

Effects of Modified Taro Flour by Heat Moisture Treatment Substitution on Dietary Fiber, Glycemic Index, and Elongation of Pasta

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Abstract. Tubers are a high-carbohydrate local food commodity with great potential to be turned into flour and processed into various food products, such as pasta. One type of tuber that can produce functional pasta products is taro. Taro has a high fiber content and a low glycemic index, making it safer for individuals with Diabetes Mellitus (DM) compared to commercial pasta available in the market. However, taro flour needs to be physically modified using the Heat Moisture Treatment (HMT) technique to improve its characteristics and enhance its functional value. HMT can reduce swelling power and solubility while producing a stable texture, thus optimizing the physicochemical characteristics of starch and making it suitable as a pasta raw material. Furthermore, HMT treatment can also increase Slowly Digestible Starch (SDS) and Resistant Starch (RS), resulting in a lower glycemic index. This research aims to produce high-fiber and low-glycemic index pasta. In this study, a comparison was made between pasta with modified HMT taro flour substitution, 100% semolina-based control pasta, and commercial pasta. The variables analyzed in this product are fiber content, glycemic index, and elongation. This research is expected to yield functional pasta products that are high in dietary fiber and have a low glycemic index, serving as a functional food alternative for individuals with DM based on local food sources. Pasta with 30% taro flour substitution contains a total dietary fiber content of 4.49%; glycemic index 22.39; and an extension of 20.17%.

1 Introduction

Pasta is a product made from semolina or durum wheat flour or other wheat or their mixture as the main raw material, with or without the addition of other food ingredients and food additives [1]. Pasta can be made with a mixture of other flours sourced from tuber commodities, one of which is taro (*Colocasia esculenta*).

Successfully formulated taro flour-based pasta as one of the basic ingredients [2]. However, the protein content in tuber flour is not as high as wheat flour so that it has weaknesses in functional properties. The pasta and noodle products produced are less elastic than wheat flour-based products [3]. In addition, some of the weaknesses of native starch

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include too sticky, lack of viscosity, and not resistant to heat and mechanical treatment [4], while pasta processing requires heat and mechanical treatment [5]. Therefore, it is necessary to modify tuber flour to obtain better characteristics, one of which is the physical modification method which tends to be safer, because it does not use chemical reagents that can leave residues in the modified flour [6].

Heat Moisture Treatment (HMT) is one of the physical starch modification methods that can be applied to tuber flour. HMT treatment is able to change the structure of starch granules so as to provide changes in the properties and physical characteristics of starch [7]. HMT modification affects the characteristics that are able to improve the characteristics of the paste, namely making the material more durable, increasing heat resistance, can maintain the functional properties of starch related to antioxidant content, reducing swelling power, reducing solubility, and producing firm texture stability so that the physicochemical characteristics of starch become more optimal and can be used as raw material for various processed food products [8]. Pranoto et al. The ideal starch characteristics for making pasta-like products, namely noodles, are starches that have high amylose, limited swelling and have type C amylography patterns, namely low peak viscosity, low breakdown viscosity, low final viscosity and high setback viscosity [9]. The HMT process proved to be able to change the starch of chimp taro from type B to type C [10]. Thus, starch modification using the HMT method has the potential to modify the characteristics of flour in accordance with the characteristics required in pasta making. In addition, crystalline starch type C has characteristics that are slow to digest. This is supported by the statement, that after HMT treatment, there is a decrease in Rapidly Digestible Starch (RDS) and an increase in Slowly Digestible Starch (SDS) and Resistant Starch (RS) compared to natural starch without modification [11]. SDS produces a slow release of glucose in the blood, a low glycemic response and is fully digested in the small intestine at a lower level compared to RDS [12]. The starch modification process can increase the resistant starch content and reduce the IG of rice starch. Resistant starch content is known to reduce blood sugar content, increase body weight in diabetic mice, reduce organ index, total cholesterol, and total triacylglycerol and can increase HDL-cholesterol levels. In obese mice, resistant starch effectively reduces weight gain and has a hypocholesterolemic effect [13].

This research was conducted as an effort to optimize the use of taro tubers through the development of local food-based pasta products accompanied by the application of HMT starch modification methods to produce good product characteristics so that they can be accepted by consumers. The purpose of this study was to determine the effect of flour type and proportion of substitute flour on physicochemical and sensory characteristics, and to determine the best treatment combination based on sensory testing data.

2 Method

This research was conducted in Integrated Laboratory II and Agricultural Technology Laboratory, Universitas Jenderal Soedirman, from November 2022 to May 2023. The materials used in this research were semolina flour, yellow uwi flour, taro flour, eggs, sunflower oil, salt, water, and chemicals.

2.1 Research stage 1 modification of taro and yellow uwi tuber flour and characterization of HMT-modified flour

The physical modification stage of taro and yellow uwi flour uses the Heat Moisture Treatment (HMT) method by modifying the method [10], which begins with conditioning the modified flour until its moisture content reaches 30% by spraying distilled water. The

amount of distilled water sprayed is determined based on mass balance calculations, with the following calculation formula:

$$(100\% - IM1) \times SW1 = (100\% - DM2) \times SW2 \tag{1}$$

Description:

IM1 = Initial condition starch moisture content

DM2 = Desired starch moisture content

SW1 = Starch weight at initial condition

SW2 = Starch weight after reaching KA2

Amount of distilled water = SW2 - SW1

Next, flour that has reached 30% moisture content is stirred until evenly distributed, then modified by sieving 60 mesh to evenly distribute the sprayed water. Next, the flour is placed in a container, then covered with aluminum foil until tight. The flour was allowed to stand in a refrigerator at 4°C for 12 hours to homogenize the water content. The pan containing the flour was heated in an oven at 110°C for 10 hours while stirring occasionally to homogenize the heat distribution. Next, the flour was cooled and dried for 8 hours at 60°C. After that, 80 mesh sieving to homogenize the particle size [14], then characterization of the physicochemical characteristics of modified tuber flour was carried out.

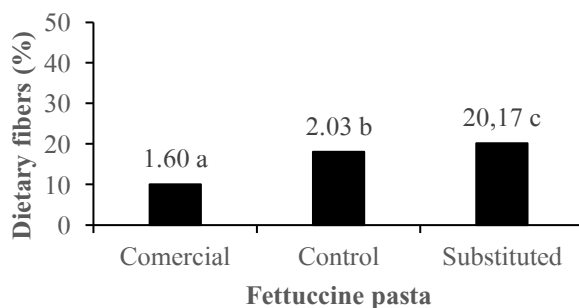
2.2 Stage 2 research of paste making

The preparation of fettucini pasta was carried out by modifying the method [15], which begins with mixing 210 grams of semolina flour with 75 grams of water, 75 grams of eggs, 6 grams of salt, and 9 grams of sunflower oil until evenly mixed and homogeneous. After that, 90 grams of HMT modified taro flour was added. Next, the dough was kneaded until mixed and ground 2 times using a meat grinder to increase its homogeneity and cohesion bond. Once homogeneous, the dough is wrapped in plastic wrap to rest for 30 minutes to make the dough more smooth and elastic. The dough is then thinned using a rolling pin and continued using a pasta grinder. Then, the dough is shaped to the same size using a pasta cutter. After that, the obtained fettucini pasta samples were stored in an hermetic container at frozen condition for further analysis.

3 RESULTS AND DISCUSSIONS

3.1 Dietary fiber

Dietary fiber content consists of insoluble, soluble, and total dietary fiber content, which is the accumulation of insoluble and soluble dietary fiber. The fiber content contained in commercial, control, and substituted pastas are presented in Figure 1.



Notes: Different letters indicate significant differences based on BNT test.

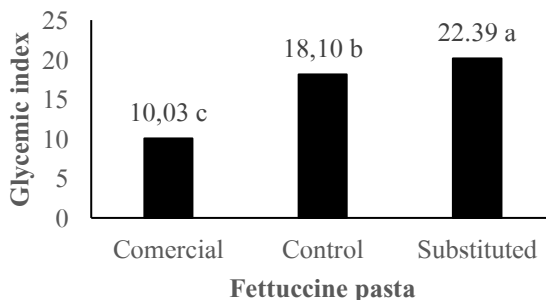
Fig. 1. Dietary fiber content of commercial control, and substituted pastas

The results of the analysis of variance and the Least Significant Difference (BNT) test in Figure 1. show that commercial pasta, control pasta, and pasta with 30% HMT-modified taro flour substitution which is the best treatment combination based on sensory characteristics, have significantly different average levels of insoluble dietary fiber, soluble dietary fiber, and total dietary fiber. Commercial pasta has the lowest levels of insoluble, soluble, and total dietary fiber compared to the control pasta sample and pasta with taro flour substitution, which are 1.56%; 0.05%; and 1.60%. Meanwhile, substituted pasta has the highest dietary fiber content compared to commercial samples and control samples, which are 4.34%; 0.14%; and 4.49%. This shows that the substitution of HMT-modified taro flour greatly affects the increase in dietary fiber content of pasta.

Total dietary fiber is the sum of insoluble and soluble fiber content. Based on Figure 1, pasta with 30% HMT-modified taro flour substitution has a total dietary fiber content of 4.49%; which is more than double the total dietary fiber content of commercial pasta (1.60%) and control pasta (2.03%). This is due to differences in the composition of the product constituents that determine how much food fiber content is contained. The composition of commercial pasta is only made from semolina flour and water which is then processed by the extrusion method. Meanwhile, the control sample and the substituted sample were made with the addition of eggs. Another thing that is suspected to cause the food fiber content of substituted pasta to be much higher than the commercial and control samples is the substitution of taro flour as much as 30% of the total flour used. Taro is one of the tuber commodities that contains high fiber [16]. In 100 grams of taro, there are 4.1 grams of dietary fiber [17]. Meanwhile, the results of research by [16], showed that the food fiber content of taro flour dried at 60°C was around 14 grams per 100 grams of taro flour. The high content of food fiber in taro results in pasta with modified taro flour substitution containing much higher food fiber content than commercial and control pasta.

3.2 Glycemic Index

The glycemic index (GI) is a description of the relationship between the carbohydrates contained in a product and the blood sugar response. The glycemic index can assess how quickly the starch in a product is digested and converted into blood sugar. Each product has a different digestibility, known through the glycemic index (GI) value approach.



Notes: Different letters indicate significant differences based on BNT test.

Fig. 2. Glycemic index values of commercial control, and substituted pastas

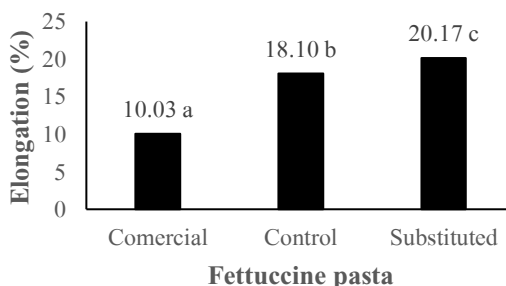
The results of the Least Significant Difference (BNT) test in Figure 2, show that there are significant differences in the glycemic index values of pasta with 30% HMT-modified taro flour substitution, control pasta, and commercial pasta. All three samples have a glycemic index that falls into the low category, which is below 55. However, substituted pasta has the lowest glycemic index, which is 22.39. The high and low glycemic index of a product can be classified based on the speed of digestion and absorption of glucose, as well as the effect on fluctuations in blood glucose levels. The higher or faster the digestibility of a starch, the more glucose is produced, causing an increase in blood glucose levels [18]. Food that has a low glycemic index will be digested more slowly, so the rate of emptying the stomach will last for a longer time [19].

Many factors influence the glycemic index value of a product. Among them are food fiber content, amylose and amylopectin content, as well as protein and fat content. In accordance with the data from this study, substituted pasta has a much higher food fiber content than the control and commercial pasta, while the glycemic index value contained is much higher than the control and commercial pasta made from 100% semolina flour. Fiber in its whole form has the ability to act as a physical inhibitor in digestion, so it can slow down the rate of food in the digestive tract and inhibit enzyme activity [19]. As a result, the digestive process, especially the breakdown of starch, becomes slower so that the blood glucose response will be lower.

In addition, the ratio of amylose and amylopectin content in a product also affects the glycemic index of the product. Foods with high amylose and low amylopectin tend to have low glycemic index values. Vice versa, foods with high amylopectin and low amylose tend to have a high glycemic index value. This is because amylopectin has molecules that are easily gelatinized and easily digested [20]. Meanwhile, high amylose content greatly affects changes in hydrogen bond strength so that starch requires greater energy for gelatinization [19]. This is supported by various research results, showing that foods that have a higher proportion of amylose than amylopectin have a lower GI value, and vice versa.

3.3 Elongation

The elongation value indicates the maximum elongation of the product under tension before the noodle breaks. The higher the elongation value, the better the quality of the pasta because it is elastic, does not break easily and when rehydrated does not crumble easily. After analysis of variance, it is known that there is a significant difference in the elongation value of the pasta, control, and commercial pastas. The BNT test results and elongation values of each sample are listed in Figure 3.



Notes: Different letters indicate significant differences based on BNT test.

Fig. 3. Elongation of commercial control, and substituted pastas

Elongation test results show that there is a significant difference between commercial pasta which has an elongation value of 10.03% with control pasta which has an elongation value of 18.20% and substituted pasta which has an elongation value of 20.17%. Elongation is influenced by the gluten content of the ingredients, the proportion of amylose and amylopectin, processing, and dough composition. The significant difference between commercial pasta with control pasta and substituted pasta is thought to occur due to differences in the method and composition of ingredients used in the pasta making process. The amount of water used in making dough can be determined based on the water absorption capacity of the flour used, because each type of flour has a different absorption capacity, therefore the use of water greatly affects the dough, especially if substitutions are made [21]. In addition, based on the composition of the ingredients listed on the packaging, the ingredients used in making commercial pasta are only durum wheat semolina flour. While the control and substituted pasta, were made with the addition of eggs as much as 25% of the total amount of flour used. Eggs added in making pasta can increase the elasticity of the dough so that it does not break easily. In addition, the protein content in eggs can form a layer that is strong enough to cause better water binding in the noodles and can increase elasticity [22]. Egg yolk can also function to develop dough and accelerate water hydration [23]. The use of eggs in pasta dough greatly helps increase the elasticity of the product, causing the elongation of the resulting product to be better than the product without the addition of eggs.

4 Conclusion

The 30% substitution of HMT-modified taro flour in the preparation of fettuccine pasta significantly affected the dietary fiber content, glycemic index, and elongation. The substituted pasta had significantly higher dietary fiber content and elongation and significantly lower glycemic index compared to commercial pasta and control pasta. The pasta had a dietary fiber content of 4.49%, glycemic index value of 22.39, and elongation of 20.17%.

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