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*Original Paper*

# Fermented Starch: Production Testing of Process Stabilization

Aton Yulianto[1], Palupi Tri Widiyanti[1*], Suparman[1] & Musa[1]

[1] Agency for Assessment and Application of Technology, National Laboratory for Starch Technology, Jl. Zainal Abidin PA 36, Bandar Lampung, Lampung, Indonesia

[*] Palupi Tri Widiyanti, Agency for Assessment and Application of Technology, National Laboratory for Starch Technology, Jl. Zainal Abidin PA 36, Bandar Lampung, Lampung, Indonesia

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***Abstract***

*Tapioca is one of starch product that is widely produced in Indonesia. The use of tapioca, especially from modern industry, as an ingredient of various food products (such as fish cake, crackers) is often limited by physicochemical characteristics, for example, swelling power, solubility, and viscosity causing limitation in its use. Therefore, tapioca needs to be modified to yield the desired characteristics. In this research, tapioca is modified through fermentation using microorganism. Starch modification via fermentation provides new chemical groups or change of shape, size and molecule structure. The fermented starch is made from fresh cassava planted by National Laboratory of Starch Technology (B2TP) in Lampung-Indonesia and starter of fermentation is lactic acid bacteria (LAB). Fermentation is carried out for five days at room temperature. Fermentation product is dried under the sun. The quality stabilization of fermented starch is observed through its functional characteristics including paste clarity, swelling power, and expanding capability. The research conducting in flask scale in B2TP obtains fermented starch with a relatively stable characteristic, especially in expanding capability, around 3.07-5.26 mL/g. The quality stabilization of fermented starch has to be maintained to preserve the desired product characteristics.*

***Keywords***

*fermented starch, tapioca, product quality*

## 1. Introduction

Starch is carbohydrate as food reserve of plants. Most of the starch is kept in roots (cassava, sweet potato, potato, etc.), grains (maize, paddy, wheat, etc.), trunk (sago) and fruits. Besides, starch is an essential nutrition in daily life, where the human body needs energy almost 80% from carbohydrate.

Starch is composed by at least three components that are amylose, amylopectin, and intermediate materials (protein and fat). Generally, starch contains 15-30% amylose, 70-85% amylopectin, and 5-10% intermediate materials. The structure and type of intermediate materials for each starch source is different depending on the botanical characteristics of the sources (Greenwood & Munro, 1979).

Starch plays an important role in the processed food industries. Native starch such as tapioca, starch from maize, sago, and other starchy substances have some obstacles when used as ingredient both in food and non-food industries. When cooked, starch needs a long time (needs quite high energy) and forms a hard and unclear paste. Besides, its character is too sticky and cannot resist with acidic treatment. These obstacles cause limitation in the use of native starch in industry. In contrast, the sources and production of starch in Indonesia is abundance, consisting of tapioca (cassava starch), starch from other roots, sago, paddy, fruits (e.g., banana) and other starch sources that have not commercially produce yet (Koswara, 2006).

Native starch can be modified so that it has desired characteristics. The modification is meant to change the molecular structure of starch that can be done by chemically, physically, and enzymatic treatment (James et al., 1997). Each method produces modified starch with a different character. Native starch can be processed as modified starch to have the desired character or as needed (Sangseethong et al., 2009). The modification involves physical treatment (heat, pressure), chemically treatment (acid, alkali, oxidation, cross-link, etc.), enzymatic, and biologically treatment (fermentation).

Tapioca is one of starch product that is widely produced in Indonesia. The use of tapioca, especially from modern industry, as an ingredient of various food products (such as fish cake, crackers) is often limited by physicochemical characteristics, for example, swelling power, solubility, and viscosity causing limitation in its use. The processed food industry prefers using tapioca from conventional tapioca manufacturer compared to modern industry. This is an obstacle for the industries that applied dewatering system before changing to use separator and hydrocyclone to improve its production capacity and brightness of its tapioca. They receive complaints from the consumers.

Therefore, an effort to modify tapioca needs to be done to yield tapioca with desired characteristics. Modification of tapioca through fermentation is a suitable method. This method involves microorganism. Starch modification via fermentation yields new chemical groups or changes of shape, size and molecular structure.

B2TP constructed Tapioca Pilot Plant with the capacity of 5 ton/day in 2015. Its process production is a combination from production system in the modern industry and that of in the conventional industry. Through the facility, there are two types of product, consisting of native starch and fermented starch. Cassava is peeled and washed, then rasped to be cassava mash. Next, the mash is extracted to obtain starch suspension. Its concentration is concentrated and purified via dewatering process using hydrocyclone. After that, starch concentrate is settled in a pond. For the product of native starch, wet tapioca is then dried either under the sun or by mill dryer. In case of fermented tapioca, the wet tapioca is fermented using starter of LAB in a certain incubation period, and then dried under the sun, so that tapioca with specific characteristic and suitably used in the food industry can be achieved. Process production of tapioca is shown in Figure 1.

The assessment for production of fermented starch in B2TP has been done since 2015. Since then, the production parameter has been determined, but the product quality has not been stable yet. Therefore, testing for the quality stabilization of fermented starch is needed. This report confirms stabilization of quality of fermented starch through several times production in flask scale.

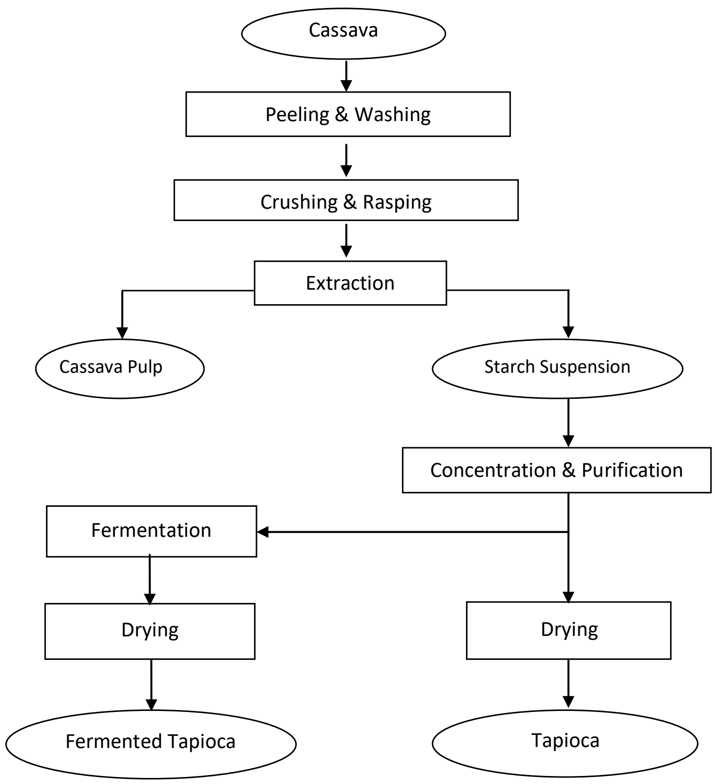


**Figure 1. Flow Diagram of the Production Process of Tapioca and Fermented Tapioca in Tapioca Pilot Plant B2TP**

## 2. Methodology

### *2.1 Materials*

Fresh cassava used is harvested from B2TP plantation in Central Lampung-Indonesia, and the starter of fermentation is LAB with a commercial brand of BIMO-CF.

### *2.2 Equipment*

Equipment used in cassava starch extraction is cassava peeler, crusher, plastic container, and filter cloth. Equipment used for fermentation is stainless steel container and erlenmeyer 5000mL. Equipment used for product analysis involves glassware, spectrophotometer, pH meter, porcelain cup, oven, desiccator, waterbath, and scanning electron microscope (SEM).

### *2.3 Method*

2.3.1 Production of Fermented Starch

In flask scale, cassava is peeled and washed, then rasped to be cassava mash. Next, the mash is extracted using filter cloth to obtain starch suspension. Then, the suspension is settled in a plastic container. For fermentation media, starch suspension is set to have a concentration of 20 °Be (46.68% w/w) and added 0.1% w/w LAB to dry weight of tapioca. Media is incubated within five days at room temperature. The wet tapioca is then washed for three times. It is then thinned out and dried under the sun to reach moisture content less than 13%. Next, dry starch is milled and sifted to have powder size of 80 mesh.

2.3.2 Functional Characterization of Fermented Starch

Functional characteristics of fermented starch observed are paste clarity 1% (method by Stuart et al., 1989), swelling power at 70 °C (method by Leach et al., 1959), and expanding capability (method by Demiate et al., 2000). Besides, the profile of starch granule is also provided by SEM.

2.3.3 Data Analysis

Testing of quality stabilization of fermented starch product is carried out by several repetitive testing. Each product is named with a code of PF-(production sequence), for example PF-2, PF-2, etc. Data obtained is then analysis to observe the stabilization of production process through quality of fermented starch product that is yielded from a series of production process.

## 3. Results and Discussions

### *3.1 Process Production of Fermented Starch*

Cassava starch is wetly extracted to separate the starch from other components. In flask scale, wet extraction of cassava starch requires quite a large amount of water compared to that of an industrial scale. This is important to release starch granule from any binding substance so that pure starch is obtained.

Process parameter for production of fermented starch in this report is mostly adjusted to that of in Tapioca Pilot Plant B2TP. Cassava is peeled to remove the outer brown skin and small part of inner white skin. Peeled cassava is then washed under running water to eliminate any dirt and mucus on the root surface so that cyanide acid can be reduced. Next, clean cassava is rasped to tear the tissue inside to facilitate starch extraction. The cassava mash is then mixed with water, squeezed, and filtered. Starch suspension is obtained and settled. Naturally, starch will settled because it is not dissolved in water and has higher density than water.

Starch fermentation in this report conducted in a media with concentration of 20 °Be (46.68% w/w) and LAB concentration of 0.1% w/w to dry weight of tapioca as used in Tapioca Pilot Plant. The top of fermentation container is tightly closed to maximize the fermentation process due to the anaerobic LAB. After five days, wet tapioca is dried under the sun. Drying process is evidently impact on the characteristics of fermented starch. Vatanasuchart et al. (2005) shows that lactic acid and ultraviolet

(UV) energy with a wave length of 310-330 nm can cause partial depolymerization on amylose structure of sour tapioca so that the resulted expanding power is higher than that of using oven. Therefore, when starch paste is heated, water molecule is easier to absorb and then forms hydrogen binding so that viscous paste is faster to be achieved.

Visually, fermented starch is not significantly different to native tapioca. Fermented starch is slightly white compare to tapioca. Besides, fermented starch has a unique odor. This comes from the LAB that generates nonvolatile odor component, lactic acid, as the main component (Onyango et al., 2004).

Furthermore, starch modification in this fermentation is able to improve the product characteristic, especially expanding capability, so that the easiness in its application may be achieved. The modification is due to hydrolysis by lactic acid generated by LAB and heat treatment from sun drying with various wavelengths. The mechanism of starch modification allows structure change of amylose and amylopectin. The amorphous and crystalline structures of those segments contribute to starch characteristic, specifically functional characteristics. The amorphous structure can be dissolved, whereas the crystalline cannot be dissolved. In fermented starch, amorphous structure is damaged by lactic acid. This structure consists of weak bonds and is generally found in intersection of starch structure so that it is easier to break by acid. When damaged by acid, the intersection is broken and then some straight chains are formed in accordance with the amount of the damage. In the production of fermented starch, the needed amount of the damage of amorphous structure is only some parts. So, the easiness of the user application can be obtained by observing the functional characteristics of the product.

### *3.3 Functional Characterization of Fermented Starch*

Data analysis for fermented starch in this report is focused on functional characteristics including swelling power at 70 ℃, and expanding capability. Result of analysis is shown in Table 1.

**Table 1. Functional Characteristics of Fermented Starch**

| Sample | Paste Clarity (%) | Swelling Power (g/g) | Expanding Capability (mL/g) |
|---|---|---|---|
| PF-1 | 33.25 | 8.59 | 3.07 |
| PF-2 | 39.00 | 12.42 | 4.32 |
| PF-3 | 50.85 | 3.37 | 5.26 |
| PF-4 | 50.75 | 4.84 | 4.69 |

#### 3.3.1 Paste Clarity 1%

Paste clarity 1% is measured by spectrophotometer. Light transmission can be used to directly determine the development of starch granule through light reflection of paste. The obtained transmission identifies the homogeneity of starch granule inside the paste. In this measurement, the more transparent the paste, the higher percentage of transmission is obtained. The value indicates that amorphous fraction from fermented starch is partly cut and dissolved in water. In other words, functional characteristic of paste clarity 1% is related to the dispersion and retrogradation of starch.

According to Table 1, the value of paste clarity 1% of fermented starch in this report is around 33.25-50.85%. This quite high value means fermented starch resulting paste that is relatively clear or transparent so that the product is suitable to be used as ingredient of food product with clear color, such as fish cake.

3.3.2 Swelling Power

Swelling power identifies ability of starch molecule to retain water in its hydrogen bond. Starch swells when heated in water. In the process, water hydrates starch granule in the amorphous area that has weak hydrogen bond among molecules. As a result, some parts of starch molecules, especially amylose, are released from starch granule and dissolved in water. The higher heating temperature, the more starch molecules are released. In fermentation process, the amount of lactic acid will continue to rise along with the length of fermentation time. Lactic acid damages the amorphous fraction, not only inside amylose but also amylopectin structure contained in fermented starch so that hydration when heated is higher. This causes starch granule to increasingly swell and result in higher swelling power. The value can be used as parameter to decide the dimension of process equipment when processed/cooked.

According to Table 1, the value of swelling power of fermented starch in this report is around 3.37-12.4 g/g. The value of swelling power is inversely proportional to viscosity. Starch with high value of swelling power has lower viscosity. This is a benefit of fermented starch. The low viscosity of fermented starch is able to yield food product with soft or tender texture (Rembulan et al., 2012).

3.3.3 Expanding Capability

Expanding capability shows starch ability to expand and raise the dough volume at the same time. The volume changing is expressed in specific volume (mL/g). Dough made from fermented starch has low viscosity, so it is faster to expand. In baking process, hydrogen bonds among molecules are weaker causing the more amorphous fractions are cut off and resulting in the higher hydration on starch granule. Besides, the drying system of fermented starch is also impact on the value of expanding capability. Sun drying provides a higher value of expanding capability than another drying method, such as oven or drying machine. Sunlight radiation, especially UV-B with the wave length of 310-330 nm will react to amylose and amylopectin causing partial depolymerization in the linear fragment and amorphous structure while in baking process (Vatanasuchart et al., 2005).

According to Table 1, the value of expanding capability of fermented starch in this report is around 3.07-5.26 mL/g. This value is quite high compared to native starch (1.44-2.52 mL/g). This is another advantage of fermented starch where it can be used as an ingredient for food product that requires expanding dough so that the use of expanding agent (e.g., yeast) can be reduced.

Based on the three functional characteristics observed, expanding capability from fermented starch in this report has quite stable value. The quality stabilization of product can be maintained by concerning some points that are suspected impact on the product quality including variety and harvest age of cassava that is varied, and also the period of sun drying.

3.3.4 Granule Shape of Fermented Starch

Fermented starch is a product modification from native starch. In detail observation of the shape of starch granules by SEM, some differences are found when compared to the granule of native starch. As shown in Figure 2, fermentation causes starch granules to have various shapes, i.e. truncated granules, granules with partly-broken surface, and even moon-like surface. Meanwhile, granules of native starch have a shape with smooth surface, but some portions are being irregular. This observation is in line with Putri et al. (2011), where some granules of fermented starch are digested during the fermentation process. They find broken granules and also irregular surface of granules as the evidence of fermentation. The granular change represents the structural change of amylose and amylopection due to the existence of lactic acid during fermentation that damages the amorphous fraction.

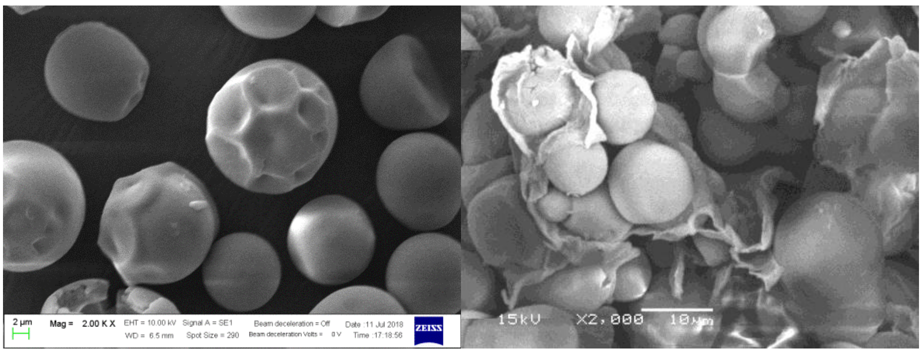


**Figure 2. Shape of Starch Granule Observed by Scanning Electron Microscope (SEM): Native Tapioca (Right) and Fermented Starch (Left)**

## 4. Conclusion

Testing of fermented starch in this report yields quite stable product, especially in the functional characteristic of expanding capability around 3.07-5.26 mL/g. The process stabilization of fermented starch production has to be maintained to preserve the desired product characteristics. Some factors need to be maintained including variety and harvest age of cassava that is used as raw material, drying period and sunlight intensity, and environmental condition that supports the fermentation process.

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