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Modification of Kimpul Flour Using Hydrogen Rich Water for Wheat Substitution

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Abstract. Wheat flour is one of the carbohydrate ingredients for making noodles, bread, cakes and fried foods that are popular with Indonesian people. The need for flour in Indonesia is still met from imports. Therefore, alternative flour raw materials are needed to reduce imports of wheat flour. Kimpul is an abundant tuber in Indonesia. Kimpul has anticancer content, but kimpul flour has a weakness, namely the starch structure is not like wheat. To improve the quality of kimpul flour, it is necessary to modify starch. Hydrogen Rich Water (HRW) can be used as an ingredient for starch modification. The advantages of HRW compared to other modifications are that it is safer, cheaper and contains antioxidants. The purpose of this study was to create and find the optimal formulation of a mixture of modified HRW kimpul flour and wheat flour to make bread. The method used is to modify kimpul flour using HRW with variable soaking time (15,30,45,60, 75 minutes), drying temperature (100, 110,120°C), pH (3,6,7,9,11). The samples were then analyzed for moisture content and appearance test with flour SNI parameters. The best results were analyzed by FTIR and used to make bread. The results obtained that the optimal water content at 45 minutes of immersion at 100°C pH 7 was 6.9%. FTIR analysis showed that there was no significant difference in the content of wheat flour, original kimpul and modified kimpul. The best bread puffiness test was obtained at the composition of 70% flour: 30% kimpul with a swelling height of 7.5 cm. The composition of this sponge cake is also preferred by the panelists.

INTRODUCTION

Indonesia relies on imports to meet its wheat needs. Since 2018, Indonesia has become the world's largest importer of wheat with a total of 10,096,299 million tons. This represents 6.1% of the total world imports [1]. Indonesia's position as a wheat importer is unlikely to change due to the rapid consumption of domestic needs for wheat for both people and livestock. It is estimated that Indonesia will need around 11.3 million tons of wheat from the global market in the 2019-2020 period [2].

Kimpul (Xanthosoma sagittifolium) is a food source of tubers that contain carbohydrates, proteins, fats, several minerals and vitamins $[3-5]$. In Indonesia, kimpul has been widely planted including North Sumatra, South Sumatra, East Kalimantan, North Sulawesi, West Nusa Tenggara, West Java, and East Java. Data on the production of kimpul in Indonesia in 2013 was around 825 tons, which was obtained from an area of 55 ha spread over 7 districts/cities [6].

Tuber kimpul has the potential to be developed as a source of carbohydrates that can support Indonesia's national food security. Kimpul is one source of local food that can be used as an alternative to meet food needs [7]. Kimpul flour can be used as a substitute for wheat flour. The use of kimpul flour in the processing of various cakes can reach

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100%, depending on the product to be produced [8,9]. The water pressure against the cell wall increases so that the needle-shaped calcium oxalate crystals are pushed out, the oxalate level during immersion will continue to decrease due to the ongoing osmosis event so that calcium oxalate will come out [5,8]. Calcium oxalate levels in kimpul can be reduced by processing kimpul, one of which is produced into flour.

Kimpul flour can be used as a substitute for wheat flour. The use of kimpul flour in the processing of various cakes can reach 100%, depending on the product to be produced [9,10]. Making kimpul flour by immersion aims to increase the economic value, functional kimpul and most importantly to reduce oxalate levels in kimpul and solve problems, namely the color of kimpul flour which is considered less bright and the aroma tends to be unpleasant. If kimpul flour without soaking is applied to food products, it will affect the physical appearance and aroma of the product, especially the color of the product that is less attractive and the aroma of the product is less pleasant [8,11].

Hydrogen rich water is used to modify kimpul starch and improve the quality of kimpul flour. Hydrogen rich water is alkaline water that can prevent oxidation, so the color becomes brighter [12]. Mixing or formulating wheat flour with modified kimpul flour will add flavor and reduce unpleasant odors in kimpul flour. Based on these problems, it is necessary to find the right formulation for the immersion time, drying temperature and the comparison of the composition of the substitution of kimpul flour and flour to produce sponge cake.

MATERIAL AND METHOD

The main ingredients used in this research are kimpul tubers and hydrogen rich water. The research procedure is as follows:

- Raw Material Preparation Stage
  Prepare 2.5 kg of tuber kimpul then start from stripping and slicing, then soaking time with alkaline water (15, 30, 45, 60, and 75) minutes and pH variation (3,6,7,9,11)
- Drying and milling stage
  The tubers that had undergone the immersion stage with salt solution and washed after that the tuber samples were put into the dryer (oven) at temperatures of 100, 110, and 120 with drying times 4, 3, and 2 hours respectively.
- Results Analysis
  The analysis was carried out in the form of Fourier Transform Infra Red (FTIR) Spectroscopy analysis, water content analysis using the thermogravimetric method, and a preference test for sponge bread making applications.

RESULT AND DISCUSSION

FTIR Analysis

Result of FTIR analysis shown in Figure 1 Waved number used to identify functional groups range of 4000-400 cm^{-1}. The results of the FTIR analysis of the structure of kimpul flour without modification, modification and wheat flour are amorphous crystals. This happens because the FTIR analysis does not show a sharp peak. Kimpul flour without modification shows a valley at a wavelength of 34281 cm^{-1}, in modified kimpul flour the wavelength is 3435.55 cm^{-1} while in wheat flour 3434.98 cm^{-1}. The wavelength at this point indicates the presence of an OH bond of about 3383 cm^{-1}. The OH bond after modification is almost close to that of flour. The next bond is carbohydrate, theoretically around 1040-1111 cm^{-1} [13]. This may be due to the immersion of hydrogen rich water which adds an OH group to the modified kimpul flour. In this study, it was found in kimpul without modification 1083.42-1159.06 cm^{-1}, in modified kimpul flour 1083.19-1158.27 cm^{-1}, in flour 1083.60-1158.99 cm^{-1}. There was a decrease in the carbohydrate bond in the modified flour. This may be due to the carbohydrate bonds turning into hydrogen (OH) bonds. The theoretical C-H bond is obtained at approximately the wavelength 2928 cm^{-1} [13]. In this study, the results obtained from kimpul to flour were 2931.30 cm-1, 2931.58 cm^{-1}, and 2929.49 cm^{-1}. From these results it can be seen that the modification does not change the C-H bond too much. The C=O bond is obtained at approximately the wavelength of 1412 cm^{-1} [13]. The results obtained for the original, modified and flour kimpul were 1371. cm^{-1}, 1376 cm^{-1}, and 1458.96 cm^{-1}. The change for the C=O group was not very significant with the modification.

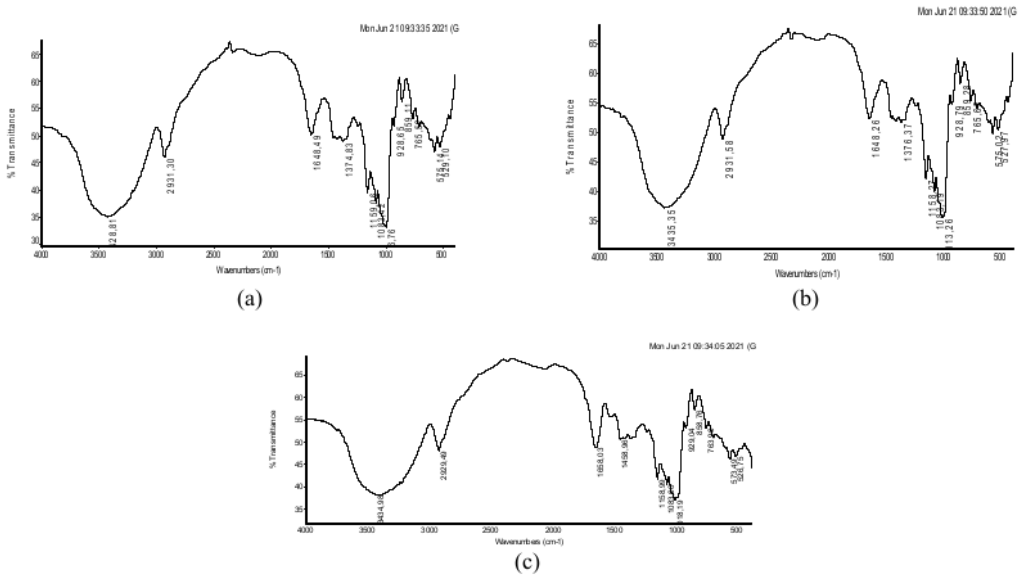

FIGURE 1. (a) FTIR result of Kimpul flour without modification. (b) Kimpul flour with modification. (c) Wheat flour

Moisture Content Test

The results of the water content analysis are shown in Figure 2-4. The variables used are pH, drying temperature, drying time and immersion time with hydrogen rich water. The results of the water content test at a temperature of 100ºC and a drying time of 4 hours are presented in Figure 2. In Fig. 2 it can be seen that the value of the water content meets the allowed SNI standard for wheat flour, which is a maximum of 14%. Calculation of water content using a dry basis. The water content obtained for each pH is as follows: for pH 3 between 8.2%-11.6%; pH 6 range of water content 8.3%-11.3%; pH 7 5.9%-12.5%; pH 9 8%-10.9%; pH 11 7.5%-8.9%. The moisture content obtained at a temperature of 110ºC with a drying time of 3 hours at each pH was as follows: pH 3 8.2%-10.6%; pH 6 8.7%-11.4%; pH 7 6.3%-9.4%; pH 9 8.2%-11.9%; pH 11 6%-8.3%. At a temperature of 120ºC with a drying time of 2 hours, the moisture content for pH 3 is 5.9%-8.1%; pH 6 7.9%-10.9%; pH 7 5.5%-9.8%; pH 9 7.7%-10%; pH 11 4.8%-9.10%.

The soaking time of hydrogen rich water affects the level of water content in flour, the longer the soaking time, the higher the water content, but there are some points that are not suitable, such as at pH 7 the lowest water content value is obtained at a time of immersion of 60 minutes. Of all the variables the lowest water content value was obtained at pH 7 at all temperatures. The water content in the kimpul flour samples showed different results. This was due to the influence of dietary fiber in it. The fiber has a strong water binding ability so it is difficult to re-evaporate even with the drying process [14]. In addition to fiber, the physiological properties of dietary fiber have the ability to bind water in the material, the bound water is difficult to evaporate again. The water content in foodstuffs also determines the freshness and durability of these ingredients. To extend the durability of the material, some of the water in the material must be removed in a way that is suitable for the type of material, such as drying. Drying of flour has the aim of reducing its water content to a certain extent so that microbial growth and enzyme activity that causes damage to flour can be inhibited[15,16].

The lowest moisture content is 120ºC with a drying time of 2 hours. But, the optimal temperature to obtain at pH 7, temperature 100ºC, soaking time 45 minutes. This is because at pH 7 and temperature 100ºC, relative constant. The higher temperature can cause damage for nutrition in food. The lowest water content is the optimal water content for storage of foodstuffs such as flour. Materials that have a high water content usually rot faster than

materials with a low water content, due to the activity of microorganisms. The minimum water content limit where microbes can still grow is 14% [17,18].

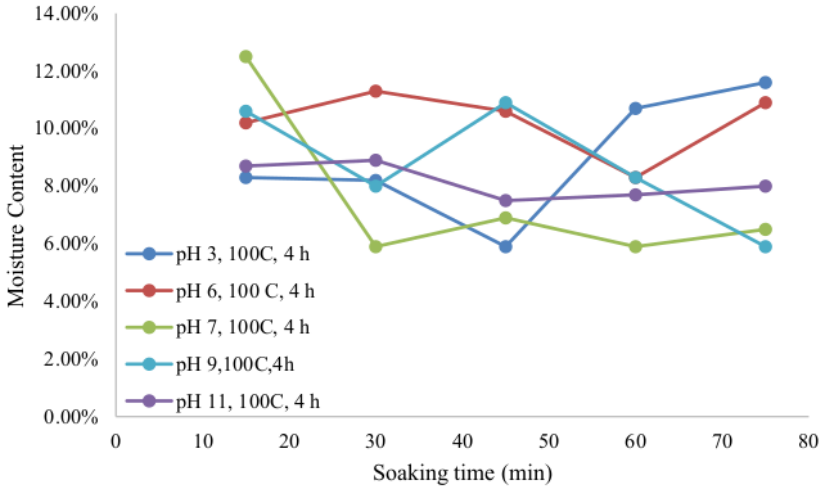

Figure 2. Moisture Content at Variation pH and Soaking Time in Temperature 100ºC, drying time 4 hours

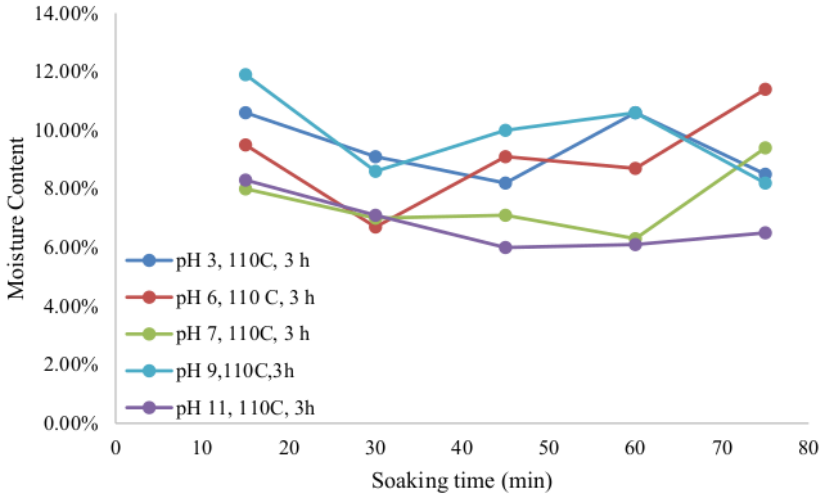

Figure 3. Moisture Content at Variation pH and Soaking Time in Temperature 110ºC, drying time 3 hours

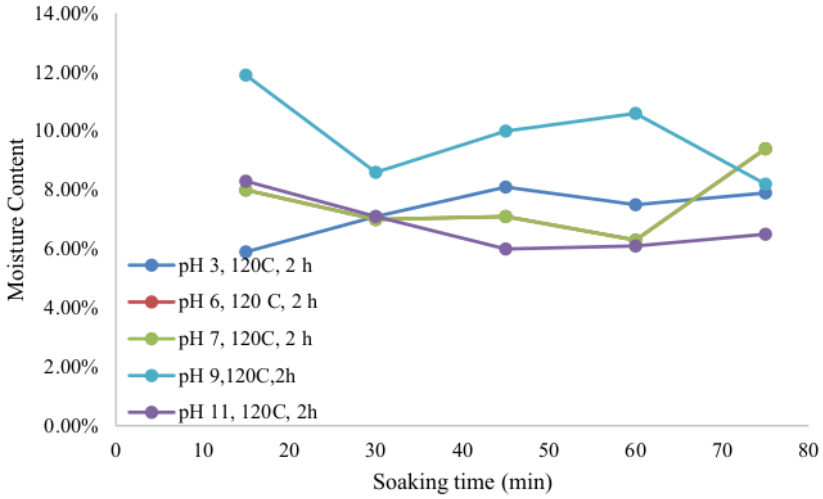

Figure 4. Moisture Content at Variation pH and Soaking Time in Temperature 120ºC, drying time 2 hours

Acceptance Test of Kimpul Flour in Sponge production

Kimpul flour is processed into bread at a temperature of 200°C and 40 minutes, the kimpul flour used is kimpul flour with the highest yield data, namely flour with a pH of 7, soaking time of 45 minutes and drying temperature of 100°C of 38.67%. The acceptability test of kimpul flour in bread making includes development test, taste test, color test, aroma and texture test. Making bread from kimpul flour is divided into 4 samples, namely A = Wheat Flour 70% : 30% Flour Kimpul, B = Wheat Flour 50% : 50% Flour Kimpul, C = Wheat Flour 30% : 70% Flour Kimpul, D = Flour 100% Flour (Control).

The development process on sponge bread can be influenced by several things, namely the raw material, the process of forming the dough and the length of time for fermentation. The use of wheat flour as a raw material in making bread can produce a good level of development as an indicator of the quality of sponge bread, this is because wheat flour contains gluten which is needed in making sponge bread in order to produce good development of the dough [19].

The results of the research carried out for development level data were obtained by taking a straight line from the bottom of the cake to the very top, observations were made after the roasting process, because during the fermentation process the bread development rate increased and will last until the baking process. The results of calculations using centimeter units show that each sample has a different level of development, namely Treatment A (70% : 30%) with a development rate of 7.5 cm, Sample B (50%: 50%) with a development rate of 7 cm, sample C (30%) : 70%) development level of 6 cm and Sample D as control with 100% wheat flour formulation, had the highest development rate of 8.5 cm.

Based on data obtained, the highest level of development is found in sample D with 100% substitution and the lowest level of development is in sample C with mixed substitution of 70%: 30%. Based on these results, it can be seen that the more use of kimpul flour as a substitute, the level of bread development decreases, this is because wheat flour has a high gluten content, while kimpul flour does not contain gluten, so the results of the analysis can be seen that the use of kimpul flour as a substitute material, affects the level of bread development because the absence of gluten in kimpul flour can indirectly inhibit the development process.

Taste test, texture test and color test were tested by 4 respondents with 4 samples. Taste, texture and color are important things that consumers consider when choosing food. Although the taste is good but the color is not attractive, consumers will tend to like the food less [20]. Respondents are required to give a value to the 4 samples that we have provided with each sample consisting of A = Wheat Flour 70% : 30% Flour Kimpul, B = Wheat Flour 50% : 50% Flour Kimpul, C = Wheat Flour 30% : 70% Kimpul Flour, D = 100% Wheat Flour (Control). Based on the bread acceptance test that we have done, we get the following assessments from the respondents:

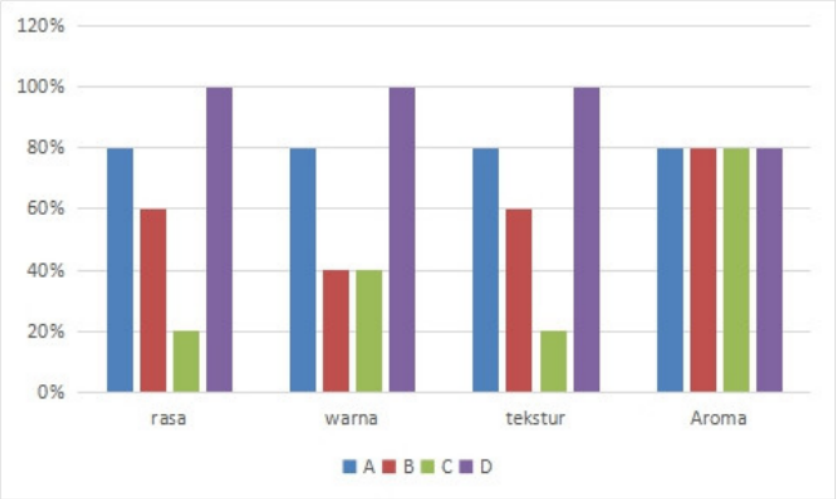

Figure 5. Test Results for Sponge Cake Preference Level

In our research, it can be concluded that the application of kimpul flour in bread making, there are differences in aspects of texture, taste, color. As for the aroma aspect, there is no difference. The addition of kimpul flour apparently affects the taste and texture as well as the color of the bread. Where bread is one of the people's favorite food.

CONCLUSION

Based on the research that has been done, it can be concluded that the best moisture content is obtained at pH 7, temperature 100 C, drying time 45 minutes at 6.9%. The FTIR results indicated the presence of carbohydrate groups, functional groups OH, C=O and CH in the modified knots that were close to the peak value of wheat. The composition of 70:30 wheat compared kimpul flour modification on sponge cake is preferred by panelist.

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