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Effect of Flash Drying on the Physicochemical Characteristics of Tapioca Starch

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Abstract. *Tapioca starch is widely used as a relatively cheap binder, thickener, and emulsion stabilizer. The product is often produced in Indonesia through several drying methods capable of influencing the functional properties and commercial price. Therefore, this study aimed to compare the effect of flash and sun drying on the physicochemical properties of tapioca starch. The focus was on the viscosity, change time from starch to dough, solubility level, gelatinization time, final gelatin height, color, white level, moisture content, degree of acid, crude fiber, and starch percentage. The results showed that flash drying significantly reduced the viscosity, a* value, white level, moisture content, and degree of acid. Meanwhile, the change time from starch to dough and L* value was significantly higher. It was concluded that flash drying had several advantages and disadvantages over sun-drying but could be used as an alternative time-efficient and more hygienic method.*
Keywords: *Flash drying, Sun-drying, Tapioca starch, Physicochemical, Cassava.*

Type of the Paper: Regular Article.

1. Introduction

Starch is a product often used, either as raw or additional material in food manufacturing, over the years. For example, tapioca starch has become a popular food thickener in Indonesia, even in the world, leading to the placement of cassava as the second largest agricultural food product after rice in the country [1]. Tapioca starch is widely used as a binder, a thickener, and emulsion stabilizer [2,3]. The continuous application is due to its low price, high viscosity, clear paste appearance, low pasting temperature, and bland flavor [4].

Tapioca starch is normally produced from the isolation or extraction of cassava root (*Manihot esculenta* (L.) Crantz) through different steps, including root cleaning, size reduction, fibrous residue separation, dewatering and protein separation, dehydration, and drying [5]. However, drying is one of the physical methods capable of causing chemical structural changes in the properties of the entire polymer [6]. For example, the temperature and humidity during the process can change rheological properties such as gelatinization, enthalpy, swelling capacity, and

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solubility with significant influence on the crystallinity and morphology of starch granules [7]. The changes in physical and chemical properties can further affect the application of starch [8]. It is important to state that the price of commercial tapioca starch varies in Indonesia based on its functional properties.

Akintunde and Tunde-Akintunde [9] discussed the effect of sun and oven drying methods on the functional properties of cassava starch extracts. Aviara et al. [10] also studied the effect of temperature on tapioca starch processed using a tray dryer method. Moreover, He et al. [11] applied hot air, freeze, and vacuum drying methods to canistel starch and analyzed the changes caused to the structure and physicochemical properties. Limited attention has been placed on the impact of the flash method on the characteristics of tapioca flour despite its popularity and less harmful effects in preserving nutrients compared to traditional drying.

The process of flash drying requires briefly exposing the sample to a high temperature to ensure a rapid rate of evaporation and maintain product quality [12]. The method is relatively simple in operation, occupies minimal space, increases energy efficiency, and has a control system that typically exhibits rapid responsiveness to changes in the drying process conditions [13,14]. Therefore, this study aimed to compare the effect of flash and sun drying on the physicochemical properties of tapioca starch. Sun drying is selected for the comparison because of its popularity in Asia and relatively low investment or machine cost while flash drying has the ability to maintain nutrients and hygiene at some investment cost.

2. Materials and methods

2.1. Sample Preparation

The two methods applied in this study to produce tapioca starch were flash and traditional sun drying while the cassava (*Manihot esculenta*) was obtained from a local store in Indonesia. The process was achieved by cleaning and washing the cassava to remove the outer peel waste using a cassava dry-sieve-and-paddle washing machine. The next step was to slice and crush the cassava using a cutting machine to release starch. This was followed by the separation of the starch and fiber in cassava pulp using an 80-mesh centrifuge as well as a fine fiber sieve to improve the starch extraction rate. Subsequently, the hydro-cyclone station was used to filter out the protein and cell liquid in the starch slurry before purification and concentration. Finally, the cassava starch pulp was dried using a peeler centrifuge before the application of the flash or traditional sun method. It was important to state that the sun drying process was conducted for a maximum of 12 hours depending on the availability of sunlight.

2.2. Physical Properties

Viscosity was measured using a Brookfield rotary viscometer while some other physical properties were also evaluated including the change time from starch to dough, solubility level, gelatinization time, and final gelatin height. Moreover, color was determined using a colorimeter based on L*, a*, b*, and white levels. It was important to state that all the properties were analyzed by mixing tapioca flour and water in the same ratio.

2.3. Chemical Properties

Moisture content, degree of acid, crude fiber, and the starch percentage were analyzed as the chemical properties and were determined using a method described in SNI (*Indonesian National Standards*) 3451:2011 Tapioka [15]. The analysis of the moisture content was conducted using the thermogravimetric method at a temperature of 130°C. Moreover, the degree of acid was assessed by dissolving 10 g of tapioca in 100 mL of 95% ethanol, allowed to stand for 24 hours, and occasionally agitated. The solution was later filtered, phenolphthalein (PP) was added to 50 mL of the filtrate, and titrated using 0.05 M NaOH. The degree of acid was subsequently calculated using the following formula (1).

$$\text{Degree of acid} = \frac{\text{NaOH Volume (mL)} \times \text{NaOH Normality} \times \text{dilution factor} \times 100}{\text{sample weight (g)}} \text{ mL NaOH 1 N/100 g sample} \quad (1)$$

Crude fiber was determined by boiling the mixture of 4 g sample and 50 mL of 1.25% H_2SO_4 for 30 minutes. Later, 50 mL of 3.25% NaOH was added and continued to boil for another 30 minutes followed by the filtration of the solution using Buchner funnel and filter paper. The precipitate in the filter paper was washed using 1.25% H_2SO_4, hot water, and 96% ethanol, consecutively. The filter paper was later dried using the oven at 105°C and weighed after cooling. The crude fiber was subsequently calculated using the following formula (2).

$$\text{Crude fiber (\%)} = \frac{\text{Precipitate weight (g) - ash weight (g)}}{\text{Sample weight (g)}} \times 100\% \quad (2)$$

The starch percentage was analyzed by boiling the mixture of 5 g sample and 200 mL of 3% HCl for 3 hours. The mixture was cooled and neutralized by adding 30% NaOH and 3% CH_3COOH. This was followed by the filtration of the mixture after dilution using a 500 mL volumetric flask while 25 mL of *Luff-Schoorl* solution and 15 mL of distilled water were added to 10 mL of filtrate. The mixture was heated for 3 minutes to boil and left for 10 minutes in the boiling condition. After the mixture was cooled, 15 mL of 20% KI and 25 mL of 25% H_2SO_4 were added before titration using $Na_2S_2O_3$. Glucose weight was later determined using *Luff-Schoorl* equivalent table and glucose content was calculated through the following formula (3). This was necessary because starch percentage was determined as 90% of the glucose content.

$$\text{Glucose content (\%)} = \frac{\text{Sample weight (mg)} \times \text{dilution factor}}{\text{Glucose weight}} \times 100\% \quad (3)$$

2.4. Statistical Analysis

Each sample was prepared in triplicate (n = 3) for the analyses and all the data were expressed as mean ± standard deviation (SD). Moreover, a t-test was applied to compare different drying methods at a significance level of 0.05.

3. Results and Discussion

The production of tapioca starch using flash drying was compared to the traditional sun drying method commonly used in several industries. It was observed that the cassava used less time, only a few seconds or even less than 1s, to contact with the drying medium in the flash dryer [16]. Cassava is an easily oxidized and heat-sensitive product that requires flash drying to maintain some physical changes that possibly occur during heating [13,17]. However, the major disadvantage is the need for high degree temperature for just a few seconds instead of the low temperature of the sun required in sun drying for a longer time. The main challenge to sun drying is product hygiene due to exposure to open air for a long time as well as the need for a large area [18]. Moreover, the process is complex and there is difficulty in achieving consistent quality standards due to climatic conditions [19].

The physical properties of tapioca starch are presented in Table 1 with the viscosity of the product from flash drying (3,028 ± 12.34 mP.s) observed to be significantly lower ($p<0.05$) than sun drying (3,303.67 ± 71.86 mP.s). This is in line with the observation of Ma'aruf and Abdul [20] that high temperature can reduce the paste viscosity (Pa.s). Starch viscosity contributes to its role as a thickening or gelling agent in food products. The lower values recorded through the flash drying were possibly due to the higher drying temperature that broke hydrogen bonds in starch granules and led to more losses of structure and a reduction in the viscosity [21]. Furthermore, high drying temperatures can leach out the soluble substances from starch granules, including water, leading to the production of more dilute gel when heated in water. The temperature also has the capacity to reduce the capacity of the product to hold water [20].

Table 1. Physical properties of tapioca starch produced from different drying methods

Parameters	Flash Drying	Sun-Drying
Viscosity (mP.s)	3028.33 ± 12.34*	3303.67 ± 71.86
Change time from starch to dough (s)	29.67 ± 2.52*	22.67 ± 1.15
Solubility level	++	++
Gelatinization time (s)	28.00 ± 4.00	26.33 ± 3.51
Final gelatin height (mL)	243.33 ± 5.77	243.33 ± 5.77

Asterisk sign (*) indicates the significant differences for different drying methods using Student's t-test at $p<0.05$.

Flash drying (29.67 ± 2.52 s) was observed to have a significantly longer change time from starch to dough ($p<0.05$) than sun drying (22.67 ± 1.15 s). However, there was no significant difference in the solubility level for both methods. A similar observation was also made for the gelatinization time of flash drying (28.00 ± 4.00 s) and sun drying (26.33 ± 3.51 s). The final gelatin height for both methods was found to be the same at 243.33 ± 5.77 mL.

The results from the color analysis of tapioca starch produced using different drying methods are presented in Table 2. This is necessary because color is very important in the commercial production and sale of starch. Consumers do not like brown-colored starch because it is believed to have a rancid smell associated with browning products and rather expect colorless, odorless, and tasteless starch [22]. The results showed that the L* value of tapioca starch produced using flash drying (70.63 ± 0.06) was significantly higher ($p<0.05$) than sun drying (67.73 ± 0.31). It is important to state that L* represents the lightness of the sample and the higher value recorded in flash drying is due to the shorter time of exposure to heat, leading to the minimization of browning. Meanwhile, the lower value in sun drying was associated with the longer thermal processing time that led to the contribution of some enzymes to non-enzymatic browning through the reduction of sugar and amino groups of proteins [23].

The a* value represents the redness and blueness. The results showed that flash drying (2.23 ± 0.10) had a significantly lower value ($p<0.05$) than sun drying (2.51 ± 0.04). The higher a* value recorded in sun drying showed the presence of more redness and this was associated with the exposure of the products to heat for a longer time which led to the browning [24]. Meanwhile, the results showed that the b* value, indicating the yellowness and greenness, of flash (5.84 ± 0.40) and sun drying (5.87 ± 0.03) was not significantly different ($p<0.05$). Another important observation was that the white degree of flash drying (97.60 ± 0.17) was significantly lower ($p<0.05$) than sun drying (98.50 ± 0.00) but both satisfied the minimum of 91 required by the SNI 01-3451-1994 for tapioca. This white degree shows the amount of amylose and amylopectin in starch and is considered important because high-amylose content leads to a more white and opaque color while high-amylopectin has a slightly gray-white appearance [25]. The lower white level in flash drying was due to the reduction in amylose concentration and an increase in the short-chain proportion of amylopectin caused by the high temperature [26].

Table 2. Color analysis of tapioca starch produced from different drying methods

Parameters	Flash Drying	Sun-Drying
L*	70.63 ± 0.06*	67.73 ± 0.31
a*	2.23 ± 0.10*	2.51 ± 0.04
b*	5.84 ± 0.40	5.87 ± 0.03
White degree	97.60 ± 0.17*	98.50 ± 0.00

Asterisk sign (*) indicates the significant differences for different drying methods using Student's t-test at $p<0.05$.

The chemical properties analyzed were the moisture content, degree of acid, crude fiber, and starch as presented in Table 3. The moisture content obtained through flash drying (12.53 ± 0.05%) was significantly lower ($p<0.05$) than sun drying (14.23 ± 0.04%). This was in line with the report of Aviara et al. [10] that the moisture content reduced as the drying temperature increased. However, the maximum allowable moisture content for tapioca in SNI 01-3451-1994 is 14% and this shows that the tapioca starch produced from sun drying does not meet the standard.

Table 3. Chemical properties of tapioca starch produced using different drying methods

Parameters	Flash Drying	Sun-Drying
Moisture Content (%)	12.53 ± 0.05*	14.23 ± 0.04
Degree of Acid (mL NaOH 1 N / 100 g)	0.29 ± 0.03*	0.44 ± 0.03
Crude Fiber (%)	0.23 ± 0.08	0.41 ± 0.28
Starch (%)	75.04 ± 2.18	74.79 ± 1.85

Asterisk sign (*) indicates the significant differences for different drying methods using Student's t-test at $p<0.05$.

The result showed a significant difference ($p<0.05$) in the degree of acid between flash (0.29 ± 0.03 mL NaOH 1 N / 100 g) and sun drying (0.44 ± 0.03 mL NaOH 1 N / 100 g). The degree of acid is correlated with the deterioration of nutritional and sensory products used for the evaluation of lipid oxidation and lipolysis of food products [27]. The values obtained for both methods meet the 4 mL NaOH 1 N / 100 g maximum allowable according to SNI 01-3451-1994. It was concluded that higher temperatures reduced the degree of acid despite the exposure of the sample for just a few seconds.

The percentage of crude fiber was observed not to be significantly different ($p<0.05$) for flash (0.23 ± 0.08%) and sun drying (0.41 ± 0.28). The same trend was also identified for the starch percentage at 75.04 ± 2.18% and 74.79 ± 1.85% respectively. However, the tapioca sample produced through sun drying did not meet the 0.4% maximum allowable crude fiber and 75% minimum allowable starch content. This showed that flash drying had better chemical properties probably due to the lesser time of exposure to heat considering the heat sensitivity of cassava and the subsequent effect on the chemical properties. The trend showed that heat temperature and the contact time between the cassava and heat significantly influenced its physicochemical characteristics. Consequently, it is important to consider and maintain heat temperature and time properly in order to improve starch characteristics.

4. Conclusions

In conclusion, the application of different drying methods in producing tapioca starch had a significant effect on the physicochemical properties. Using the flash drying method reduced the viscosity, a* value, white level, moisture content, and degree of acid but increased the change time from starch to dough and L* value. This showed that both methods had advantages and disadvantages but flash drying could be used as an alternative to achieve more hygiene, lower production time, and maintenance of chemical properties in line with the required standard.

Abbreviations

Not applicable.

Data availability statement

Data will be made available on request.

Credit authorship contribution statement

Januar Nasution: Conceptualization, Methodology, Investigation, Formal analysis; **Felix**

Widodo: Writing – original draft, Writing – review and editing, Data curation; **Diana Lo:** Supervision, Project administration, Validation; **Thitipong Phothisoot:** Research design, Funding acquisition; **Teeradate Kongpichitchoke:** Funding acquisition, Writing – review and editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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