

## Effect of micronization on Physicochemical Properties of Tapioca Starch

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**Abstract.** The purpose of this study was to investigate the physicochemical properties of tapioca starch (TS) after micronization. The thermal properties analysis suggested that the gelatinization temperature was decreased after the treatment of micronization and decreased with increasing processing time. Solubility and swelling properties analysis showed that the solubility of TS was dramatically increased from 0.93%, 1.94%, 3.59%, 20.90%, 24.71% to 81.63%, 87.15%, 92.67%, 94.19%, 95.50% after micronization at 50°C, 60°C, 70°C, 80°C and 90°C respectively, while the swelling was decreased. Enzymolysis analysis demonstrated that the enzymatic hydrolysis rate was significantly increased after micronization from 0.0012 g/min to 0.1493 g/min. These results provided the basic information on the physicochemical properties of tapioca starch after micronization.

### 1. Introduction

Tapioca starch (TS) is widely produced in Latin America and is also one of the most important industrial crops in Thailand. It shows lower pasting temperature, higher viscosity[1], higher amylopectin content and relatively lower price when compared to other starch in the world market [2], which makes it suitable for food industries.

Micronization is an important technique which was widely used in food processing to make ultra-fine powder. The ultra-fine powder has many particular characteristics, such as increasing the utilization rate of materials, improving the processing performances and the quality of products. Wu et al. (2008) studied that enzymatic hydrolysis rate of corn starch improved sharply after micronization[3]. Fu et al. (2015) Suggested the solubility and enzymatic hydrolysis rate of waxy rice starch increased remarkably after high speed jet[4]. However, only a few reports study the effect of micronization on physicochemical properties of tapioca starch. The objective of this research was to study the tapioca starch prepared by micronization, and its physicochemical properties were also investigated.

### 2. Experimental

#### 2.1 Materials.

The purity degree of tapioca starch (Thai World Import and Export, Bangkok, Thailand) was 99.7% (dry weight basis) and it was purchased from a food factory in Thailand. All chemicals used were of analytical grade.

#### 2.2 Preparation of Samples After Micronization

Micronized starch prepared by a vibrating superfine mill (WZJ6, China) with a micronization time of 10 min, 20 min, 30 min, 40 min, 50 min and 60 min.

### 2.3 Determination of Thermodynamic Properties.

Samples (3 mg, db) were placed in a aluminum DSC pan and a certain amount of sodium azide distilled water(0.02%,w/w) was added by a microsyringe to obtain a ratio of 1:2.5 (w/v). The sample pan was sealed,then equilibrated at room temperature for 5 h, and then heated from 10°C to 100°C at a heating rate of 10°C/min. The onset temperature( $T_0$ ),peak temperature( $T_p$ ),conclusion temperature( $T_c$ ) and gelatinization enthalpy( $\Delta H_g$ ) were recorded[5].

### 2.4 Determination of Solubility Properties and Swelling Properties

Starch samples(1 g,different treatment times) were suspended in water with stirring for 30min at 50°C, 60°C, 70°C, 80°C and 90°C respectively, centrifuged at 4000 rpm for 15min. The supernatant was solubilized starch, part of the paste subsidence was expansion of starch. To separate the supernatant and precipitated paste,evaporated to dryness in a water bath 105°C to constant weight. that is, the amount of solubilized starch and the amount of expanded starch,calculated the solubility and swelling degree.

$$\text{Solubility} = \frac{\text{soluble starch weight(g)}}{\text{starch sample weight (g)}} \times 100\%$$

$$\text{Swelling degree} = \frac{\text{expanded starch weigh(g)}}{[\text{starch sample weight(g)} \times (100 - \text{solubility})]} \times 100\%$$

### 2.5 Determination of Enzymatic Resolution

Starch samples(3.00 g)of different treatment time was weighed respectively ; then water was added to volume to 50mL. The samples were heated at 100°C for 15min to be completely gelatinized. When the samples were cooled to 58°C, 1mL of  $\alpha$ -amylase was added and hydrolyzed for 15 min, and then keeping stirring. The filtrate obtained was filtered through a filter paper which has been weighed and washed with alcohol and diethyl ether. The mixture was dried at 105°C until constant weight, and the weight of the residue was recorded. The Enzyme hydrolysis rate was calculated using the following equation:

$$\text{Enzymolysis rate (g/min)} = \frac{\text{the weight of residue(g)}}{\text{time(min)}}$$

## 3. Results and Discussion

### 3.1 Thermal Properties of Micronized Tapioca Starch.

The DSC thermogram of samples is shown in Fig.1. It demonstrated that the endothermic peak was gradually flat and TS was more easily to gelatinization with the increasing of micronization time, which indicated gelatinization transition temperatures and the enthalpy of gelatinization ( $\Delta H_g$ ) shifted to lower values with increasing the time of micronization. The reason was that the sharp mechanical shear destroyed the starch molecule with the increase of micronization time, which led to the acceleration of the debranching rate of branch structure and the disintegration rate of ordered structure. An increasing number of amorphous starch molecules were formed and the gelatinization of starch will happen more easily.

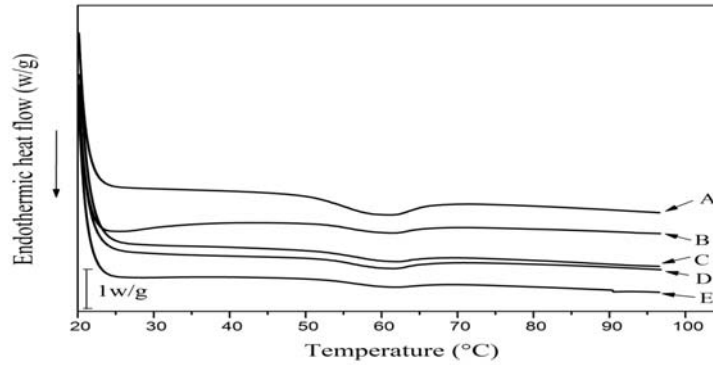


Fig.1 DSC thermograms of micronized tapioca starch  
A, untreated B, micronized 15 min C, micronized 30 min D, micronized 45 min  
E, micronized 60min

Tips:Upward is exothermic,Downward is endothermic.

### 3.2 Solubility and Swelling Properties

#### 3.2.1.The Solubility of Tapioca Starch.

The effect of different micronization time on the solubility of tapioca starch is shown in Fig.2.It was found that the solubility was obviously increased compared to control with micronization time increasing at the same temperature.The solubility of control was 0.93% at 50°C,which was increased to 23.58% after treated for 15 min, and the lowest values was observed after treated for 60min (81.63%).The reason may be that the mechanical force in the process of micronization destructed the lattice structure of starch,which contributed to the combination of the water molecule and the free hydroxyl of the starch.The starch can be precipitated from the particles at a lower temperature, resulting in a significant increase in the solubility of the micronizaed tapioca starch[8]. Similar result was also found by Fu et al. (2015) who reported that the solubility of indica rice starch was increased significantly from 1.34 to 32.4%[9].

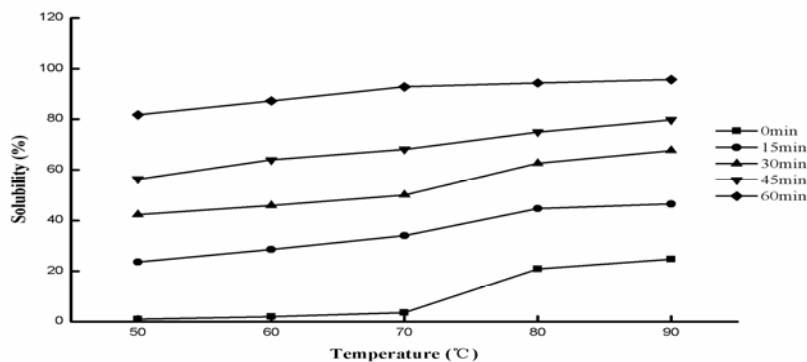


Fig.2 Solubility of tapioca starch at different temperatures in different micronization time

#### 3.2.2 The Swelling Properties of Tapioca Starch.

The effect of different micronization time on the swelling properties of tapioca starch is shown in Fig.3.With the micronization time increasing,solubility had a sharp decrease at the same temperature. The reason could be that the crystal structure of starch granules is disintegrated and the degree of indentation is exacerbated by the continuous action of various mechanical forces. In addition, micronization can significantly increase the content of amylose and medium polymerization molecules in starch, Which play the role of thinner, resulting in a gradual decrease in dilation[10].

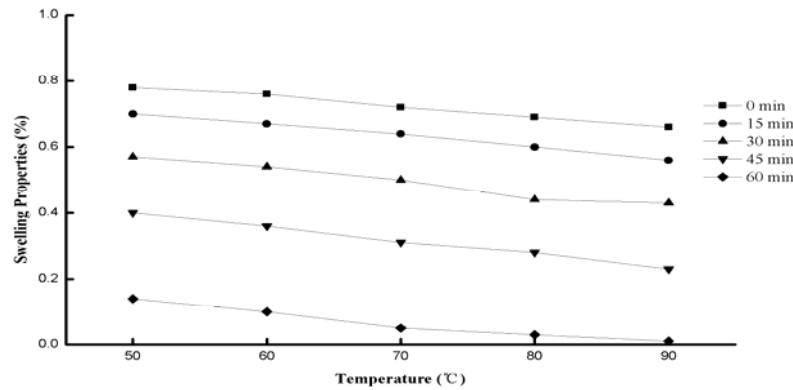


Fig.3 Swelling properties of tapioca starch at different temperatures in different micronization time

### 3.3 Effect of Enzymolysis Properties.

The effect of micronization time on the enzymolysis rate of tapioca starch is shown in Table 1. Enzymolysis rate of tapioca starch increased remarkably with increase of the micronization time. It is likely due to augmenting the contact area between the enzyme and the substrate because of the increasing of tapioca starch’s solubility. Moreover, starch surface appear cracks and micropores after micronization, leading it easier for hydrolysis[11]. The lamellar structure of starch granule was destroyed during the pulverization process, the double helix structure becomes loose[12], and the enzymolysis rate of the starch was increased.

Table 1 Enzymolysis rate of tapioca starch in different micronization time

Time(min)	0	15	30	45	60
Enzymatic hydrolysis rate(g/min)	0.0012	0.0258	0.0860	0.1024	0.1493

## 4. Conclusion

The thermal properties analysis indicated that micronization makes the tapioca starch more easily to be gelatinized. Micronization effectively contributes to the solubility and enzymolysis rate of tapioca starch, whereas it decreases the swelling property obviously. Micronization is a practical technique to improve the quality of food, which play a huge role in the full utilization of food resources, the development of new functional foods and upgrade traditional crafts. The tapioca starch gains better solubility and faster enzymolysis rate to improve its pasting properties, which can increase its applicability in food industry.

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