PHYSICO-CHEMICAL PROPERTIES OF CASSAVA STARCHES IN THAILAND

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ABSTRACT

Cassava starches prepared from 7 recommended (Thai Ministry of Agriculture and Co-operative) varieties of cassava roots Rayong 1, Rayong 3, Rayong 5, Rayong 60, Royong 90, Kasetsart 50 and Sriracha 1 were studied in detail. The chemical properties were moisture content (7.02-9.12 %), ash content (0.220-0.227 %), phosphorus content (0.014-0.017 %), lipid content (0.019-0.104 %), crude protein content (0.097-0.190%) and amylose content (12.66-16.74 %). The physical properties were; granular size (average 12.64 - 15.67 μm) granular shape (magnification x 1000), percent transmittance (%T) (80.06 - 83.50), X-ray diffraction pattern (scanning region 4° - 60° of 2θ), gelatinization temperature (60.45-69.75 °C), maximum viscosity of starch paste (315-495 B.U.), and thermal properties (T_o = 63.97-68.05 °C, T_p = 70.60-73.90 °C, T_C = 81.20-84.40 °C, ΔH = (-436.37) – (-660.37) cal/mol. In addition, 2 brands of commercial cassava starches were analyzed to compare with the recommended-variety cassava starches. Some differences properties were found between the two groups of cassava starches.

KEYWORDS: Cassava starches, recommended-variety cassava starches, commercial cassava starches

1. INTRODUCTION

Tapioca or cassava plant was originally a native of Central America, but is now grown in Brazil, The Dominican Public, Africa and South-East Asia [1]. In Thailand, cassava is an important economic plant. The Thai Cassava Flour Industries Trade Association found that there were more than 128,000 hectares planted with cassava [2]. In Thailand, about 70% of total cassava roots were supplied as cassava chips and pellets and the remaining 30% was manufactured into cassava starch. Approximately, 60% by volume of cassava starch is exported to foreign markets and the rest is used for domestic consumption.

The value of exported cassava products (pellets, chips and cassava starch) is more than twenty-three thousand million baht annually. However, the prices of cassava products which are exported at present are determined by the demand for them in the importing countries. At present the great proportion of cassava product is exported more than the local used. Therefore the prices of cassava root in Thailand depend on the demand in export market.

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When the exported price was low, its produces the great impact to the poor farmers. Solution of these problems will require an increased volume of the cassava products to be used in the domestic market. Although cassava pellets and chips had a low price level, cassava starch price was even lower. Cassava and its modified starches are produced in order to offset the price decline of cassava chips and pellets. [2, 3].

In Thailand, there are 7 varieties of cassava plants which have been recommended to farmers by the Department of Agriculture, Ministry of Agriculture and Cooperatives. They are Rayong 1, Rayong 3, Rayong 5, Rayong 60, Rayong 90, Kasetsart 50, and Sriracha 1. Each variety has different specifications. However, the properties of cassava starch from these recommended varieties have not been examined indepth. Aim of this study was indented to characterize the physico-chemical properties of these starches, which will be produced the knowledge of seven varieties of cassava plants growth in Thailand and will help the researcher to understand their properties in order to use in the future research on chemical modification on the cassava starch or modify them into the high price materials. Therefore, this research will be supported the further research in the future.

2. MATERIALS AND METHODS

2.1 Materials

The cassava starch samples were divided into two groups. The first set of cassava starch samples were from the recommended varieties, which were Rayong 1 (R1), Rayong 3 (R3), Rayong (R5), Rayong 60 (R60), Rayong 90 (R90), Kasetsart 50 (K50), and Sriracha 1 (S1) were given by W. Oui Pathipanawat, the Department of Agriculture, Ministry of Agriculture and Cooperatives. The cassava tubers were harvested from Rayong Field Crops Research Centre, Rayong Province located in the eastern part of Thailand. The second was commercial cassava starch. The Commercial 1 (C1) brand was available in market and Commercial 2 (C2) brand was donated from Tai Wah Public Company Limited. The other chemicals were AR grade.

2.2 Methods

2.2.1 Starch Preparation

The cassava tubers were cleaned with water, peeled and chopped into pieces. Starches were extracted by water and filtered with a cheese cloth to separate waste fibrous materials. The filtrate was allowed to settle, decanted, and the supernatant was discarded. The sedimented starch granules were dried by a hot-air oven at 50-60 ^{o}C overnight. The agglomerate starches were ground to fine particles and sieved through the sieve No.106 (140 mesh).

2.2.2 Chemical Analysis

All analyses were performed in triplicate, and results are reported on dry solids basis(dbs), except for moisture content, which is reported for the samples as supplied.

Moisture Content [4]: Moisture content were determined by drying at 40^{0}C for 1 hr and then for 4 hrs. at 120 ^{0}C.

Ash Content [5]: Accurately weighed ca. 3 g of starch in a porcelain crucible was ignited in a furnace at 550^{o}C, until the light gray ash was obtained. The results were calculated on a dsb.

Protein Content [6]: Protein content was measured by the Kjeldahl procedure described by Aurand [6], using 1.0 g samples of material. Nitrogen content was converted to crude protein using the conversion factor 6.25.

Lipid Content [7]: Starch (10.0 g) was suspended in 40 ml of distilled water. Added boiling 120 ml of 4 N HCl, and then heated to boiling for 15 min. All precipitate was recovered by gravity filtration, and dried for 3 hr in a hot air oven at 50°C. The residues were extracted (6 times, 20 ml each) with a mixture of chloroform and methanol (2:1, v/v). The combined extracts were filtered, evaporated to dryness and weighed. Lipid contents were reported on a dsb.

Phosphorus Content [4]: Phosphorus content was determined by molybdivanado-phosphoric acid method using spectrophotometer (UV-160 spectrophotometer, Shimadzu) at a wavelength of 460 nm.

Amylose Content [8]: The method for amylose determination is based on the absorption of iodine by amylose to produce a blue color, read absorbance at 630 nm using the standard amylose solution, and iodine blank.

2.2.3 Physical Properties Analysis

Percent Transmittance (%T) [7]: Starch solution (1% w/v in water, dsb) was heated in a boiling water bath and stirred for 30 min. After temperature equilibration at room temperature, the %T was measured at 650 nm using the Spectronic 21.

Thermal Properties [9]: The thermal properties were measured by using the differential scanning calorimeter (DSC-50, Shimadzu). Starch sample (2 mg,dsb) was weighed in an aluminium sample pan, mixed with distilled water (8 μl), and sealed. The sealed pan was allowed to stand from 1 to 3 hr at room temperature before heating. The reference material was 8 μL distilled water. The sample was heated from 30 to 120 °C at a heating rate of 10 °C/min. the enthalpy was calculated on dsb.

Pasting Properties: Pasting characteristic of starch suspension (6% w/v, dsb) was measured by using a Brabender viscoamylograph (PT 100, BRABENDER OHG Duisburg), and operating at a bowl speed of 75 rpm. The temperature was raised from 30 °C to 95 °C at a rate of 1.5 °C/min maintained at 95 °C for 30 min and decreased to 50°C at the same rate.

The Size Distribution of Starch Granules: The average of starch granules size and size distribution were studied by a particle size analyzer (Master Sizer-X, Malvern Instruments) and calculated with MAVERN ver. 1.1a. The starch granules were suspended in methanol (3 times distilled and filtered through 0.45 μm nylon filter).

Scanning Electron Microscope (SEM): Starches were examined with a scanning electron microscope (SEM) (JSM-T220A, JEOL). Starch granules were sprinkled on adhesive tapes, attached to specimen stubs, and coated with gold-palladium. Representative micrographs were taken at magnification of x 1000.

X-ray Diffraction [10]: The starch was allowed to reach equilibrium moisture content by storing over saturated sodium chloride for three days before measuring with X-ray diffractometer. The X-ray diffraction patterns were obtained with an X-ray diffractometer (TW 1710, Philips) which generated Cu-K_α radiation. Operation condition was at 40 kV, 30 mV, and scanning region 4°-60° of 2θ.

3. RESULTS AND DISCUSSION

3.1 Chemical Properties of Cassava Starches

Results of chemical compositions shown in Table 1 indicated that the starch preparation process affected the chemical compositions. The percentage of moisture contents of the commercial cassava starches (10.93 and 12.24 %) was higher than all the recommended-variety cassava starches (7.02-9.12 %). Because of the effect of the different drying processes, in the laboratory drying process used hot-air oven and the industrial drying process used cyclone pulp drying.

The phosphorus contents also indicated the difference between two groups of samples. The phosphorus contents of the commercial cassava starches (0.01 %) were less than that cassava starches from the recommended varieties (0.01-0.02 %). This suggested that the purification stage by sulfuric acid and centrifugation, only industrial manufacture, might reduce the phosphorus content in the commercial cassava samples.

The values of the other chemical analyses (including amylose) between two groups were in the same range and no substantial differences were found. All the values of amylose and the minor chemical compositions fell within the range of the values obtained by other researchers [11].

Table 1 Amylose content and minor components of cassava starches[c].

Sample	Moisture (%)	Ash (%)	Phosphorus (%)	Crude Fat (%)	Crude Protein (%)	Amylose Content (%)
R1[a]	7.02	0.24	0.02	0.06	0.10	15.09
R3[a]	7.82	0.27	0.02	0.04	0.19	14.85
R5[a]	8.81	0.27	0.02	0.10	0.15	13.97
R60[a]	8.50	0.28	0.02	0.02	0.14	16.74
R90[a]	7.35	0.25	0.01	0.04	0.12	13.12
K50[a]	8.30	0.22	0.02	0.10	0.13	12.66
S1[a]	9.12	0.22	0.02	0.05	0.12	13.44
C1[b]	12.24	0.26	0.01	0.04	0.05	13.42
C2[b]	10.93	0.22	0.01	0.04	0.15	13.97

[a]recommended-variety cassava starches,
[b]commercial cassava starches,
[c]all results were calculated on dry-starch basis (dsb).

3.2 Physical Properties of Cassava Starches

The average granule sizes of cassava starches (Table 2) from the recommended varieties were 12.64-15.67 μm, and from the commercial sources were 17.07-19.16 μm. All the recommended-variety starches granules were smaller than the commercial starches granules which could be seen in the micrographs. Most scanning electron micrographs of the cassava starches displayed round with a truncate end (Figure 1). The SEM micrographs also showed that the commercial starches granules were bigger and more agglomerate than the recommended-variety starches granules.

The percent transmittance (%T) of the cassava starches from the recommended varieties were 80.06-83.50 % and from the commercial sources were 79.44-79.72 %. The percent transmittances of commercial starches were lower than the recommended-variety starches. This was due to the granular sizes and the agglomerations of the commercial starches granules being more than the recommended-variety starches granules, so that the clarities of commercial starch pastes were less than the recommended-variety starches pastes.

The pasting properties analyzed by the Brabender viscoamylograph are shown in Table 2 and Figure 2. Gelatinization temperatures of the recommended-variety cassava starches were 60.45-69.75°C and their maximum viscosities were between 315-495 B.U. The viscoamylograph patterns of them were different, however, some patterns were similar for both the commercial and the recommended variety starches.

All x-ray diffraction patterns of the cassava starches showed 'A' pattern (Figure 3).

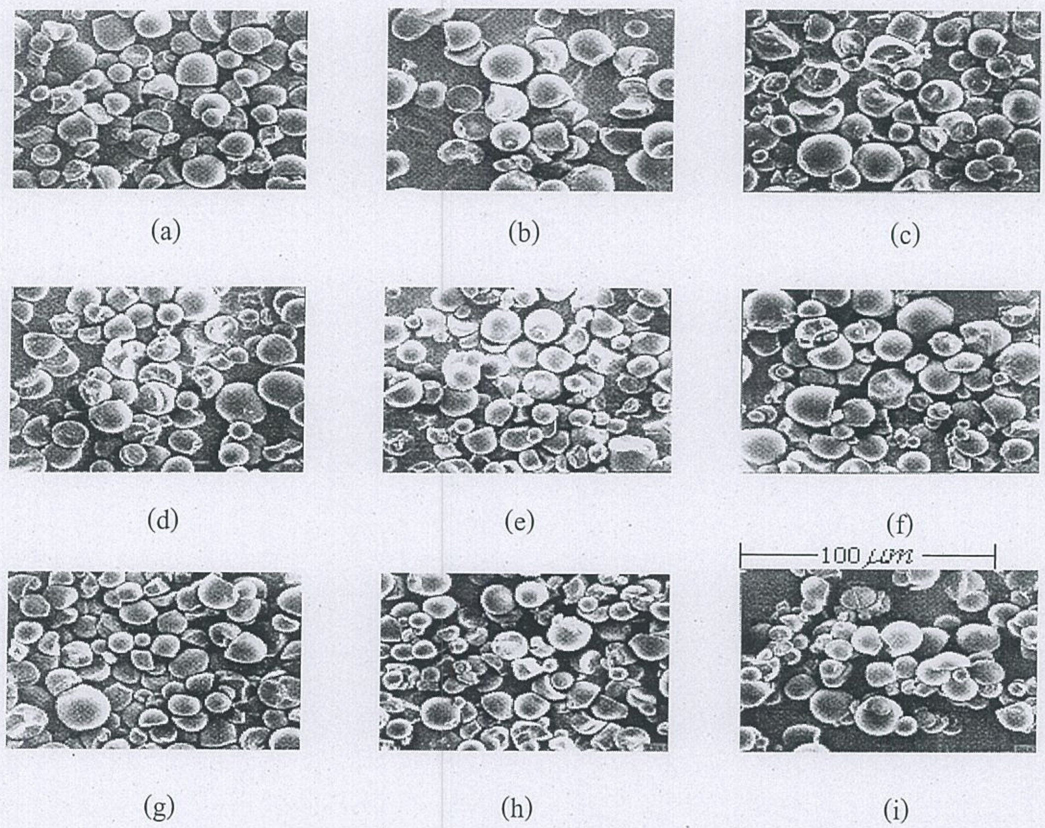

Figure 1 SEM micrographs of cassava starches. (Magnification x 1000)
(a) R1 (b) R2 (c) R60 (e) R90 (f) K50 (g) S1 (h) C1 (i) C2

Table 2 Physical properties of cassava starches.

Sample	Pasting Properties[c]		%T[d]	Granule Size (µm)[e]			
	Gelatinization Temperature (°C)	Maximum Viscosity (B.U.)		d(0.1)	d(0.5)	d(0.9)	mode
R1[a]	69.75	315	80.28	5.49	13.66	25.71	14.49
R3[a]	67.50	480	83.50	2.82	13.31	22.75	14.74
R5[a]	66.00	460	83.00	2.72	14.07	23.39	15.67
R60[a]	60.45	390	81.83	2.41	13.00	22.70	14.68
R90[a]	66.00	495	81.28	2.43	12.79	22.69	14.29
K50[a]	68.25	370	80.59	2.59	13.36	22.60	15.25
S1[a]	69.60	320	80.06	2.27	11.48	19.93	12.64
C1[b]	71.25	355	79.72	6.29	19.16	38.42	22.79
C2[b]	64.50	585	79.44	5.11	17.07	35.54	18.54

[a]recommended-variety cassava starches,
[b]commercial cassava starches,
[c]6% starch (dsb.) concentration,
[d] % Transmittance at 1% starch (dsb.) concentration,
[e]calculated by MasterSizer-X version 1.1

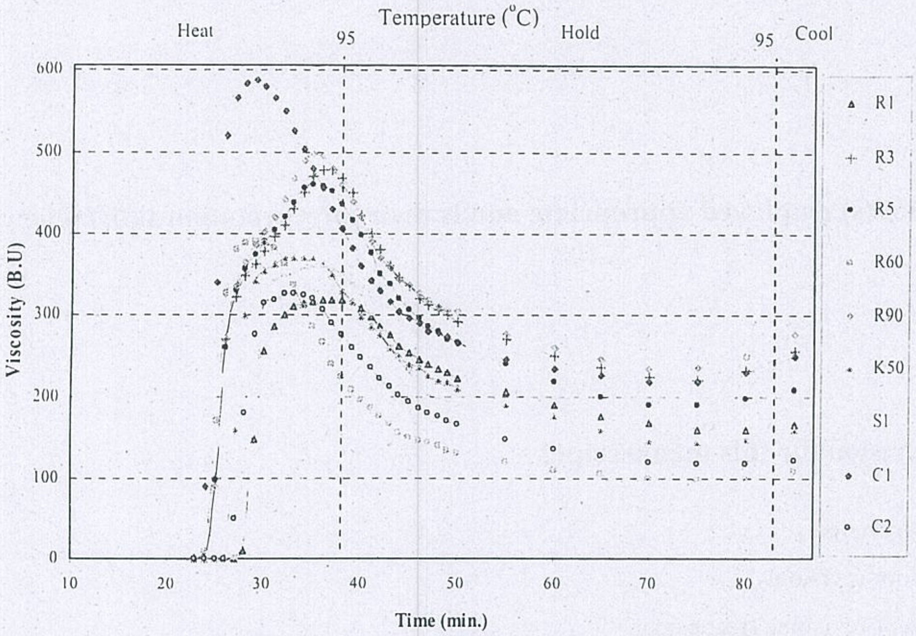

Figure 2 Barbender viscoamylograph of cassava starches.

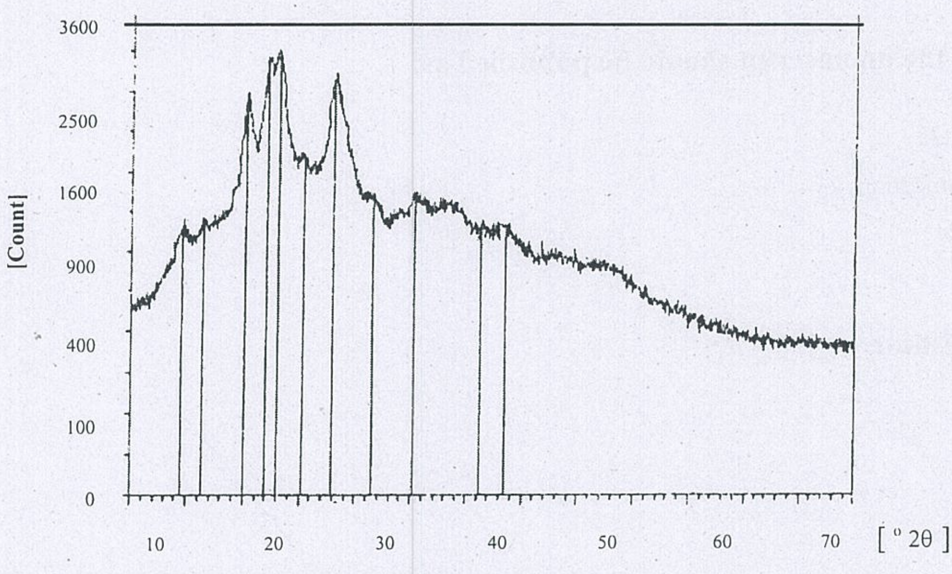

Figure 3 X-ray diffraction patterns of cassava starches.

Thermal properties (i,e., onset [T_o], peak [T_p], and complete [T_c] gelatinization temperatures and enthalpy changes [ΔH] indicated by DSC analysis (Table 3 and Figure 4) were slightly different. There was no significant relation between these values and the preparation process. The values of the two sample groups fell within same range.

Table 3 Thermal properties of cassava starches[c].

Sample	T_o(°C)	T_p(°C)	T_c(°C)	ΔH (cal/mol)
R1[a]	67.2±0.1	73.9±0.3	82.7±0.5	-541.5± 36.8
R3[a]	65.5±0.1	70.7±0.0	81.2±1.0	-502.4± 30.6
R5[a]	64.8±0.2	70.6±0.3	81.9±1.6	-436.4± 34.9
R60[a]	65.2±0.3	70.6±0.1	82.2±0.6	-528.0± 38.9
R90[a]	66.7±0.4	73.3±0.0	83.2±0.4	-534.3± 3.3
K50[a]	68.0±1.0	72.7±0.7	83.2±0.7	-660.4±103.2
S1[a]	65.5±0.1	71.2±0.3	84.4±4.0	-590.7±139.6
C1[b]	64.0±1.5	73.9±0.2	83.2±0.6	-616.8±101.1
C2[b]	64.1±0.7	72.3±0.3	83.1±0.3	-491.2± 64.5

[a]recommended-varieties cassava starches,
[b]commercial cassava starches,
[c]starch 2 mg (dsb) : water 8 μl.

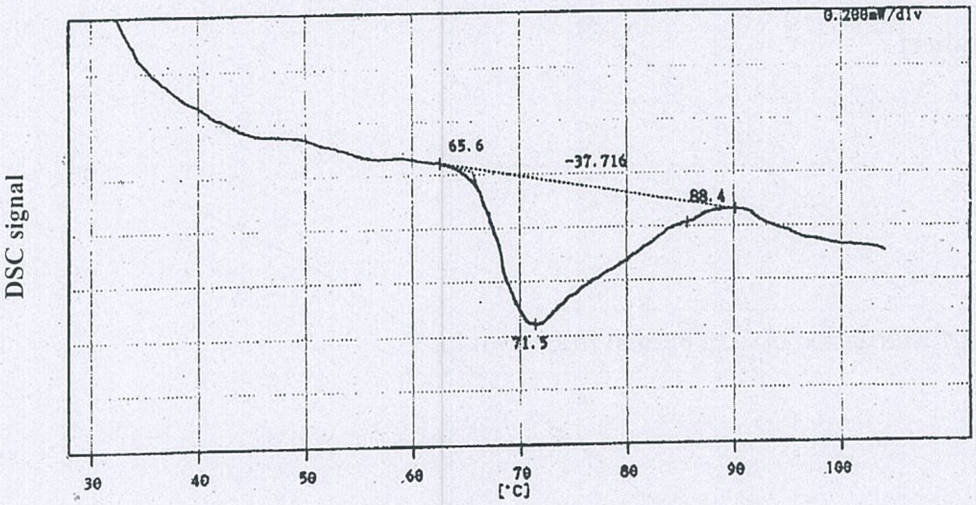

Figure 4 DSC Thermogram of Sriracha (S1) Starch

4. CONCLUSION

The characteristics of the recommended-variety cassava starches were studied and compared with commercial cassava starches. The values of physico-chemical properties from the both groups showed only slight differences between the groups and fell within the ranges reported by other researchers. From the data, it could be concluded that the variety of starches did not influence the properties of the cassava starches, but the starch preparation process effected on moisture content, % phosphorus and average granule size.

5. ACKNOWLEDGEMENTS

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