Extraction and Characterization of Water Insoluble Starch from Rice (Shwe-ma-naw)

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Abstract

Shwe-ma-naw rice sample was collected from the place that is situated Sauk-taw-wa village, Amarapura Township, Mandalay Region. Starch was extracted from the Shwe-ma-naw rice and the yield percent of rice starch was calculated from the total weight of used material. Physicochemical properties such as pH, moisture content, hydration capacity, viscosity, bulk density, swelling power and solubility of rice starch were determined. The pH values of sample and rice starch were measured by digital pH meter. The moisture contents of sample and rice starch were determined by Oven method. The bulk density of rice starch was estimated by specific gravity bottle. The swelling power and solubility of rice starch were determined by the method described by Leach *et a*l., over a temperature range of 50-90°C. The elemental contents of Shwe-ma-naw rice sample were measured by EDXRF. Finally, semi-crystalline nature of rice starch was determined by X-ray diffraction analysis.

Introduction

Myanmar is an agricultural and rice producing country. Rice is the staple food of over half the world's population. It is the predominant dietary energy source for 17 countries in Asia and the Pacific, 9 countries in North and South America and 8 countries in Africa. Rice provides 20 % of the world's dietary energy supply, white wheat supplies 19 % and maize (corn) 5 %. Three billion people worldwide depend on rice for over half of their daily calorie intake.

There are many different varieties of rice. They differ in amounts of nutrition and more importantly, the type of starch. Starch is the primary sources of stored energy in cereal grains. Starch exists in plants as insoluble starch granules in the cytoplasm. Each starch granule contains a mixture of two polysaccharide forms, amylose and amylopectin. Cereals may contain

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from 50 to 70 percent of starch. Starch constitutes the chief source of carbohydrate in human nutrition and has many important industrial uses.

Depending upon the plant sources and its maturity, granules vary widely in their shape, size and gelatinization temperature that is used to describe the swelling and hydration of granular starches. Starch or amylose is a carbohydrate consisting of a large number of glucose units joined together by glycoside bonds. This polysaccharide is produced by all green plants as an energy store.

Pure starch is a white, tasteless and odorless powder that is insoluble in cold water or alcohol. At first, starch was probably obtained from wheat by the Egyptians, possibly also by the Chinese and Arabs. It was later made by the Greeks from Egyptian and Creton wheat called amylum.

In Myanmar, rice and rice starch is used as only eatable and domestic food. Rice is the essential food for us. It is plentiful in our country, too and people use to eat rice starch with some curry and our main food. Furthermore we eat various snacks that are made with rice starch. The main purpose of this research work is to study the extract starch and some of the properties of this selected rice (Shwe-ma-naw) available in Myanmar.

Aim and Objectives

Aim

The aim of this research is to extract the starch from rice (Shwe-ma-naw) and to characterize the physicochemical properties of rice starch.

Objectives

- to determine the pH of rice powder
- to determine the moisture content of rice powder
- to estimate the ash content of rice powder
- to analyze the mineral contents of rice powder by EDXRF spectroscopy
- to extract the starch from rice powder
- to examine the physicochemical properties of rice starch such as pH, moisture content, hydration capacity, viscosity, bulk density, solubility in water and swelling power
- to determine the semi-crystalline nature of rice starch by X-ray powder diffraction method

Botanical Description

Fig. 1. The Plant of *Oryza sativa* L.

Family	:	Poaceae
Genus	:	*Oryza*
Botanical name	:	*Oryza sativa* L.
Common name	:	Asian Rice
English name	:	Rice
Myanmar name	:	Shwe-ma-naw

Rice grain is ripened ovary with lemma and palea firmly adhered to it. The rice fruit is a caryopsis in which single seed is fused with the wall of the ovary. The seed consists of endosperm and an embryo. The growth duration of the rice plant is 3-6 months, depending on the type of rice and the environment under which it is grown. During this time, rice completes two distinct growth phases vegetative and reproductive. The vegetative phase is subdivided into germination, early seedling growth and tillering. The reproductive phase is subdivided into stem elongation, panicle initiation, panicle development, flowering, milk grain, dough grain and mature grain stage. A 120-day variety, when planted in a tropical environment, spends about 60 days in the vegetative phase, 30 days in the reproductive phase, and 30 days in the ripening phase. The rice grain is formed by the ripened ovary of the flower and is between 5 and 12 mm in length.

Materials and Methods

Sample Collection

The samples of rice (Shwe-ma-naw) were collected from Sauk-taw-wa Village, Amarapura Township, Mandalay Region. The collected samples were stored in plastic bag to prevent from pests, mice and insects. It was kept in dry and safe place.

The clean air-dried seed sample was ground by grinding machine into finely powder and it was sieved by using 80 and 100 mesh size sieves. The powder (less than 100 mesh size) was stored in screw-capped bottle.

Fig. 2. Rice Grains and Rice Powder

Determination of pH of the Rice Powder

1 g of rice powder was put into the beaker. 100 ml of distilled water was added into the beaker and stirred with magnetic stirrer for 30 min at room temperature at a rate of 1600 rpm. It was allowed to stand for 30 min. Then, pH was determined with a pH meter.

Fig. 3. Determination of pH.

Determination of Moisture Content of the Rice Powder

1 g of rice powder was accurately weighted in a pair of weighted watch glass. The watch glasses containing the sample were placed in the air oven and dried for 30 min at 101°C. They were then removed from the oven and cooled in a desiccator to room temperature and weighed. The procedure was repeated until the loss in weight does not exceed 0.005 % per minute drying period. The moisture content of the sample can be calculated from the following formula.

$$\text{Moisture content (\%)} = \frac{\text{loss in weight (g)}}{\text{weight of sample (g)}} \times 100$$

Fig. 4. Determination of Moisture Content

Determination of Ash Content of the Rice Powder

The porcelain crucible and its cover were heated, cooled and weighted at room temperature. About 1 g of sample powder was added in crucible. The covered crucible containing sample was heated on open flame. After evolution of vapours and gases had stopped, the crucible was heated on hot plate. Heating was stopped, when the incombustible residue was completely free from carbon and a white ash was obtained. The crucible and ash content were cooled in a desiccator and then weighted. Heating, cooling and weighting were repeated until a constant weight was obtained. Ash content can be calculated from difference between the mass of crucible with the ash and that of empty crucible.

$$\text{Ash \%} = \frac{\text{Wt of residue (g)}}{\text{Wt of sample (g)}} \times 100$$

Fig. 5. Determination of Ash Content

Determination of Mineral Contents of the Rice Powder

The dried sample was ground into powder with mortar and pestle and sieved by using 80 mesh and 100 mesh sieves. The powder between 80 and 100 mesh size were stored in screw-capped. Determinations of minerals of sample powder were done by EDXRF spectrophotometer at Department of Physics, Mandalay University. These results were described in Table (4).

Extraction of Starch from Rice Powder

Rice starch was extracted from rice grains. Distilled water (600 ml) was added to the powder, stirred manually for 1 hr and allowed to settle about 1 hr. The supernatant was decanted off and filtered through double-layered cotton cloth. Then the starch obtained was dried in air for 48 hr at room temperature. The starch lumps were powdered before it was stored in polyethene bag prior before use and the yield percent of rice starch powder was calculated.

Determination of Some Properties of Rice Starch

pH, moisture content, hydration capacity, viscosity, bulk density, solubility in water, swelling power and x-ray powder diffraction studies of rice starch were determined.

Determination of Hydration Capacity of the Rice Starch

Hydration capacity was determined according to the method of Kornblum and Stoopak (1973). Rice starch powder (1.0 g) (Y) was placed in a centrifuge tube and covered with 100 ml of distilled water. The tube was shaken intermittently for about 2 hr and left to stand for 30 min before centrifugation at 3000 rpm for 10 min. The supernatant was decanted and the weight of the powder after water uptake and centrifugation (X) was determined. Hydration capacity was calculated as;

$$\text{Hydration capacity} = \frac{X}{Y}$$

Determination of Viscosity of the Rice Starch

Into 1.5 g of rice starch powder, a few ml of distilled water was added to make a paste. The paste was added into 150 ml boiling water and then boiled for 10 min to obtain 1 % starch solution. Using an Oswald's viscometer the viscosity of starch solution was determined.

$$\eta_1 = \frac{d_1 \times t_1}{d_2 \times t_2} \times \eta_2$$

where, η = viscosity (centipoises)

η_1 = viscosity of 1 % starch solution

η_2 = viscosity of water

d_1 = density of starch

d_2 = density of water (1.00)

t_1 = flow time of starch solution

t_2 = flow time of water

Determination of Bulk Density of the Rice Starch

The clean and dry specific gravity bottle (25 ml) was weighted. The bottle was filled with the powder sample and weighted. Bulk density of the powder sample was calculated as:

$$\text{Bulk density} = \frac{b - a}{v}$$

where, a = wt of specific gravity bottle

b = wt of specific gravity bottle and powder sample

v = volume of specific gravity bottle

Determination of Solubility in Water and Swelling Power of the Rice Starch

1 g of rice starch was weighted and put into the beaker; 100 ml of distilled water was added into the beaker. The suspension was stirred at 1100 rpm and heated at 50°C for 1 hour. Then the suspension was cooled for 30 min. After 30 min, it was poured into preweighted centrifuge tubes and centrifuged for 10 min. The supernatant was carefully removed using a pipette. The suspension was added again to the centrifuge tube and the procedure was repeated till the suspension was over. Weight of sediments was determined. Solubility was measured by pouring supernatant into evaporating dishes and evaporated at 110°C and weight of dry solids was determined.

$$\text{Starch solubility (\%)} = \frac{\text{weight of suspension (dry)} \times 100}{\text{weight of starch powder}}$$

$$\text{Swelling power (wt / wt)} = \frac{\text{weight of swollen sediment}}{\text{weight of starch powder}}$$

Swelling power and solubility of rice starch were determined at 60°C, 70°C, 80°C, and 90°C by using the similar above procedure.

X-ray Powder Diffraction Studies on Rice Starch

The structure of rice starch was investigated by using Rigaku X-ray powder diffractometer at Universities' Research Center, Yangon. The powder of rice starch was scanned by using Cu K_{α} radiation (λ = 1.54056 Å) at 40 kV and 40 mA.

Results and Discussion

Determination of Physicochemical Properties of Rice Powder

The samples of rice (Shwe-ma-naw) were collected from Sauk-taw-wa Village, Amarapura Township, Mandalay Region. The physicochemical properties such as moisture content and pH of the rice powder were determined.

Determination of pH of Rice Powder

pH of the rice powder were determined and the results were presented in Table (1).

Table 1. The Results of pH of Rice Powder

No. of experiment	pH (1g/ 100 ml)
1	6.68
2	6.68
3	6.69

According to Table (1), pH value of rice powder was found to be 6.68 and it was slightly acidic.

Determination of Moisture Content of Rice Powder

The moisture content of the rice powder was determined and the results were presented in Table (2).

Table 2. The Results of Moisture Content of Rice Powder

No. of experiment	sample weight (g)	loss weight (g)	Moisture (%)
1	1.0000	0.0962	9.62
2	1.0000	0.0960	9.60
3	1.0000	0.0960	9.60

According to Table (2), the moisture content of the rice powder was found to be 9.60 – 9.62 %.

Determination of Ash Content of Rice Powder

The ash content of starch sample was calculated and results obtained were shown in Table (3).

Table 3. The Results of Ash Content of Rice Powder

No. of experiment	sample weight (g)	loss weight (g)	Ash content ((%)
1	10.0000	0.0600	0.60
2	10.0000	0.0570	0.57
3	10.0000	0.0570	0.57

According to Table (3), the ash content of the rice powder was found to be 0.57– 0.60%.

Determination of Mineral Rice Powder

Determinations of minerals of rice powder were done by EDXRF spectrophotometer at Department of Physics, Mandalay University. These results were described in Table (4).

Table 4. Results of Minerals from Rice Powder

No.	Parameters	Measuring value (%)
1.	Chlorine	0.2014
2.	Phosphorus	0.1093
3.	Potassium	0.1051
4.	Sulfur	0.04094
5.	Aluminum	0.0231
6.	Calcium	0.01002
7.	Antimony	0.00092
8.	Chromium	0.00065
9.	Silicon	0.00051
10.	Hafnium	0.00043
11.	Cesium	0.00040
12.	Tantalum	0.00039
13.	Copper	0.00035

Extraction of Water Insoluble Starch from Rice Powder

The starch was extracted from rice powder and the yield percent were described in Table (5).

Table 5. Yield Percent of Water Insoluble Starch from Rice Starch

No.	Rice powder weight (g)	Starch weight (g)	Yield percent of starch (%)
1	100.00	82.3204	82.3204
2	100.00	82.3477	82.3477
3	100.00	81.6415	81.6415

According to Table (5)**,** the yield percent of the water insoluble rice starch was found to be 81.6415-82.3477 %.

Determination of Some Properties of Rice Starch

pH, moisture content, hydration capacity, bulk density, swelling power, solubility in water and viscosity of rice starch were determined.

Determination of pH of Water Insoluble Rice Starch

pH of the water insoluble rice starch were determined and the results were described in Table (6).

Table 6. The Results of pH of Water Insoluble Rice Starch

No. of experiment	pH (1g/ 100 ml)
1	7.2
2	7.1
3	7.1

According to Table (6), pH of the water insoluble rice starch was found to be 7.1 - 7.2. It was noted that the rice starch were slightly alkaline.

Determination of Moisture Content of Water Insoluble Rice Starch

The moisture content of the water insoluble rice starch was determined and the results were presented in Table (7).

Table 7. The Results of Moisture Content of Water Insoluble Rice Starch

No. of experiment	sample weight (g)	loss weight (g)	Moisture (%)
1	1.0000	0.1385	13.85
2	1.0000	0.1383	13.83
3	1.0000	0.1383	13.83

According to Table (7), the moisture content of water insoluble rice starch was found to be 13.83-13.85 %.

Determination of Hydration Capacity of Water Insoluble Rice Starch

Hydration capacity of water insoluble rice starch was determined and the results are presented in Table (8).

Table 8. The Results of Hydration Capacity of Water Insoluble Rice Starch

No. of experiment	Hydration Capacity (g/ml)
1	1.3102
2	1.2923
3	1.2934

According to Table (8), hydration capacity of water insoluble rice starch was found to be 1.2923 - 1.3102 g/ml.

Determination of Viscosity of the Water Insoluble Rice Starch

Viscosity of the rice starch was determined and the results are described in Table (9).

Table 9. The Results of Viscosity of Water Insoluble Rice Starch

No. of experiment	Viscosity (cP)
1	3.9242
2	3.9207
3	3.9207

According to Table (9), the bulk density of water insoluble rice starch was found to be 3.9207-3.9242cP.

Determination of Bulk Density of Water Insoluble Rice Starch

Bulk density of rice starch was determined and the results were shown in Table (10).

Table 10. The Results of Bulk Density of Water Insoluble Rice Starch

No. of experiment	Bulk Density (gcm^{-3})
1	0.9125
2	0.9126
3	0.9342

According to Table (10), the bulk density of rice starch was found to be 0.9125 – 0.9342 gcm^{-3}.

Determination of Solubility in Water and Swelling Power of Rice Starch

Swelling power and solubility of rice starch were determined and the results were presented in Table (11) and Table (12).

Table 11. The Results of Swelling Power of Rice Starch

No.	Temperature (°C)	Swelling Power (g/g)
1	50	2.55
2	60	3.95
3	70	4.85
4	80	6.72
5	90	9.55

Swelling power of the rice starch was found to be increase with increasing temperature.

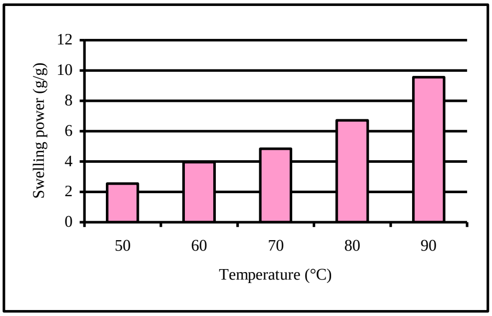

Fig. 6. Swelling Power of Rice Starch with Temperature

Table 12. The Results of Solubility in Water of Rice Starch

No.	Temperature (°C)	Solubility in water (%)
1	50	5.0
2	60	5.7
3	70	6.9
4	80	7.8
5	90	8.9

Solubility of the rice starch was found to be increase with increasing temperature.

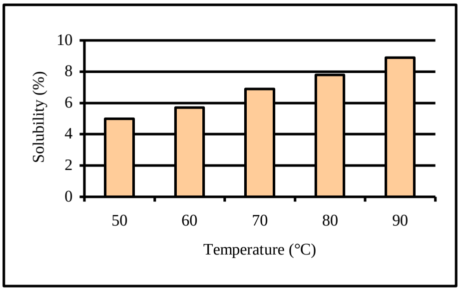

Fig. 7. Solubility of Rice Starch with Temperature

X-Ray Powder Diffraction Studies on Rice Starch

Semi-crystalline of starch was observed in X-ray powder diffractogram (Fig. 9) because of the presence of both sharp and diffuse diffraction peaks. Rice starch showed strong diffraction peaks at 15.8°, 17.9° and 23.6° of 2θ. Parallel double amylopectin molecules result in the formation of crystalline regions, while amylose molecules result in the formation of amorphous regions in the starch structure.

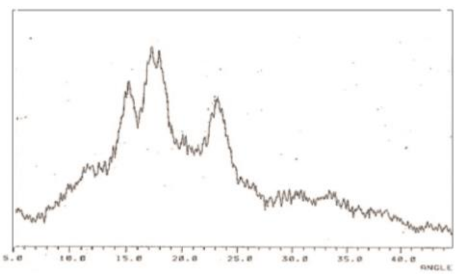

Fig. 8. X-ray Diffractogram of Reference Starch

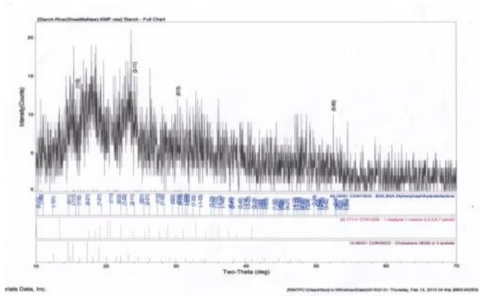

Fig. 9. X-ray Diffractogram of Rice Starch

According to Fig. (9), Two-theta angle at the rice starch sample was found to be 15.8, 17.9, 23.6 respectively. These data shows characteristics caystalline peaks of rice starch. Therefore, these data agrees with reference starch data.

Conclusion

The rice sample was collected from Sauk-taw-wa village, Amarapura Township, Mandalay Region. The pH value of rice powder solution was measured by digital pH meter. pH of the rice powder was found to be 6.68-6.69. The moisture content of rice powder was determined by Oven method. The moisture content of rice powder was found to be

9.60-9.62 %. Starch was extracted from the rice and the yield percent of rice starch was calculated from the total weight of used material. The yield percent of the rice starch was found to be 81.6415-82.3477%.

The pH value of rice starch was found to be 7.1-7.2. The moisture content of rice starch was found to be 7.0-7.13 %. The hydration capacity of rice starch was found to be 1.2923-1.3102. The viscosity of rice starch was found to be 3.9207-3.9242cP. The bulk density of rice starch was estimated by specific gravity bottle and it was found to be 0.9125-0.9342 gcm^{-3}. The swelling power and solubility of rice starch were found to be increased with increasing temperature. Rice starch showed characteristics crystalline peaks at 15.8°, 17.9° and 23.6° of 2θ. The elemental contents of rice sample were measured by EDXRF and sample contains high amount of chlorine and phosphorus and potassium moderate amount of sulfur aluminum and calcium. Phosphorus along with calcium is essential for bones and teeth. Potassium is essential for nerve functions, muscle contraction and maintenance of normal blood pressure. Chlorine is essential for the regulation of osmotic pressure and acid-base balance. Chlorine also plays an important role in the transport of oxygen and carbon dioxide in the blood. So Shwe-ma-naw rice sample contained the essential elements is suitable for human to obtain healthy body.

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