

Analysis of Starch Content and Impurities During Tapioca Flour Production Process

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Received 10/08/2025

Revised 13/02/2026

Accepted 06/03/2026

ABSTRACT

Tapioca is a processed product from cassava tubers (*Manihot esculenta*) that plays an important role in the food industry, both as a main ingredient and an additive. The quality of tapioca is greatly influenced by its starch content as the main component and the level of contaminants in it. Starch content is the main indicator of quality because it determines the physical and functional characteristics of tapioca, while contaminants are important parameters that reflect the presence of foreign substances or unwanted contaminants. The main contribution of this study is to focus on samples from one tapioca industry in Central Java without seasonal replication or interlaboratory validation. Starch content was measured using the hydrolysis method, which began with sample weighing, the addition of 0.5N HCl, hydrolysis in a water bath, and finally titration. The scientific significance of this study is that it provides real-time field data on daily variations in starch content (79.83–83.67%) and impurity content (0.19–0.28%), which supports continuous quality monitoring for SNI 3451:2011 (starch content $\geq 75\%$) and SNI 01-3451:1994 (impurity content $\leq 0.6\%$). This research is expected to provide data-based practical recommendations to optimize the production process and contribute to increasing the added value of tapioca in Indonesia. With a starch content of $>80\%$ and impurities of $<0.3\%$, it can increase export competitiveness because it meets the international Codex Alimentarius standard (food-grade tapioca).

KEYWORDS

Cassava; Impurities; Starch content; Tapioca

1. INTRODUCTION

Tapioca is a processed product made from cassava tubers that has many applications in the food industry, both as a main ingredient and an additive. The production process has a significant impact on the quality of the tapioca produced [1], [2]. Cross-modification of tapioca starch with Sodium Trimetaphosphate (STMP) increases phosphorus content and changes granule structure, but highlights the need to evaluate the basic production process to ensure initial quality. This is because the quality of tapioca is very important to meet industry standards and consumer needs [3], [4], [5]. There are several stages involved in tapioca production, starting from the selection of quality cassava tubers, sorting, washing, peeling, grating, squeezing, drying, milling, and packaging [6], [7]. Each stage carried out affects the final quality of the tapioca produced.

Starch content is a key indicator of tapioca quality. This is because starch is the main component that gives the product its physical and functional characteristics [8]. Based on *Standar Nasional Indonesia* (SNI) 34.51:2011, the minimum starch content that tapioca must have is 75%. However, previous studies have focused more on post-production modifications rather than monitoring contaminants and starch during the local industrial process. A high starch content indicates the efficiency of the starch extraction process

from cassava tubers. Low starch content can be caused by suboptimal production processes, such as suboptimal pressing and filtering processes [9], [10].

In addition to starch content, impurity content is also an important parameter in determining the quality of tapioca. Impurities are unwanted foreign substances or contaminants found in a product. The presence of impurities can affect the color, texture, and taste of tapioca. Impurities can arise due to various factors, such as errors in the production, storage, or distribution processes [8], [11]. According to the SNI for tapioca flour 01-3451-1994, the maximum impurity content in tapioca is 0.60%. Impurities can be controlled through various methods, one of which is by implementing good manufacturing practices. In addition, this can also be done by using high-quality raw materials and conducting regular laboratory tests [12].

Cassava (*Manihot esculenta*), also known as manioc, is a tropical and subtropical shrub belonging to the *Euphorbiaceae* family [13]. Cassava originated in Latin America and was brought by the Portuguese to various parts of the world, including Indonesia. Cassava can grow up to 7 meters tall. Cassava tubers are usually white or yellowish in color [2], [14]. Cassava has various health benefits, such as being a good source of energy, containing fiber that can help maintain digestive health, and containing vitamin C and beta-carotene that play a role in protecting the body from free radicals [1], [15], [16]. In addition, cassava also contains minerals such as calcium (Ca), phosphorus (P), manganese (Mn), iron (Fe), and potassium (K). However, it is important to note that cassava contains toxic compounds such as cyanide if not processed properly [17], [18], [19].

Therefore, starch and impurity content analysis is expected to be a strategic step to ensure product quality consistency while improving production process efficiency [20], [21]. Not only is it important to meet existing quality standards, but this analysis is also important to increase product competitiveness in domestic and international markets [22], [23]. High-quality tapioca has greater added value and can be used in various industrial applications such as noodle manufacturing, adhesives, and pharmaceutical products [7], [24], [25].

Although several studies have investigated starch modification and physicochemical properties of tapioca starch, limited information is available regarding routine monitoring of starch and impurity contents during industrial-scale tapioca production. Data describing quality consistency under actual manufacturing conditions remain scarce, particularly in Indonesian tapioca industries. Therefore, monitoring these parameters is essential to evaluate compliance with national quality standards and identify opportunities for quality improvement. Therefore, this study was conducted to evaluate starch and impurity contents of tapioca flour produced in an industrial processing facility, determine compliance with SNI quality standards, and provide baseline data for routine quality monitoring. The results of this analysis are expected to contribute positively to improving product quality and production efficiency.

2. MATERIALS AND METHODS

2.1. Materials

The materials used for this research include tapioca as a sample, 0.5 N HCl, distilled water, and 45 μ m filter paper.

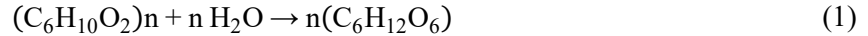
2.2. Tapioca Production Process

The tapioca production process in industry involves several stages, starting from sorting, washing, peeling, grating, extraction, and drying. The stages of tapioca production can be seen in Figure 1.

2.3. Starch Content Analysis

Starch content analysis was performed using the starch hydrolysis method, which breaks down starch molecules into simple components such as dextrin, maltose, and glucose. The first step was to weigh 2.5 grams of tapioca sample. The sample is then placed in an Erlenmeyer flask and 200 ml of 0.5 N HCl solution is added. The sample is then shaken until homogeneous and placed in a hydrolysis apparatus. The solution is left to undergo hydrolysis, indicated by a change in color to clear. Finally, the hydrolysis results are recorded [26], [27]. The starch hydrolysis reaction represents as equation (1) and the formula for starch

content analysis can be seen in equation (2), where factor 0.9 accommodation 1 g starch equal with 1.11 g glucose and recovery 95–105%.



$$\%Starch = (V \text{ HCl} - V \text{ blank} \times N \times 0.9 \times \frac{100}{m} \quad (2)$$

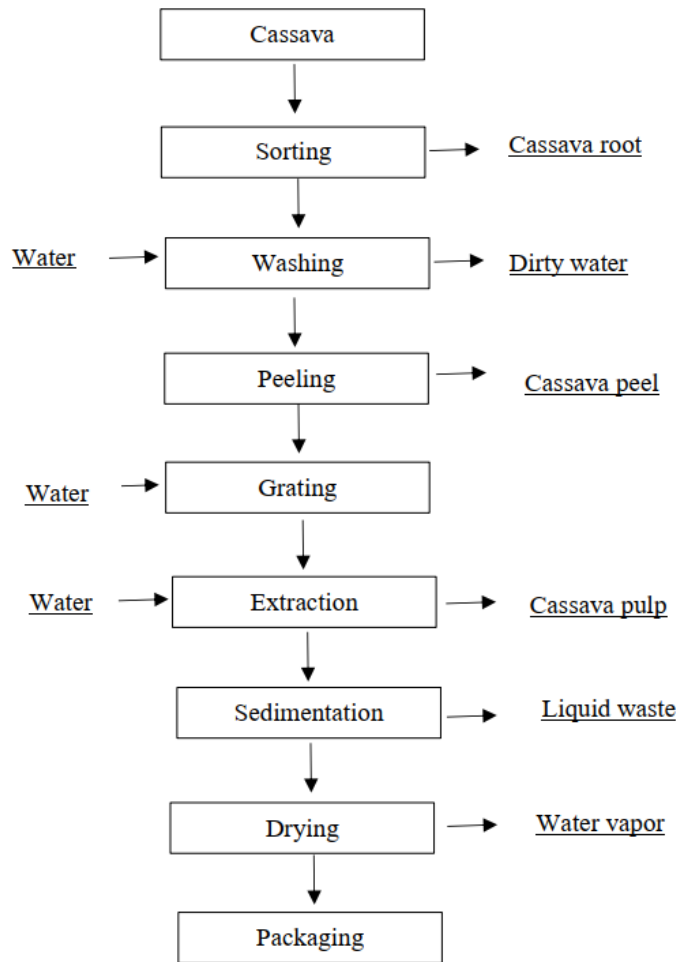


Figure 1. Tapioca production process flow chart.

2.4. Impurities Level Analysis

Impurity level analysis is conducted to determine the amount of residue present in tapioca [28], [29]. Impurity level analysis uses a 325 mesh sieve. The 325 mesh sieve separates impurities other than tapioca that are present in tapioca and are larger than 325 mesh. The first step in analyzing the contaminant level involves weighing 100 g of tapioca sample, then placing it in a 1500 ml measuring cup. The sample is dissolved with 300 ml of distilled water. After homogenization, the sample is filtered using a 325 mesh sieve, then the residue is washed with distilled water. The residue is then filtered using filter paper of known weight and dried in an oven at 150 °C for 1 hour. The filter paper is then cooled in a desiccator for 15 minutes. The filter paper is then weighed, and calculations are performed to determine the impurity content in tapioca. The formula for analyzing impurity content can be seen in the equation (3).

$$\% \text{Impurities} = \frac{m \text{ residue} - m \text{ paper}}{100} \times 100 \quad (3)$$

2.5. Sampling

Samples were taken 15 times, each weighing 500 g, at a frequency of 1–3 days during February to March 2025, stratified from the production batch.

3. RESULTS AND DISCUSSION

Tapioca is a product derived from cassava and plays an important role in the food and non-food industries. This flour is used as a raw material in the manufacture of various products [30]. The quality of tapioca is influenced by its starch content as the main component and the level of impurities it contains [8]. The quality requirements for tapioca are regulated in SNI-3451:2011 with a minimum starch content of 75%. Meanwhile, fiber and impurities in accordance with the SNI for tapioca flour 01-3451:1994 are a maximum of 0.6%.

Starch is a polysaccharide composed of glucose units bound together [31], [32]. Starch is a glucose homopolymer bound through α -glycosidic bonds and can be found in various food ingredients. The amylose and amylopectin content affects the gel properties and elasticity of the product [33], [34]. The starch content directly affects the texture and consistency of the final product. Tapioca with a high starch content tends to produce a crispier product with good expanding ability [35], [36].

In addition to starch content, impurities are also an important parameter in assessing the quality of tapioca. Impurities refer to the presence of foreign substances or materials that contaminate a material/product, thereby reducing its purity or quality [8], [37]. Impurities can be physical contaminants, chemical compounds, microorganisms, or other undesirable materials in a material. There are several impacts caused by the presence of impurities, including a decline in product quality, both organoleptic, physical, and chemical [38]. Contaminated products can also cause various health problems, ranging from digestive disorders such as diarrhea and nausea to more serious risks such as poisoning [39], [40]. When a product is proven to contain impurities or contamination, it can reduce consumer confidence in the brand. In addition, products with high impurities are not suitable for marketing because they do not meet existing regulatory standards [41].

The tapioca production process involves several stages, such as peeling, washing, grating, squeezing, settling, drying, milling, and sifting. Each stage of the production process has the potential to affect the starch and impurity content of the final product. Analysis of starch and impurity levels can help producers identify production stages that need to be optimized to improve product efficiency and quality. Products with high starch content and low impurities will be preferred by consumers because they are of high quality. In addition, high-quality products can also provide added value for producers in building brand reputation and increasing competitiveness in local and international markets.

3.1. Starch Content

Starch content analysis was performed using the starch hydrolysis method, which breaks down starch molecules into simple components such as dextrin, maltose, and glucose [42], [43]. The results of starch content analysis using the starch hydrolysis method are shown in Table 1. The highest starch content was found in the sample taken on February 24, 2025, which was 84.67%, and the lowest was on February 12, 2025, which was 79.83%. The analysis results show that the tapioca produced tapioca manufacture in Central Java complies with the existing SNI 3451:2011 tapioca quality standard, which is a minimum of 75%. Several factors can affect the starch content in tapioca, such as the cassava variety used, the age of the cassava harvest, and the processing method. Each cassava variety has a different starch content [44]. For example, the *Pandesesi* variety can have a starch content of up to 86.87%, while the *Meni* variety has a starch content of around 35.57%. Amylose and amylopectin are also chemical compositions that can differ in cassava and can affect the physical and functional properties of the starch produced. Cassava varieties with higher amylose content tend to produce starch with better gelatinization [45].

The age of cassava at harvest affects the starch content produced. Older cassava tends to have a higher starch content than younger cassava. Cassava that is still in the active growth phase and has not reached optimal maturity. The starch and amylose content in cassava that is not yet optimal tends to be lower than cassava that has reached optimal harvest age. Starch is the main component in tapioca, so older cassava can produce better quality flour. The process of processing cassava into tapioca, which includes washing, grinding, filtering, settling, and drying, can cause starch loss. The optimal grinding process can increase the starch content by 5.2%, while an inadequate drying process can reduce the starch content by up to 2.1%. This is because small particles may be discarded along with fine fibers. An ineffective washing process can increase contaminants by up to 0.45% or 1.9 times the average limit. The milling process, an extraction process carried out by mixing the grated cassava with water, can also affect the starch content produced. At this stage, small particles are discarded along with the wastewater, while large particles that do not pass through the filter remain in the pulp. High rainfall causes cassava plants to absorb more water, thereby increasing the water content in the tubers and relatively decreasing the starch content.

Table 1. Tapioca starch content.

Sampling date	Starch content (%wb)
6 February 2025	80.56
7 February 2025	80.82
10 February 2025	81.40
12 February 2025	79.83
13 February 2025	83.65
17 February 2025	83.59
18 February 2025	82.99
19 February 2025	83.21
21 February 2025	84.58
24 February 2025	84.67
25 February 2025	83.26
26 February 2025	80.69
28 February 2025	82.84
5 March 2025	82.40
6 March 2025	82.89
Average	82.48

Note: SNI-3451:2011 minimum starch content 75%.

3.2. Impurities

Impurity analysis (impurity residue) was conducted to determine the amount of residue in tapioca. Impurities are unwanted substances or materials in a product, whether in liquid, gas, or solid form. Impurity content analysis was performed using a 325 mesh residual screen for 15 days, and the results are presented in Table 2.

The highest impurity level was obtained in the sample dated March 5, 2025, which was 0.28%, and the lowest impurity level was obtained in the sample dated February 6, 2025, which was 0.19%. Based on the results obtained, it can be concluded that the tapioca produced by one of tapioca manufacture in Central Java meets the requirements set by the SNI, namely a maximum fiber and impurity content of 0.6%. There are several factors that affect the impurity content in tapioca, including the quality of raw materials, the production process, and machine conditions. Figure 2 shows the factors that influence the impurity content in tapioca.

One important factor that affects the level of impurities in tapioca is the quality of the raw materials used. The quality of raw materials has a significant effect on the level of impurities in the final tapioca product. Fresh cassava has a higher starch content and less coarse fiber. During storage, reactions such as oxidation and hydrolysis occur, causing the formation of new undesirable compounds, which can increase the impurity levels in the final product. In addition, dirt and coarse fibers such as soil and sand attached to

cassava can be carried over during the production process if not thoroughly cleaned. Cassava harvested during the rainy season tends to have higher soil content due to wet fields.

Table 2. Impurities content of tapioca.

Sampling date	Impurities content (%wb)
6 February 2025	0.19
7 February 2025	0.25
10 February 2025	0.22
12 February 2025	0.21
13 February 2025	0.2
17 February 2025	0.26
18 February 2025	0.24
19 February 2025	0.23
21 February 2025	0.25
24 February 2025	0.21
25 February 2025	0.23
26 February 2025	0.22
28 February 2025	0.24
5 March 2025	0.28
6 March 2025	0.24
Average	0.23

Note: SNI-3451:2011 Minimum impurities content 0.6%.

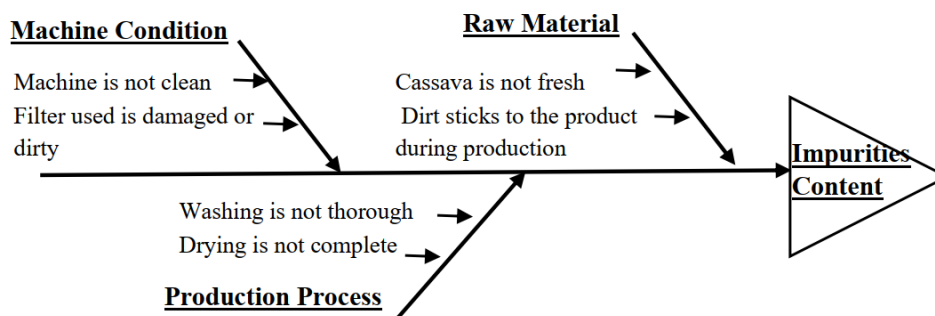


Figure 2. Fishbone diagram of the causes of high impurity levels in tapioca.

The second factor is the production process. The tapioca production process, which includes washing, grating, extraction, sedimentation, and drying, greatly affects the final quality of tapioca. For example, ineffective washing of cassava can leave dirt and other contaminants behind, thereby increasing the impurity content. In addition, incomplete drying of tapioca can increase the water content in the flour, making it an ideal medium for the growth of microorganisms such as fungi and increasing the impurity content. Furthermore, dust mixed in during the drying process can also be a factor in high impurity levels. Therefore, the production process is an important factor that needs to be considered.

The third factor that affects impurity levels is the condition of the machinery. Dirty machinery can be a source of contamination. Residual materials stuck to the machinery can contaminate the flour produced. If the sieves used are damaged or dirty, operator turnover will be less than optimal. Therefore, repairs and maintenance are necessary, including washing the sieves and replacing them if they are damaged or torn. The machines used in the grinding, extraction, and starch separation processes must also function properly so that the starch can be separated from the pulp and other contaminants as much as possible. Overall, the condition of the machine plays an important role in maintaining the quality of tapioca and reducing the

level of impurities. Therefore, machine cleaning and maintenance must be carried out regularly to maintain the quality of the final product.

The Sustainable Development Goals (SDGs) are a set of global goals agreed upon by all member states of the United Nations in 2015. The SDGs aim to end poverty, protect the planet, and ensure prosperity for all by 2030. This research supports SDG 9 by increasing the efficiency of the local tapioca industry (82.48% starch > 75% standard). It supports the achievement of SDG 12 by controlling impurities to 0.23% (62% below the SNI limit). SDG 8 is achieved through improving product quality, which has the potential to increase the competitiveness of Indonesian tapioca exports. In addition to supporting the SDGs, this research is also expected to increase competitiveness in the market with a starch quality of 82.84% that is able to compete with the export standards of Vietnam (82-84%) and Thailand (81-83%). The impurity level of 0.23% is better than the average in China (0.41%). With the dual SNI parameters met, this product is eligible to compete in the domestic and ASEAN export markets.

4. CONCLUSION

The tapioca flour produced has a starch content of 82.48% (79.83–84.67%) and an impurity content of 0.23% (0.19–0.28%), which indicates that it meets SNI 3451:2011 (starch >75%) and SNI 01-3541-1994 (impurities <0.6%). Recommended production processes include stepwise washing, the use of double sieves, monthly machine calibration, and the selection of raw materials less than 10 months old. Further research that can be conducted includes real-time starch crystallinity analysis using FTIR spectroscopy, seasonal studies, and HACCP.

AUTHOR CONTRIBUTION

Istiqomah: contributed to the concept and design of the study and drafted the initial manuscript, responsible for data collection and statistical analysis. **Aprilia Fitriani:** served as corresponding author, supervised the overall research process and gave final approval of the version to be submitted. **Nur Dinan:** contributed to the conceptualization of the research, provided critical academic supervision, and conducted final proofreading of the manuscript.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

ACKNOWLEDGMENT

The author would like to thank all those who contributed to the writing of this scientific article.

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