A comparison of microwave and ultrasonic treatment on swelling power and water solubility of tapioca

F Pratama1*, I P Sari1, S Ridhowati1, and F S Arsyad2

1Faculty of Agriculture Universitas Sriwijaya, Jalan Raya Palembang-Prabumulih KM 32, Indralaya 30662, Ogan Ilir, South Sumatera, Indonesia
2Faculty of Mathematics and Natural Sciences Universitas Sriwijaya, Jalan Raya Palembang-Prabumulih KM 32, Indralaya 30662, Ogan Ilir, South Sumatera, Indonesia

E-mail: fillipratama@gmail.com

Abstract. Analysis of swelling power [SP] and water solubility index [WSI] of tapioca starch as affected by microwave and ultrasonic treatments was determined. The moisture content of the native tapioca starch was adjusted to 30%, 40%, and 50% [wb]. The microwave treatment was performed at the power level of 450 W for 2 minutes, and the ultrasonic treatment was carried out at 40 kHz of 40°C for 30 minutes. Analysis of variance showed that the method of modification had a significant effect on SP and WSI. It was found that the microwave treatment decreased the SP and WSI, whereas the ultrasonic treatment increased the SP and WSI at a higher moisture content of native tapioca starch.

1. Introduction

Tapioca starch is the major ingredient that is responsible for the texture firming of some traditional foods in south Sumatera such as pempek. The firming texture is due to the retrogradation process of the gelatinized tapioca starch during the processing of pempek, therefore modification of tapioca was proposed to slow down the retrogradation. There are some starch modifications: chemical, physical, microbiological and enzymic modifications. Among those starch modifications, the physical is favorable due to the environmentally friendly methods without residue.

The physical starch modification included autoclaving and cooling, heat moisture treatment, microwave and sonicated treated methods. Different starch modifications have different impacts on the textural properties of the product. The texture of pempek that was made of modified tapioca with the autoclaving-cooling method was softer compared to that of native tapioca [1]. However, the very soft texture of pempek is unfavorable by consumers. This research focused on retarding the retrogradation of a tapioca-based product by modifying tapioca with microwave and ultrasonic treatment.

Microwave and sonicated treatments of starch could affect the swelling power due to the more flexibility of starch molecule [2][3][4]. The flexible starch molecule could absorb and retain more water during gelatinization. The moisture absorbed in a product would retain more moisture during storage. Swelling power [SP] and water solubility index [WSI] are the main indicators for modified starch. The quality of modified starch could be affected by the moisture content of the native starch; therefore, the current research focused on the SP and WSI of the tapioca starch as modified by microwave and ultrasonic treatments at a different level of moisture content of the native tapioca starches.
2. Materials and methods

2.1. The preparation of tapioca.
The native tapioca starch was obtained from commercial tapioca. The tapioca was adjusted to 30, 40, and 50 % [wet basis] of moisture content before modification. The adjustment of moisture content of the native tapioca starch followed the method of Mandei [5].

2.2. Microwave treatment [MT].
The moisture adjusted – native tapioca was kept in a sealed container then it was equilibrated at the temperature of 10°C overnight before microwave heating. An amount of 150 g equilibrated tapioca was placed into a microwaveable container and heated in a microwave oven [Panasonic-Japan] at the power level of 450 W for 2 minutes. The microwave heated tapioca was dried in an oven at 45°C for 24 hours.

2.3. Ultrasonic treatment [UT].
The moisture adjusted - tapioca starch as the amount of 150 g was equilibrated at the temperature of 10°C for overnight before microwave heating, then it was heated in an ultrasonic processor [Cole Parmer] at the amplitude-frequency of 40 MHz for 30 minutes and it was dried in an oven at 45°C for 24 hours.

2.4. Swelling power analysis.
The swelling power of starch was determined according to the method of Onyango [6]. The swelling power [SP] is the ratio of the weight of the wet sediment [Ws] to the initial weight of dried starch [equation 1]

\[
SP = \frac{W_s (g)}{\text{initial weight of dried starch} (g)} \quad \text{[1]}
\]

2.5. Water solubility index analysis.
The water solubility index of starch was determined according to the method of Onyango [6]. Solubility is the ratio of the weight of the dried supernatant to the initial weight of dried starch [Equation 2].

\[
WSI = \frac{W_1 (g)}{0.1 (g)} \quad \text{[2]}
\]

2.6. Statistical analysis
The experiments were arranged in a factorial completely randomized design with two factors. The first factor [A] was modification methods consisting of microwave [A1] and ultrasonic treatment [A2] and the second treatment was the moisture content of native tapioca starch [B] namely 30% [B1], 40% [B2] and 50% [B3]. The data were analyzed by using ANOVA and the significant different treatment was further analyzed by Tukey’s mean test at a 5 % level.

3. Results and discussion

3.1. Swelling power
The SP of modified tapioca starch by microwave radiation ranged from 0.146 g/g to 0.157 g/g; whereas modified tapioca by ultrasonic treatment tanged from 0.181 g/g to 0.197 g/g. Analysis of variance showed that the factor of modification method had a significant effect on the SP, on the other hand, for the factor moisture content and the interaction between the two factors had no significant effect on SP. The detail of the SP values of all treatments is presented in Figure 1.
The SP of native tapioca starch was also determined before modification in which the SP was $[0.162\pm0.0002]$ g/g. The tapioca starch modification by the method of microwaved radiation resulted in lower values of SP, on the other hand, the modification by the method of ultrasonic treatment increased the SP.

The modification of tapioca starch by microwave radiation was generating heat at the power level of 450 Watt for 2 minutes during which the energy of microwave could vibrate the water molecules in starch. The microwave heat weakened the internal bond and destroyed the arrangement of amylose and amylopectin, therefore the capability of the starch granule to retain moisture was decreased.

![Figure 1. Swelling power of modified tapioca starch](image)

It was shown by the lower SP of microwaved modification compared to native tapioca. This finding was in line with Palav and Seetharaman [7] who stated that microwaving resulted in the loss of crystallinity of starch. A similar effect was observed by Emami [8] who stated that the microwave heat affected on the physicochemical properties of starch. The SP of the ultrasonically treated tapioca starch was higher than that of microwave treatment. This was due to the increase of the water absorption capacity as well as the solubility during ultrasonic processing.

3.2. Water solubility index [WSI].

The WSI of native tapioca was 10.168±2.387. The average of WSI for all treatments was shown in Figure 2. Analysis of variance showed that factor A [modification method] and factor B [moisture content of tapioca starch] had a significant effect on WSI, but the interaction between those two factors had no significant effect on WSI. The microwave treated tapioca starch was decreased during the microwaving of tapioca starch. Unlike the modification of microwave treatment, the WSI of the ultrasonic treatment was decreased at a moisture content of 40% and 50%, on the other hand, the WSI slightly increased for the moisture of 50%. The increase of WSI could be explained by ultrasound treatment disrupted starch granules resulting in easier water penetrates the granules. The higher moisture content caused more vigorous vibration of starch granule and therefore the WSI increased.
4. Conclusions
The microwave treated tapioca starch decreased the SP and WSI, and the ultrasonically treated tapioca increased the SP and WSI at a higher moisture content.

References
[1] Oksilia O and F Pratama. 2018. Karakteristik fisik, kimia dan sensoris pempek berbahan dasar pati resisten tipe III tapioca, Prosiding Seminar Nasional Hasil Litbangyasa Industri 163-175
[2] Brasoveanu M and MR Nemtanu. 2014. The behaviour of starch exposed to microwave radiation treatment, Starch-Starke, 66 (1-2) 3-14
[3] Palav T and K Seetharaman. 2007. Impact of starch heating on the physico-chemical properties of a starch-water model system, Carbohydrate Polymers, 67 (4) 596-604
[4] Anderson AK, and HS Guraya. 2006. Effects of microwave heat-moisture treatment on properties of waxy and non-waxy rice starches, Food Chemistry 97 (2) 318-323
[5] Mandei JH. 2016. Penggunaan pati sagu termodifikasi dengan heat moisture treatment sebagai bahan substitusi untuk pembuatan mi kering. Jurnal Penelitian Teknologi Industri, 8 (1) 57-72
[6] Onyango C, Mewa EA, Mutahi AW, and Okoth MW. 2013. Effect of Heat-Moisture-Treated Cassava Starch and Amaranth Malt on the Quality of Sorghum-Cassava Amaranth Bread. African Journal of Food Science, 7 (5) 80-86
[7] Palav T and K Seetharaman. 2006. Mechanism of starch gelatinization and polymer leaching during microwave heating, Carbohydrate Polymers, 65 364-370
[8] Emami S, A Perera, V Meda, and RT Tyler. 2012. Effect of microwave treatment on starch digestibility and physiochemical properties of three barley types, Food and Bioprocess Technology, 5 (6) 2266-2274

Acknowledgments
This manuscript has arisen from the research that was financially supported by the research grant of Universitas Sriwijaya [Hibah Profesi 2019]. Many thanks to the Faculty of Agriculture of Universitas Sriwijaya for the facilities during conducting this research.

Figure 2. Water solubility index of modified tapioca starch