and size of starch granules by using polarized light microscope.

The viscoamylographical properties of each flour was studied by using Brabender Viscoamylographer. Flour solubility and swelling power at 30°C and 70°C, paste clarity, and freeze-thaw stability were analyzed by using modified Perez *et al.* [16]. Viscosity of 5% flour paste was analyzed by using Brookfield viscosimeter.

3. Results and Discussion

Breadfruit should be harvested at the stage of maturity that is required for the method of preparation for consumption. In this research, the breadfruit is harvested as “green mature”. At this stage the fruit has completed its development and has reached the dimensions of a mature fruit but has not begun to ripen and is still very firm. The flesh is very starchy and not sweet to the taste.

Native breadfruit flour (A0R0) and six pregelatinized flour were analyzed for their chemical composition (Table 1). It has shown that all flour contained relative low minor components such as fat (1.004-3.671%) and protein (3.694-5.028%), but high in carbohydrate and fiber. The starch is the main carbohydrate in breadfruit flour. The starch content in native flour was determined as 31.6%. Similar results also reported by Wooton and Tumaalii [5], besides the starch the flour also contained lots of total sugar with fructose is predominant sugar found in less mature fruits. The protein and fat contents showed decreasing values compared to native flour. The major cause of this significant decrease in the crude protein content may be the pre-gelatinization process, which allows elution and

dissolution of water-soluble proteins during steam treatment [17]. In food application, this composition is a key to achieve desirable product quality as well as nutrition value and even the lipid content in flours was low, it could affect to the flour properties dramatically such as swelling and pasting properties [18].

Table 1 Proximate components of breadfruit flour

Treatment	Chemical components*(%)					
	Moisture	Ash	Crude Protein	Crude Fat	Crude Fiber	Carbohydrate (by difference)
A0R0	3.537	0.429	5.028	3.671	5.044	82.286
A1R1	2.237 ^a	0.332 ^a	3.694 ^a	1.004 ^d	11.037 ^a	82.953 ^a
A1R2	1.876 ^a	0.402 ^a	4.060 ^a	2.249 ^{bc}	8.536 ^a	82.547 ^a
A1R3	2.721 ^a	0.38 ^a	3.977 ^a	2.576 ^a	8.060 ^a	82.493 ^a
A2R1	2.438 ^a	0.384 ^a	4.824 ^b	2.070 ^c	10.200 ^a	80.501 ^a
A2R2	2.048 ^a	0.382 ^a	4.019 ^b	2.789 ^a	10.613 ^a	79.464 ^a
A2R3	2.844 ^a	0.510 ^a	4.315 ^b	2.494 ^{abc}	7.091 ^a	85.377 ^a

*All calculated in dry-basis except for moisture content; ^aValues shown in same column with the same letters are not significantly different (P<0.05)

Pregelatinized flour is flour that has undergone a cooking process until complete or partial gelatinization and a simultaneous drying process. Since the process is physical process, it did not affect to the chemical composition, as shown in Table 1 for different slurry concentration and rotational speeds of drum dryer. The main consequence of this treatment is the destruction of the granular structure, resulting in complete granular fragmentation, and the absence of birefringence properties as shown in Figure 1.

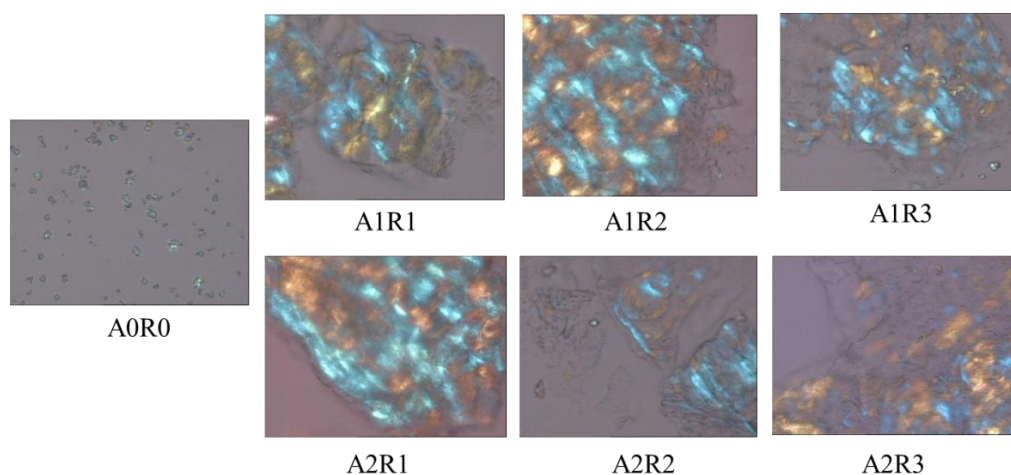


Figure 1. Morphology of breadflour in water by using polarized light microscope (magnification 200 times)

Figure 1 (A0R0) showed the small size granule of breadfruit native starch. Rincon and Padilla [4] reported the breadfruit granules size are around 3-8 μm . It expressed the common granules that could not swell in room temperature, but vice versa the pregelatinized flour have tendency to cold swelling properties. The principal properties of pregelatinization flour are an increase in swelling capacity, solubility and cold water dispersion. Table 2 showed that pregelatinization slightly increased the solubility and swelling power at 30°C and 70°C, paste viscosity and clarity. Murayama et al. [17] reported that the solubility of the native flours showed slight changes between 50 and 70°C, and

significant increases at 80°C and above. The treatments (slurry concentration and rotational speed of drum dryer) did not significantly affect to the flour properties, but it caused darkening of the flour as shown as low degree of whiteness (35-42%).

The native breadfruit flour has high tendency to retrogradation as shown in high freeze-thaw stability and pasting properties (Figure 2 and Table 3 for A0R0). Similar pattern for breadfruit starch also reported by Rincon and Padilla [4]. Pregelatinization effectively affected to the cold swelling flour with low (30°C) initial gelatinization temperature. Higher slurry concentration and higher rotational speed caused the increasing of maximum viscosity and reduced the tendency to retrogradation.

Table 2. Physico-chemical properties of breadfruit flour

Characteristics	Flour Treatment						
	A0R0	A1R1	A1R2	A1R3	A2R1	A2R2	A2R3
Solubility at 30°C (%)	23.08	31.28 ^b	29.39 ^b	33.12 ^a	28.92 ^b	31.50 ^b	33.40 ^a
Solubility at 70°C (%)	37.43	41.53 ^a	43.16 ^a	43.82 ^a	40.62 ^a	41.80 ^a	37.51 ^a
Swelling Power at 30°C (%)	36.97	44.65 ^a	51.06 ^a	44.41 ^a	41.74 ^a	42.57 ^a	44.37 ^a
Swelling Power at 70°C (%)	44.94	50.93 ^a	50.81 ^a	53.52 ^a	58.99 ^a	50.32 ^a	63.40 ^a
0.1% Paste Clarity	90.55	83.55 ^a	93.90 ^a	94.60 ^a	89.85 ^a	94.05 ^a	93.75 ^a
Freeze-thaw stability (% Sineresis)	80.00	85.71 ^a	84.06 ^b	84.29 ^b	90.71 ^a	84.29 ^b	84.29 ^b
Paste viscosity (cP)	5.50	7.00 ^a	9.25 ^a	9.25 ^a	8.35 ^a	6.65 ^a	9.10 ^a
Degree of whiteness (%)	54.77	40.77 ^a	42.41 ^a	35.82 ^a	38.73 ^b	37.41 ^b	38.27 ^b
Amylase digestibility (%)	44.27	32.72 ^a	42.76 ^a	45.31 ^a	47.71 ^a	42.33 ^a	37.88 ^a

^aValues shown in same row with the same letters are not significantly different (P<0.05)

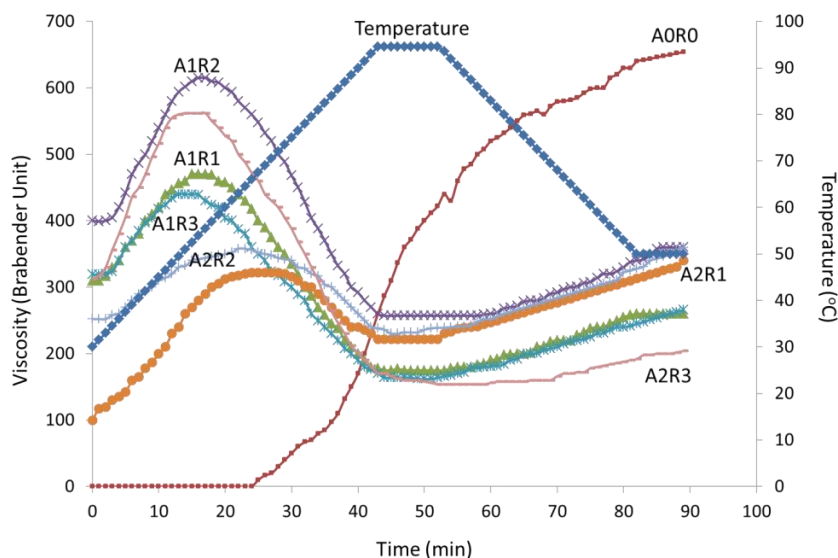


Figure 2. Pasting properties of breadfruit flour by Brabender Viscoamylographer

4. Conclusion

Breadfruit flour contained high amount of carbohydrate mainly starch, and low minor components such as protein and fat, but the pregelatinization process did not influence to the chemical composition. Pregelatinization of the flour improved the water solubility and swelling power on room and hot solutions, reduced the freeze-thaw stability, caused partial gelatinization which is monitored by losing the birefringence of starch granule, and darkened the flour. The

pregelatinization also reduced the initial gelatinization temperature and had low final viscosity. Low concentration of slurry and low rotation speed of drum increased the gelatinized part of the flour, which is influenced to the cold and hot water solubility.

Table 3 Parameters of Brabender Viscoamylography of Breadfruit Flour

Treatment	Initial Gelatinization Temperature (°C)	Maximum Viscosity (BU)	Breakdown Viscosity (BU)	Set Back Viscosity (BU)	Final Viscosity (BU)
A0R0	67.5	nd*	nd	nd	654
A1R1	30	470	295	85	260
A1R2	30	615	358	103	360
A1R3	30	440	278	104	266
A2R1	30	322	100	118	340
A2R2	30	358	126	127	359
A2R3	30	562	408	50	204

*nd: not detected

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Acknowledgements

Thank you very much to Forest Research and Development Agency for providing the raw material (breadfruit) for this research.