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By GITA INDAH BUDIARTI

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G I Budiarti* and E Sulistiawati

Department of Chemical Engineering, Faculty of Industrial Technology, Universitas Ahmad Dahlan, Yogyakarta, 55191 Indonesia

*gita.indah@che.uad.ac.id

Abstract. Potato may be used as a substitute to wheat which cannot be grown in the tropics. However, potato flour has characteristic physicochemical limitation compared with wheat flour. Potato limitation can be reduced by modification starch. Hydrogen rich water is water that contains antioxidants. It has only been used in the health sector as an anticancer and anti-inflammatory. The antioxidant content in hydrogen rich water can be used for modification of potato starch which is safer than using chemicals. This study examined whether hydrogen-rich water can improve the physicochemical characteristic of potato flour as a substitute for wheat flour. We used a variation of soaking time in hydrogen-rich water (1,2,3,4 hours) and drying method (oven and UV). We found, physicochemical characteristic (water content, swelling power, and reducing sugars) better than wheat if soaked for 3 hours with UV drying method. So, modified potato flour using hydrogen-rich water can be considered as a substitute for wheat.

1. Introduction

Wheat demand increased every year. Indonesia, one of the country the most consume wheat in the world. Wheat mostly used for the food industry, such as bread and noodles with a composition of 25% for bread production, 20% instant noodles, 30% wet noodles and 25% for other [1]. Wheat is a subtropical plant which is currently only able to be planted in the Indonesian highlands, an area that has commercially developed tropical wheat is Pasuruan Regency in East Java and Manggarai Regency in NTT, but productivity per land area has not been optimal, ranging from 3-4 tons/ha. Wheat demand in Indonesia is not met with the domestic production wheat.

Potatoes is one of the tubers abundant in Indonesia. According to data from the Badan Pusat Statistik and Direktorat Jendral Hortikultura in 2015 [2] potato production in Indonesia amounted to 1.2 million tons. Potato production in Indonesia per year over the past five years is 1.1 million tons/year. The data showed potato flour used as an alternative ingredie4 for wheat flour because it included high carbohydrates, protein, fiber, vitamins, and minerals. Potato flour contains phytochemicals such as polyphenols and flavonoids known as antioxidants, anticancer, and anti-hypertension [3,4] [Ratnayake]. Based on the advantage of potato, it is potentially for wheat substitute. Potato flour is gluten free, so it's safe for diabetics [5].

The disadvantage of potato flour is the physicochemical lower than wheat. It is caused potato flours cannot expanse well. Thus, it is must be improved with modification physically or chemically [4]. Several of previous research modification are Yadav, et al. investigated characteristic with acetylated and enzyme-modified potato flour [6]. Sun et al. modified potato flour by heat-moisture treatment,

modification with heat [7]. Lack method of the swelling power of enzyme modification is lower than native potatoes. Besides, the price of enzymes is higher. Then heat modification obtains the highest swelling power at 95°C. It will break protein or other nutritional content on potato flour. Therefore, we need to look for other methods that do not damage potato nutrition and are inexpensive.

Hydrogen-rich water is water-like zam-zam water. Hydrogen gas is a gas that has high antioxidant, is non-toxic and inexpensive [8]. The other advantages are being able to become anti-inflammatory and antioxidants [9,10]. Today the use of hydrogen rich water is limited to the health and several for agricultural sector, not yet applied to food, especially starch modification. This study tried to modify potato flour u6hydrogen-rich water for find the safe and cheaper method starch modification.

The focus of this research is to investigate the physicochemical characteristic of potato flour, such as water content, swelling power, and reducing sugars. The physicochemical properties are one of the parameters that can show the quality of flour, so we can know the comparison of modified potato starch with wheat flour.

2. Material and method

2.1. Material

The materials used in this study include the main ingredients of potatoes from the traditional market of Yogyakarta and Hydrogen Rich Water pH 9 made using electrolysis equipment (Leveluk SD501).

2.2. Sample preparation

Potatoes cleaned first, then peeled and then cut to (2 mm thick. Then the potato slices soaked Hydrogen Rich Water pH 9 as much as 100 mL with variations of time 1, 2, 3, 4 hours. Then the sample was dried using an oven (Memmert, Germany) and sunlight. After drying the sample was blended and sieved sized 80 mesh (MBT S180201501).

2.3. Water content analysis

Water content analysis refers to the use of a moisturizing test (HoldPeak HP-7032G). The tool indicator was inserted into the sample, and then the tool showed the sample water content value.

2.4. Reducing sugar analysis

The dried potato flour is taken 0.1 g and dissolved in 10 ml the aquadest. Then the solution is heated using a water bath (Memmert, Germany) with a temperature of 60oC for 30 minutes. The supernatant was separated using a centrifuge (Gemmy Industrial Corp., Taiwan) at 2500 rpm for 15 minutes.

2.5. Swelling power

Swelling power was analyzed by Waterschoot Method [11]. A number of starch suspension was heated at 95°C for 30 min. Then it was cooled in water bath and centrifuged for 30 min. Number of swelling power was calculated by sediment weight divided by dry matter starch weight.

2.6. Statistical analysis

The data obtained was analyzed by Completely Randomized Design (CRD) with three replications. As the treatment is the soaking time 1,2,3 and 4 hours. To test whether or not there is a difference between treatments using ANOVA with a significance level of 5%.

3. Result and discussion

3.1. Water content

The result of moisture content of modified potato starch was presented in table 1.

Table 1. Effect of soaking time hydrogen rich water on water content.

Soaking Time (hours)	Water Content (%)
0 (control)	11,5(0,61)
1	10 (0,61)
2	10(0,61)
3	10,5(0,61)
4	10,5(0,61)

In table 1, it can be seen that the water content tends to be constant only decreasing from 11.5% to 10.5%. It caused by the flour drying process. Conventional flour is dried using sunlight (UV) while modified flour uses an oven at 60°C for 8 hours. The erratic intensity of sunlight results in an extended drying process. Comparison of modified flour with oven and UV drying was presented in table 2.

Table 2. Effect of variation drying method on water content.

Drying Method	Water Content (%)
UV	12(0,75)
Oven	10,5(0,75)

The best water content was obtained by oven drying. The relationship between HRW soaking time was shown from the results of ANOVA analysis with a real difference of 5%. The ANOVA results obtained $p > 0.05$, and it shows that the soaking time affects the moisture content of potato flour. The result was because the longer the soaking time, the more Hydrogen Rich Water (HRW) molecules are absorbed in potato starch granules. Water content was a determinant of the durability of a flour. The less water content in the flour, the longer the storing capacity of the flour [8]. The standard of water content values allowed by SNI 3751: 2009 concerning the quality of flour for food ingredients is 14.5%. Modified starch flour meets the water content standards allowed by SNI. One that affects the quality of flour is how it is drained. the results obtained indicate a difference in the UV dryer with an oven [12]. The moisture content in flour with UV dryer is higher than oven dryer because UV dryer is more difficult to regulate the temperature, it only depends on the intensity of sunlight.

3.2. Reducing sugar

The results of the study of the influence soaking time of Hydrogen-Rich Water (HRW) on reducing sugar or potato flour can be seen in table 3.

Table 3. Effect of soaking time hydrogen rich water on reducing sugar.

Soaking Time (hours)	Reducing sugars (%)
0 (control)	23,89(6,36)
1	24,33 (6,36)
2	27,16(6,36)
3	37,39 (6,36)
4	20,91 (6,36)

Table 3 showed that the most significant reducing sugar obtained in soaking time 3 hours, 37.40%. Reduced sugar content with HRW soaking time treatment was higher than the control variable at 23.90%. The results showed that the longer the soaking time, the reducing sugar also increased. However, at 4 hours soaking time, flour modification experienced a non-significant decrease. The best-reducing sugar was obtained by UV drying of 48.05% (table 4).

Table 4. Effect of variation drying method on reducing sugar.

Drying Method	Reducing sugars (%)
UV	37,39(11,34)
Oven	48,05(11,34)

Reduced sugar value of modified potato flour is higher than wheat flour which is 47.56%. Reducing sugar is sugar which can reduce other compounds because it has a hydroxyl group. The increase in reducing sugars shows the increasing number of amylose starch groups which are cut off and overhauled into monosaccharide groups [13,14]. The longer contact time between hydrogen rich water and starch causes a lot of hydrogen to enter the starch granules. This causes the starch to become acidic so that the reducing sugar rises. In addition, an increase in temperature also causes an increase in reducing sugars [15].

3.3. Swelling power

Swelling power is a property that determines the level of volume increase and the maximum weight experienced by starch in water [1]. The highest swelling power was obtained at 3 hours soaking time of 4.52 g / g (table 5).

Table 5. Effect of soaking time hydrogen rich water on swelling power.

Soaking Time (hours)	Swelling Power (g/g)
0 (control)	4,32(0,87)
1	3,75(0,87)
2	2,4(0,87)
3	4,52(0,87)
4	4,38(0,87)

Potato starch consists of amylose (21–27%) and amylopectin (73–79%) [16]. Swelling power value is influenced by amylose as one of the constituent components of starch, a decrease in the amount of amylose causes swelling power to increase [11,14]. At 1 hour of soaking time, swelling power decreased from 4.32 g / g to 3.75 g / g. However, the 2-hour soaking time decreased from 3.75 g / g to 2.4 g / g. It was because many amyloses had not been dissolved. At 3 hours of soaking time, there is an increase, which is 4.53 g / g. Optimal soaking is 3 hours repeated, then dried with a UV dryer for 12 hours (Table 6).

Table 6. Effect of variation drying method on swelling power.

Drying Method	Swelling Power (g/g)
UV	4,65(0,16)
Oven	4,52(0,16)

The swelling power of modified potato flour with UV drying was 4.62 g / g. This value is higher than the modified flour with an oven dryer. Swelling power of potato flour control was more significant than wheat which was 4.32 g / g. Research on modification of potato flour is alkaline with HRW pH 9. Modification of flour in an alkaline atmosphere with Hydrogen Rich Water has been done previously in pumpkin flour. The alkaline situation causes the amylose content to be challenging to split and causes a decrease in swelling power value in modified potato flour [17].

4. Conclusion

Based on the result, we concluded the physicochemical characteristic of modified potato flour that has been done is obtained by the results of swelling power, reducing sugar and maximum moisture content at soaking time of 3 hours with an oven dryer of 4.53 g / g, 47.56%, 10.5%. Based on this research, hydrogen-rich water recommended for the modification starch method. The physicochemical result showed that potato flour modified recommended for wheat substitution.

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