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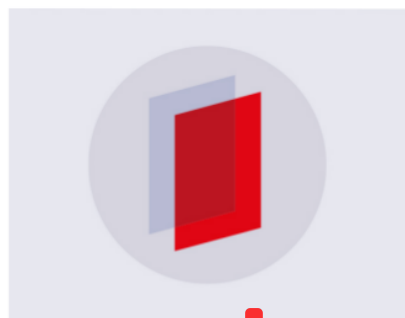
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Gembili (*Dioscorea esculenta*) tube modification via hydrogen peroxide oxidation

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Abstract. *Dioscorea esculenta* or known as gembili in Indonesian is a tuber that can grow easily in almost tropical areas. Gembili is one of the important food sources in the tropical regions. It contains 22.44% carbohydrate which makes it very potential to be developed into tuber flour. This study aims to improve the quality of gembili flour by assessing the effect of several parameters such as oxidation time, the ratio of slurry, and agent concentration on swelling power level. The optimum condition of the oxidation process was at the ratio of slurry 10% with 2% of H₂O₂ concentration and 60 min operation time that presented the swelling power level of 7 (g/g). Therefore, this swelling power of gembili flour complies with American wheat standards.

1. Introduction

Gembili (*Dioscorea esculenta* L.) is one of the important food sources in terms of culture, nutrition and economy for people in the African, the islands of the Caribbean, Asia, and Oceania regions [1]. It contains 21.44% starch which makes it very potential to be developed into tuber flour [2].

The benefits of inulin for the human body are as bifidogenic (to maintain the growth of bifidobacterium in the colon), to stimulate the immune system, and to reduce the risk of osteoporosis. Bioactive compounds in inferior local tubers such as Gembili, have another function as antioxidants which aims to ward off the free radicals in bodies [3]. The advantage of Gembili is that it contains bioactive compounds and dietary fibers such as inulin [4]. Gembili contains high carbohydrate levels and inulin levels of 14.77%, it is higher than the inulin levels from other types of tubers [5].

Flour is one of the intermediate products needed in various food applications. In the food industry, flour is used as the raw material in bread making, breakfast cereals, pasta, sauces, soups, and meat products [6]. Although it has been developed into flour, some weaknesses of the functional properties of Gembili flour are still found which affects to the low quality of the flour produced. Therefore, the improved quality efforts to improve the characteristics of Gembili flour are important, including modifying functional properties.

Flour modification has been done to improve the properties of natural flour so that it is suitable for the desired food application. According to Zhou [7], natural flour has the stability properties on poor heat, low resistance to heating, and easily retrogradation, so modification is needed to overcome these weaknesses, one of which is a chemical modification, the oxidation process. Oxidized flour has low viscosity, high heat stability, low retrogradation, binding capacity, film formation properties, and the clarity that is better than natural flour, so that it can expand its use in various processed food products



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such as cake products, thick soup-making, biodegradable film, and as a binder for confectionary products [8-10].

Tubers modification with oxidation technic was also done in Hidayat J.P research. [11], the tuber used is Ganyong tuber (*Canna*). The variables used in this study are 3, they are the concentration of slurry, the concentration of oxidizer (H_2O_2), and the oxidation time. The variable concentration of slurry used 10%, 20%, and 30%. The oxidizing concentration is 1%, 2%, and 3%. These variables will be analyzed in the swelling power content. The optimum results were obtained at the highest swelling power level of 2.9 at 10% slurry operating conditions, 2% oxidizer concentration and 60 minutes time, it can be concluded that modified Ganyong flour (*Canna*) is not decent as an alternative flour that has a swelling power level between 6.8-7.9. In previous studies, there has never been a modification of Gembili flour by the oxidation process.

2. Method

2.1. Materials

Gembili (*Dioscorea esculenta L.*) were bought from local market in Blora, Indonesia. The flour were obtained by conventional preparation such as slicing, drying and grinding. Demineralized water was obtained from Chemical Engineering Universitas Negeri Semarang Laboratory. Other pro-analyst chemical reagents was bought from Merck.

2.2. Oxidation process

This study was designed using a completely randomized design (CRD) consisting of 3 independent variables such as slurry concentration (10%, 15%, 20%) , hydrogen peroxide (1%, 2%, 3%) and the oxidation time is (20, 40, 60, and 80 minutes.)

Gembili tube flour was oxidized by hydrogen peroxide until reaches the concentration according to the variables. the oxidized flour is washed with distilled water for 4 times and filtered, then dried in an oven at 60°C for approximately 12 hours. The modified flour mashed and sifted with 100 mesh.

2.3. Swelling power analysis

Swelling power of flour were determined by the following methods. The method was conducted by heating a flour-water slurry (0.1 g flour in 10 mL demineralized water) in a reaction tube at 60 /C for 30 min, with constant mixing (Ariyanti, 2013). The slurries was centrifuged at $1600 \times g$ for 15 min in a Superspeed centrifuge. the best swelling power were analysis by thetproximate method.

3. Results and Discussions

3.1. Effect of Oxidation Time

The oxidation time was variated of 20, 40, 60, 80 minutes. With 2% H_2O_2 concentration and 10% Slurry concentration, research with such variables have also studied by Hidayat JP and Munfarida S, (2015). Data results from the research on the effect of time with 2% H_2O_2 concentration and 10% Slurry concentration on swelling power levels are presented in figure 1.

Figure 1 shown that the swelling power level of each oxidation time varies. The oxidation time on swelling power with 2% H_2O_2 concentration and 10% Slurry concentration on 20 minutes the swelling power reached 5.5 g/g; 40 minutes reached 5.7 g/g; 60 minutes reached 7 g/g; and 80 minutes decreased to 6.5 g/g. the optimum oxidation time was 60 minutes.

The oxidation process begins with the formation of Gembili flour hydroxyl (OH) oxidation from the hydrogen peroxide which then cuts the amylose molecular chain bonds first so that it becomes a shorter chain. Amylose concentration in starch can reduce the swelling power level while the high amylopectin concentration can increase swelling power [12]. At the beginning of the oxidation reaction, amylose is more easily hydrolyzed so that amylose depolymerization occurs and triggers swelling power [13]. The polymerization of amylose molecules result in a decrease in the degree of crystallinity and water molecules which can be easily accessed by the amylopectin molecule resulting in increased flour swelling power [11].

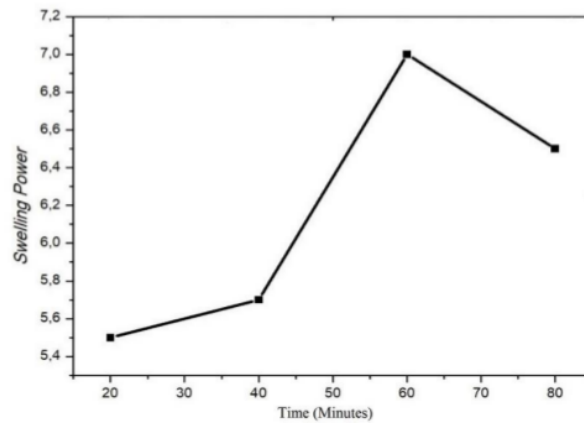


Figure 1. Effect of Oxidation Time on Swelling Power

At more than 60 minutes of oxidation, further depolymerization occurs which causes the amylopectin molecule to be depolymerized. At more than 60 minutes of oxidation, the swelling power level decreases because the amount of hydroxyl radical has been greatly reduced so the reaction is slow. The optimum time for this oxidation process is 60 minutes. The same study was also carried out by Zang et al. [14] who stated that the optimum time of the oxidation process took place in 60 minutes.

3.2. Effect of Slurry Concentration on Swelling Power

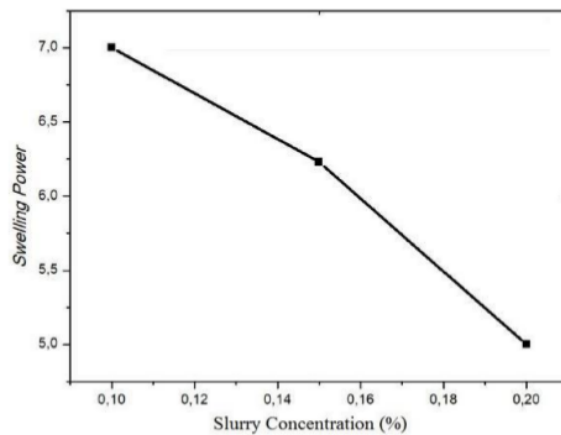


Figure 2. Effect of Slurry concentration on Swelling Power

Figure 3.2, shown the effect of the concentration of slurry on the swelling power level decreases. At 10% slurry concentration swelling power reached at 7 g/g; 15% concentration of slurry decreased to 6.23 g/g, and at a concentration slurry of 20% decreased to 5 g/g. The high and low swelling power depends on the content of amylose and amylopectin. Amylose and amylopectin content in Gambili flour is 20.93% and 79.07% [15]. When the percentage of slurry is low, the swelling power level will be high because amylose can be absorbed maximally. Whereas when the percentage ratio is greater,

the amount of flour increases while the volume of water remains so that the same amount of water cannot dissolve the amylose maximally. The percentage of 10% slurry in this study is the composition that produces the highest swelling power level of the three concentrations which is 7 g/g. 15% and 20% slurry percentages produce a lower swelling power level. The swelling power level will keep decreasing as the increase of slurry percentage [11].

3.3. Effect of hydrogen peroxide Concentration on swelling power.

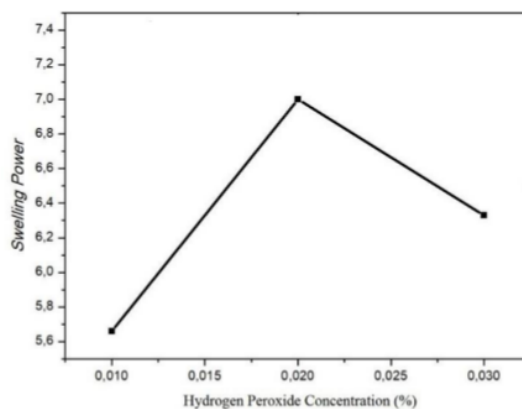


Figure 3. Effect of hydrogen peroxide concentration on swelling power

Figure 3 shown that the swelling power at hydrogen peroxide 1%, 2%, and 3% concentration are 5.66 g/g; 7 g/g; and 6.33 g/g. That generally swelling power in modified Gembili flour increases from 1% to 2%. But then using a 3% concentration has decreased. Theoretically, the swelling power level increases as the increase of H_2O_2 concentration added. The higher concentration of H_2O_2 solution used means more hydroxyl radicals are available in the system, therefore amylose and fat in oxidized flour grains will be less and the starch swelling power will increase [16]. At a 3% H_2O_2 concentration, it decreases due to the occurrence of further oxidation or the conversion of hydroxyl groups from amylose and amylopectin molecules to be carbonyl groups then become carboxyl groups [13]. The carboxyl group is susceptible to the formation of cross-linking. This bond inhibits the absorption of water by amylopectin so that the swelling power tends to be lower [12].

3.4. Nutrient Contents of Modified Gembili Flour Compared to Wheat Flour

The optimum condition of the modified Gembili flour research results was obtained by operating conditions of 10% slurry concentration, 2% of hydrogen peroxide concentration, and in 60 minutes. As it can produce flour with the highest swelling power. The difference between Gembili flour before and after modification can be seen in table 3.1.

Tabel 1. Swelling power

Flour Types	Swelling Power (g/g)
Non-Modified Gembili Flour ^a	3.9
Modified Gembili Flour ^b	7
American Wheat	6.8 – 7.9

Sources: a) Susetyo D (2018), b) this study

On table 1 above it can be concluded that the modified Gembili flour meets American wheat standards. It can be stated that modified Gembili flour is suitable to replace flour. Changes after the modification process also have impacts on the nutritional contents of Gembili flour which can be seen in table 2 below.

Table 2. Nutrient contents of gembili flour and modified gembili flour

Flour Types	Carbohydrat e %	Protein %	Fat %	Moisture %	Ash %
Gembili Flour	83,17	4,2	0,83	7,8	2,28
Modified Gembili Flour	86,27	2,77	0,21	11,61	1,42
National Standard Flour	-	Min 7	-	Max 14,5	Max 7

From the results of the nutrient content test in table 2, it was found that the carbohydrate level increased from 83.17 to 86.27. The carbohydrate content increases because long and complex chains in the starch break which makes carbohydrate concentrations increase [17]. The protein levels dropped from 4.2 to 2.77. Protein levels decrease due to the amino acids that are broken when reacting with hydrogen peroxide or carbonyl compounds [17]. Likewise, the fat and ash dropped from 0.83 and 2.28 to 0.21 and 1.42. Ash content decreases because of the enlargement of the granule structure after oxidation which causes a decrease in the number of small particles such as ash [11]. Fat content decreases because of the damage to the structure during oxidation. The moisture content increased from 7.8 to 11.61. Moisture content increases because of the less optimal in the drying process. From the contents, it was found that the moisture content and ash content compiles with Indonesian National Standard or SNI for flour. However, the protein level still did not meet the standards.

4. Conclusion

The optimum Swelling power level is at 10% slurry concentration in 60 minutes of oxidation time and 2% Hydrogen peroxide concentration. The proximate test results obtained carbohydrate 86.27%, protein 2.77%, fat 0.21%, moisture content 11.61%, and ash 1.42%.

5. Acknowledgement

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