Improvement of Whiteness Degree and Functional Properties of the Fermented Awachy 5 Sweet Potato Flour Using Calcium Hypochlorite

Edy Subroto, Yana Cahyana, Rossi Indiarto, Endah Wulandari, Angiestya Pinekesti

Abstract**: *Fermented Awachy 5 sweet potato flour has the potential to substitute the low protein wheat flour, but this flour has the disadvantage of having a low whiteness degree. The objective of this research was to improve the whiteness degree and the functional properties of naturally fermented of Awachy 5 sweet potato flour using calcium hypochlorite. The research was conducted by the addition of calcium hypochlorite to the fermented sweet potato chips consisted of 5 treatments; namely control (without calcium hypochlorite), 100 ppm, 150 ppm, 200 ppm, and 250 ppm. The results showed that the bleaching treatment using calcium hypochlorite increased the whiteness degree and pasting stability of fermented sweet potato flour. The optimum concentration of calcium hypochlorite was 200 ppm which produced flour with a whiteness degree of 84.60%, ash content of 0.73%, swelling volume of 7.75 mL/g, water absorption capacity of 195.80%, and pasting properties that include of peak viscosity, hold viscosity, breakdown viscosity, setback viscosity, and final viscosity about 2979 cP, 1704 cP, 1275 cP, 1345 cP, 3049 cP, respectively.***

Keywords: Awachy 5, sweet potato flour, calcium hypochlorite, functional properties, pasting properties

I. INTRODUCTION

Wheat flour is widely used for various food industries such as bread, noodles, biscuits, and cookies, but its availability is limited [1], [2]. Therefore it is necessary to diversify flour to substitute wheat flour partially or completely. On the other hand, the availability of sweet potatoes in Indonesia is abundant and can be used as a substitute for wheat flour. One of the sweet potato varieties developed by Universitas Padjadjaran is the sweet potato of *Awachy* 5 clone. Sweet potato of *Awachy* 5 clone is a superior type that has unique, uniform and high productivity [3]. This clone is potential to be used as raw material for substituting wheat flour. This sweet potato has yellow flesh color without secondary color, high starch content, low water content, applicable for food products, and high beta carotene content about 261 mg/100 g [4].

The native sweet potato of Awachi 5 flour has disadvantages such as native flour or starch as syneresis, retrogradation, heat stability, and other functional properties [5], [6]. The functional properties of *Awachy* 5 sweet potato flour can be improved through a modification using the natural fermentation method. Fermentation and other biotechnology methods can improve food characteristics [7].

Fermentation improve the solubility, viscosity, pasting stability, flavor, and color of flour [8]. However, *Awachy* 5 sweet potato flour which has undergone a fermentation process still has a low whiteness degree. This flour needs to be improved on its whiteness degree through the bleaching process including using a bleaching agent, namely calcium hypochlorite ($Ca(ClO)_2$). The use of bleaching agents or other oxidizers also affects the functional properties of flour/starch [9]. Oxidation in flour/starch change its functional properties through the introduction of carbonyl and carboxyl groups which increase the stability of starch paste [10], [11].

In this research, the effect of calcium hypochlorite concentration to the whiteness degree and functional properties of fermented *Awachy* 5 sweet potato flour was studied. Functional properties include swelling volume, water absorption capacity (WAC), and pasting properties of fermented *Awachy* 5 sweet potato flour.

II. MATERIALS AND METHODS

A. Materials

The material used in this research was the sweet potato of *Awachy* 5 clone which has a yellowish white flesh color of 4 months harvest age obtained from the Plant Breeding Laboratory of Universitas Padjadjaran. Calcium hypochlorite and another chemical used in this research were analytical grade.

B. *Awachy* 5 sweet potatoes flour preparation

Awachy 5 sweet potatoes were peeled to separate the skin part from the tuber, then washed with water and cut into sweet potato chips with the thickness of 1-2 mm. Chips of sweet potato were fermented naturally by soaking sweet potato chips in water. The fermentation was controlled at a temperature of 26-28 ºC for 48 h. Soaking water was

Revised Manuscript Received on July 05, 2019

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separated then sweet potato chips soaked with calcium hypochlorite at various concentrations (0 (control), 100, 150, 200, and 250 ppm) for 24 h. The sweet potato chips were then dried using a cabinet drier at 60ºC for 18 h, then finely ground using a disc mill and sifted at 100 mesh.

C. Determination of whiteness degree

The whiteness degree was determined according to Subroto et al [6] using the Photoelectric Tube Whiteness Meter for Powder Model-1 with a standard of BaSO4 that has a white degree of 100% (110.8). The sample was put into a sample container then compacted (± 50 g), closed, and then the BaSO4 standard and the sample was inserted into the hole in the instrument. Whiteness degree was indicated by the numbers displayed on the screen. The whiteness degree was then determined according to the equation 1.

$$\text{Whiteness (\%)} = \frac{\text{Value of sample}}{\text{value of standard } (BaSO_4)} \text{ x } 100\ \% \quad (1)$$

D. Determination of swelling volume

A total of 0.35 g flour samples were put into a centrifuge tube, then 12.5 mL of aquades were added and vortexed for 30 seconds. The tube was then heated in a water bath at 92.5ºC for 30 min with occasional stirring, then cooled in ice water for 1 min and cooled at room temperature for 5 min. The samples were centrifuged at 3500 rpm for 30 min until gel and supernatant were separated. The volume of the supernatant was then measured to determine the swelling volume according to the equation 2 [12].

$$Swelling\ volume = \frac{total\ volume - supernatan\ volume}{weight\ sample\ (db)} \quad (2)$$

E. Determination of ash content

Determination of ash content was according to AOAC [13]. The sample (2 g) was inserted into a porcelain dish whose weight was known and then ignited into the furnace at 600ºC for 4 h or until white ash was obtained. Then the cup was cooled in a desiccator to room temperature and weighed.

F. Determination of Water absorption capacity

The sample (1 g) was put in a centrifuge tube, then 9 mL of distilled water was added and vortexed for 30 seconds until all the mixture was dispersed. The sample was left for 30 min, then centrifuged at 3500g for 30 min until sediment and supernatant were obtained. Sediments and supernatants were separated and WAC was then calculated as mL of water absorbed per gram of flour.

G. Determination of Pasting properties

Pasting properties of *Awachy* 5 sweet potato flour were determined according to Koksel et al [14] using Rapid Visco Analyzer (RVA-SM2), Warriewood Australia. Sample of 3.5 - 4 g was weighed and put it in an aluminum canister. The sample was then added with 25 g of distilled water and mixed. The following temperature profile: heating at a temperature of 50ºC that was maintained for 1 minute, heating the sample from 50 to 95ºC at 6ºC/min. The temperature of 95ºC was maintained for 5 min. The sample was then cooled to a temperature of 50ºC at 6ºC/min, then maintained at a temperature of 50ºC for 5 min.

H. Statistical analysis

One way ANOVA was used to analyzed data, then Duncan Test was performed to detect differences. Significance was confirmed at a P value of <0.05.

III. RESULTS AND DISCUSSION

A. Whiteness degree

Fig 1. shows that whiteness degree of fermented *Awachy* 5 sweet potato flour increased significantly in the addition of calcium hypochlorite to 200 ppm (from 77.50% to 84.60%). This was due to the carotenoid pigments in fermented sweet potato were oxidized by calcium hypochlorite. The oxidation process caused the severance of the conjugated double bond in the carotenoid pigment so that the color of the carotenoid compound became paler and whiter [15].

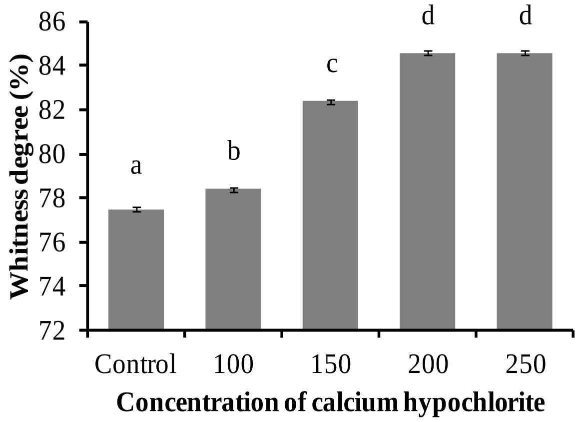

Fig 1. The effect of calcium hypochlorite on whiteness degree of awachi 5 sweet potato flour

Whiteness degree increased until the addition of 200 ppm of calcium hypochlorite with a value of 84.60%. Further addition of calcium hypochlorite (250 ppm) did not improve the whiteness degree significantly. The calcium hypochlorite concentration was an important factor in the flour bleaching process, but the use of excess bleaching agents did not improve the whiteness degree. The whiteness degree of fermented *Awachy* 5 sweet potato flour in the treatment of 200 ppm calcium hypochlorite was higher than wheat flour (82.17%). Therefore, the addition of calcium hypochlorite increased the whiteness degree of fermented sweet potato flour effectively.

B. Swelling volume

The addition of calcium hypochlorite of 100 ppm resulted in a significant increase in swelling volume from 6.33 mL/g to 7.61 mL/g, but the addition of higher calcium hypochlorite (≥150 ppm) did not increase swelling volume significantly (Fig. 2). The increase in swelling volume was affected by the ability of a starch molecule to bind water through the formation of hydrogen bonds. Addition of calcium ions (Ca^{2+}) from calcium hypochlorite encouraged the formation of cross-linking between starch molecules so that it bound more water and formed a strong gel structure. In addition, calcium ion promoted the breaking of the bonds between the hydroxyl groups in the starch, thus changing the hydroxyl groups to become porous and hollow. Sangseethong et al [9] reported that the surface of starch granules oxidized by hypochlorite had a rough and hollow surface, so that the starch granules expanded optimally. The expanded of starch granules was caused by the amount of water absorbed into starch granules resulting in increased swelling volume.

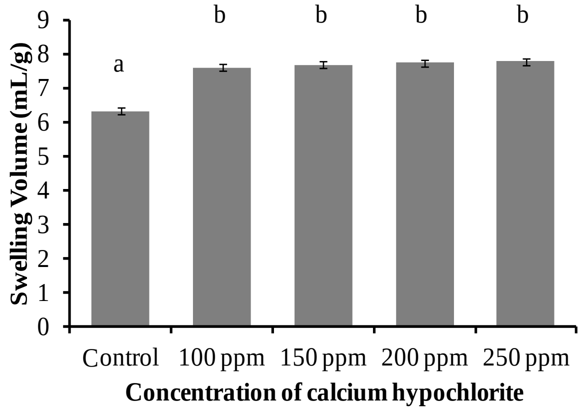

Fig 2. The effect of calcium hypochlorite on the swelling volume of fermented Awachi 5 sweet potato flour

C. Water absorption capacity

Fig 3. shows that the bleaching treatment with calcium hypochlorite of 100 ppm increased WAC significantly, from 159.20 g/g to 190.19 g/g, but the addition of the higher calcium hypochlorite (≥150 ppm) did not increase WAC significantly. The increased in WAC can be caused by the presence of calcium ions (Ca^{2+}) from calcium hypochlorite where calcium ions were facilitating water-binding starch. Calcium ions reacted with the hydroxyl groups in the structure of amylose or amylopectin to form cross-linking bonds between starch molecules, then the starch formed bonds that strengthen hydrogen bonds, so that sweet potato flour has the ability to bind more water [16].

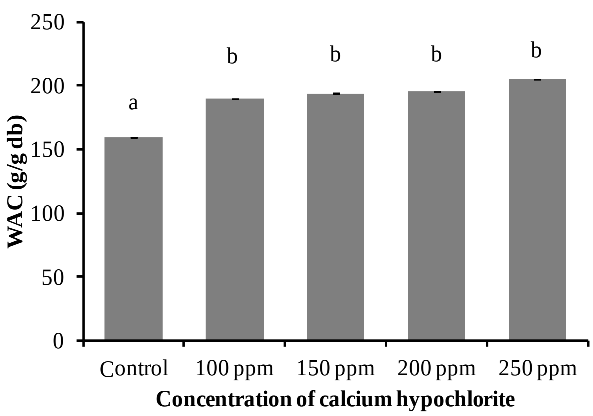

Fig 3. The effect of calcium hypochlorite on WAC of fermented Awachi 5 sweet potato flour

D. Ash content

The bleaching treatment with the addition of calcium hypochlorite of 100 ppm increased the ash content from 0.43% to 0.73%, but the addition at higher concentrations (≥150 ppm) did not increase the ash content significantly (Table 1). This was due to the immersion in calcium hypochlorite solution to encourage interaction between calcium and sweet potato flour. Calcium ion entered into the particles of sweet potato flour thus increasing the mineral content of the bleached fermented sweet potato flour. Calcium salts also react with starch to form cross-linking bonds between amylose and amylopectin molecules [17]. The binding of the calcium ion to the starch molecule increased the ash content of fermented *Awachy* 5 sweet potato flour.

Table 1. The effect of calcium hypochlorite on ash content of fermented Awachi 5 sweet potato flour

Concentration of calcium hypochlorite	Ash content (% w/w)
Control	0.43 ± 0.03a
100 ppm	0.73 ± 0.01b
150 ppm	0.73 ± 0.01b
200 ppm	0.73 ± 0.01b
250 ppm	0.74 ± 0.03b

Each value is presented as mean ± standard deviation. Different letters in the same column indicated significantly different values ($p < 0.05$).

E. Pasting properties

Fig 4. and Table 2. show that fermented + bleached Awacy 5 flour had a pasting point that was not different from the control significantly, 77.35 ºC and 77.39 ºC, respectively. This was in line with Sangseethong and Sriroth [10] in the modification of cassava starch with sodium hypochlorite did not change the pasting temperature significantly, but it affected the pasting properties. A lower pasting point had an effect on decreasing a peak viscosity which resulted in a clearer and softer gel. The higher the pasting point affected the resistance to swelling of the material, which can be correlated with the amount of amylose and amylopectin [18].

The peak viscosity of the fermented + bleached *Awachy* 5 sweet potato flour was lower than control that was not given bleaching treatment, 2979 cP and 3260 cP, respectively (Fig. 5. and Table 2). This was consistent with Garrido et al [19] that starch modification with sodium hypochlorite decreased the peak viscosity significantly. This was due to the partial degradation of starch polymers resulted in lower molecular weight of starch polymers. As a result, the starch particles which were bleached were more easily fragmented or broken during the gelatinization. Peak viscosity indicated the strength of the dough formed during processing in food applications. Peak viscosity was closely related to swelling of granules which increases the peak viscosity [20].

Based on Fig 4. and Table 2. Hold viscosity of the fermented + bleached *Awachy* 5 sweet potato flour was lower than the control, 1704 cP and 1818 cP, respectively. This was due to the oxidation of hypochlorite in starch molecules resulting in the degradation of double helix amylose and amylopectin bonds, especially in the amorphous region. Sangseethong and Sriroth [10] also found that the higher the concentration of hypochlorite decreased the peak viscosity and hold viscosity of cassava starch. Hold viscosity is an index of ease of warming and reflects the weakness of the granule in expanding during heating.

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Table 2. Pasting properties of fermented and fermented + bleached of Awachi 5 sweet potato flour

Properties	Control (fermented)	Fermented + Bleached
Pasting Point (°C)	77.39 ± 0.50a	77.35 ± 0.45a
Peak viscosity (cP)	3260 ± 106b	2979 ± 75a
Hold viscosity (cP)	1818 ± 51b	1704 ± 33a
Breakdown viscosity (cP)	1442 ± 107b	1275 ± 92a
Final viscosity (cP)	2934 ± 103a	3049 ± 142a
Setback viscosity (cP)	1116 ± 87a	1345 ± 92b

Each value is presented as mean ± standard deviation. Different letters in the same row indicated significantly different values ($p < 0.05$).

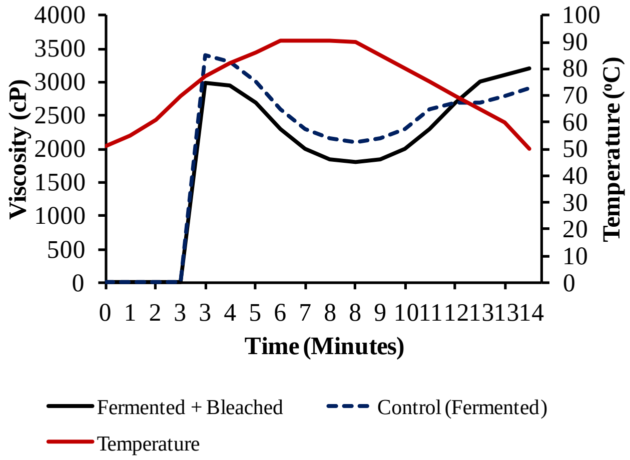

Fig 4. The RVA viscoamylograph of fermented and fermented + bleached of Awachi 5 sweet potato flour

Breakdown viscosity of fermented + bleached *Awachy* 5 sweet potato flour was lower than control, 1275 cP and 1442 cP, respectively (Fig 4. and Table 2). This was in line with Sangseethong and Sriroth [10] in the modification of cassava starch with sodium hypochlorite that the higher the concentration of hypochlorite resulted in the lower of the breakdown viscosity. This was caused by an increased in the regularity of the matrix crystals which then reduced the capacity of swelling of the granules and increased the stability of the paste during heating. In addition, calcium ions encouraged cross-linking formation between amylose and amylopectin polymers to form structures that were more resistant to the heating. The lower breakdown of viscosity indicates that flour/starch is more stable in the heating process [21].

Fig. 5. and Table 2. show that the setback and final viscosity of fermented + bleached *Awachy* 5 sweet potato flour were higher than the control. Setback viscosity of 1345 cP and 1116 cP, respectively, while final viscosity of 3049 cP and 2934 cP, respectively. The higher setback and final viscosity indicated the high tendency for retrogradation, which was the formation of microcrystalline of amylose and amylopectin molecules after the paste has cooled. These results indicated that bleaching by calcium hypochlorite increased the strengthen the granular structure of the fermented *Awachy* 5 sweet potato flour. The pasting properties of flour obtained were similar to the modified flour or starch by cross-linking. This can be caused by calcium ions from hypochlorite also played in forming of the cross-linking bonds between amylose and amylopectin molecules.

IV. Conclusion

The treatment of fermented + bleached *Awachy* 5 sweet potato flour increased the whiteness degree, ash content, swelling power, and WAC significantly. Bleaching by 200 ppm of calcium hypochlorite produced flour with a optimum whiteness degree of 84.60%, ash content about 0.73%, swelling volume of 7.75 mL/g, WAC of 195.80%, and the pasting properties showed more stable to heat. So, the bleaching using calcium hypochlorite was able to improve the quality of fermented of Awachy 5 sweet potato flour.

ACKNOWLEDGMENT

The author would like to thank the Rector of Universitas Padjadjaran and the Ministry of Research, Technology and Higher Education of the Republic of Indonesia for the Grant. This research/article's publication is supported by the United States Agency for International Development (USAID) through the Sustainable Higher Education Research Alliance (SHERA) Program for Universitas Indonesia's Scientific Modeling, Application, Research and Training for City-centered Innovation and Technology (SMART CITY) Project, Grant #AID-497-A1600004, Sub Grant #IIE-00000078-UI-1.

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