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Original Article

Improvement of Crispiness and Sensory Characteristics of Cookies Substituted with Shiitake Mushroom Flour (*Lentinula Edodes*)

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Abstract *- Crispiness and taste characteristics determine consumer cookie preferences. There is great interest in using edible mushrooms as functional ingredients in bakery products due to their bioactive component content and traditional consumption for their delicious texture and taste. This study explores the effect of substituting wheat flour with shiitake mushroom (Lentinula edodes) flour on cookies' crispiness and sensory characteristics. A completely randomized experimental design with 5 treatments of shiitake mushroom flour proportions, namely 0%, 7.5%, 15%, 22.5%, and 30%, was used in the cookie recipe to substitute wheat flour. The study results showed that substituting wheat flour with shiitake mushroom flour increased the crispiness of cookies. However, 22.5% and 30% substitution proportions decreased the panelist's preference for color, aroma, and taste. This study concluded that wheat flour can be substituted with shiitake mushroom flour with an optimum proportion of 15% in the recipe. Shiitake mushroom flour has the potential to be used as a raw material and reduce the use of wheat flour to produce bakery products, especially cookies with a low glycemic index.*

Keywords *- Cookies, Crispiness, Sensory, Shiitake mushrooms.*

1. Introduction

Cookies are a popular snack because of their variety of shapes and sizes, high digestibility, high energy value, relatively low production costs, practicality, and long shelf life [1]. Indonesia's average consumption of cookies reaches 0.40 kg per capita per year, and it imports 9.5 million metric tons of wheat grains to make 6.661 million metric tons of wheat flour [2]. Cake dough consists of three main components. Besides flour, the dough contains fat, sugar, and water [3]. Wheat flour has a high glycemic index, increasing blood sugar levels quickly after consumption. Consumer behavior encourages food manufacturers to design products with better nutritional composition and benefits for health [4]. The use of edible mushrooms as functional ingredients to improve the nutritional profile of foods, including bread and cakes, is increasing [5,6]. The addition of edible mushrooms has been reported to have no adverse effects on functional foods' appearance, texture, taste, and shelf life [7]. The substitution of shiitake mushroom flour in cookies is an interesting area of research, especially in terms of sensory properties such as taste, aroma, color, and the product's crispness. Shiitake mushroom (*Lentinula edodes*) is a popular edible mushroom in Asia. It has a similar taste to meat and is used to enhance aroma. Additionally, shiitake mushrooms are often used in traditional medicine in Japan, Korea, and China because they contain a wide range of nutrients and compounds beneficial for human health [8]. The phytochemical content of shiitake mushrooms includes secondary metabolite compounds and antioxidants [9]. Shiitake mushrooms are edible and nutritious, have a unique taste, and have been widely cultivated in many Asian countries [10]. Shiitake mushrooms are rich in essential amino acids, dietary fiber, vitamins, and minerals but low in calories and fat [11, 12, 13, 14, 15]. This mushroom reduces the risk of health problems because it is rich in bioactive compounds, including polysaccharides, terpenoids, steroids, phenols, nucleotides, and glycoprotein derivatives [16]. Shiitake mushrooms have high economic value and have been cultivated under various conditions.

The shiitake mushroom market is expected to witness growth. Bridge Market Research [17] predicts that the shiitake mushroom market will grow at a CAGR of 9.1% from 2022 to 2029 and is expected to reach USD 1,483.41 million by 2029. Shiitake mushrooms can be grown indoors or outdoors on almost any type of wood in a well-managed environment [18]. Shiitake mushroom was also reported to be a meat replacer in sausage production [19], a rice flour substitute in muffin production [20], an antioxidant in frankfurter production [21],

enricher flavor [22, 23], tuna flesh color stabilizer [24], and phosphate substitute in pork patties [25]. This study explores the effect of substituting wheat flour with shiitake mushroom (*Lentinula edodes*) flour on cookies' crispiness and sensory characteristics.

2. Materials and Methods

Experimental studies were conducted using a completely randomized experimental design with 5 levels of shiitake mushroom flour, namely 0%, 7.5%, 15.0%, 22.5%, and 30%, to substitute wheat flour in the cookie recipe. In this study, each treatment was repeated 5 times.

2.1. Preparation of Shiitake Mushroom Flour

Fresh shiitake mushrooms are obtained from mushroom farmers in Surabaya, Indonesia. Fresh shiitake mushrooms were cleaned from dirt and dried in an oven dryer at 75°C for 50 hours. The dried shiitake mushrooms are then finely ground to a moisture content of 12% and pass through a 60-mesh sieve.

2.2. Cookies Making

The production of cookies substituted with shiitake mushroom flour is done by mixing palm sugar, butter, powdered milk, eggs, vanilla, baking powder, low-protein wheat flour, and cornstarch in specific proportions. The substitution treatments for shiitake mushroom flour and wheat flour are as follows: (1) 0% shiitake mushroom flour and 100% wheat flour (P0); (2) 7.5% shiitake mushroom flour and 92.5% wheat flour (P1); (3) 15.0% shiitake mushroom flour and 85% wheat flour (P2); (4) 22.5% shiitake mushroom flour and 77.5% wheat flour (P3); and 30% shiitake mushroom flour and 70% wheat flour (P4). The cookies are baked in an electric oven at 150°C for 30 minutes. Afterwards, the cookies are stored in airtight containers for 10 days at room temperature (25-30°C). The ingredients formula for the cookies is presented in Table 1.

Table 1. Recipe composition for making cookies

Ingredient	Amount in recipe				
Wheat flour (g)	170	157.25	144.5	131.75	119
Shiitake Mushroom flour (g)	0	12,75	25,5	38,25	51
Butter (g)	100	100	100	100	100
Palm sugar (g)	100	100	100	100	100
Baking powder (g)	15	15	15	15	15
Powdered milk (g)	15	15	15	15	15
Cornstarch (g)	15	15	15	15	15
Egg (medium)	1	1	1	1	1

2.3. Crispness Test of Cookies

The crispness level of cookies substituted with shiitake mushroom flour is tested using a penetrometer. The first step is to prepare the penetrometer, place it on a flat surface, and then attach the needle. The penetrometer has a water pass to ensure the needle and needle holder are positioned perpendicular (90°) to the surface. Uniformly sized cookie samples in cubic shapes measuring 1.5 cm x 1.5 cm x 1.5 cm are used, with a weight load of 50 g. The measurements are repeated three times, and the average is taken. The resulting figures indicate the crispness level of the product.

2.4. Sensory Characteristics

Thirty semi-trained panelists were used to evaluate the sensory qualities of cookies made with shiitake mushroom flour. All panelists had a taste threshold of 10% sugar in tea, did not smoke, and were not color-blind. The panelists were asked to evaluate their liking of the cookies stored in an airtight container for 10 days. The panelists evaluated the color, aroma, and taste of the cookies that had been coded with 3 digits using a Likert scale where 1 = very disliked, 2 = disliked, 3 = neutral, 4 = liked, and 5 = very liked.

2.5. Statistical Analysis

The data from the observations were analyzed using a one-way Analysis of Variance (ANOVA) according to the experimental design, which was a completely randomized design at a significance level of 0.05. If the analysis results indicate significance ($P<0.05$), a Tukey significant difference test is then performed at a significance level of 0.05 to determine the differences among the treatments. Before being analyzed for variance, the sensory characteristic data from the panelists' assessment results were first transformed into a logarithmic number of 10 plus 0.5.

3. Results and Discussion

3.1. Crispness of Cookies

This study (Figure 1) shows that substituting wheat flour with shiitake mushroom flour can increase the crispiness of cookies. The crispiness of the cookies significantly ($P<0.05$) increases as the proportion of shiitake mushroom flour that substitutes wheat flour in the recipe increases. The highest level of crispiness of cookies was found at a proportion of shiitake mushroom flour of 30% and the lowest at 7.5%. The increasing crispness in cookies substituted with shiitake mushroom flour is alleged because of the increased tenderness of the cookie dough, resulting in a better texture and outer layer, which leads to crisper cookies and an overall improved product texture.

The increased crispness in cookies substituted with shiitake mushroom flour may be caused by the high protein and fiber content in shiitake mushrooms. This study differs from Olawuyi and Lee [20], who reported that substituting rice flour with shiitake mushroom flour increased muffin hardness. The differences are thought to be due to differences in the composition of the ingredient formula and the cooking process. Panghal et al. [3] reported that processing and main raw materials affect the quality of cookies. This study also aligned with Biao et al. [7], who reported that 15% of wheat flour can be replaced with *Pleurotus eryngii* mushroom flour to improve the texture and appearance of cookies.

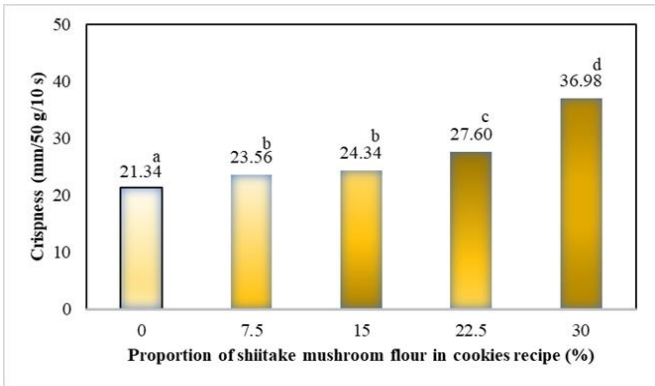

Fig. 1 The level of crispiness of cookies when wheat flour is substituted with shiitake mushroom flour, mean values marked with different superscript letters indicate significant differences (P<0.05)

Cookies are a type of bakery product that does not require leavening (unleavened product) and emphasizes a crispy texture rather than hardness. Cookies are among the foods that easily break into particles during chewing, a phenomenon known as crumb. The quality of cookies is influenced by the type of flour used [26].

The quality of cookies, including sensory characteristics, is influenced by ingredients such as sugar, flour, eggs, and margarine [27]. Panghal et al. [3] and Chevallier et al. [28] reported that the dough's nature, quality, and composition and the cooking method determine the quality of cookies. Shiitake mushroom flour is a suitable alternative to wheat flour in snack foods like cookies because they have good and relatively complete nutritional value.

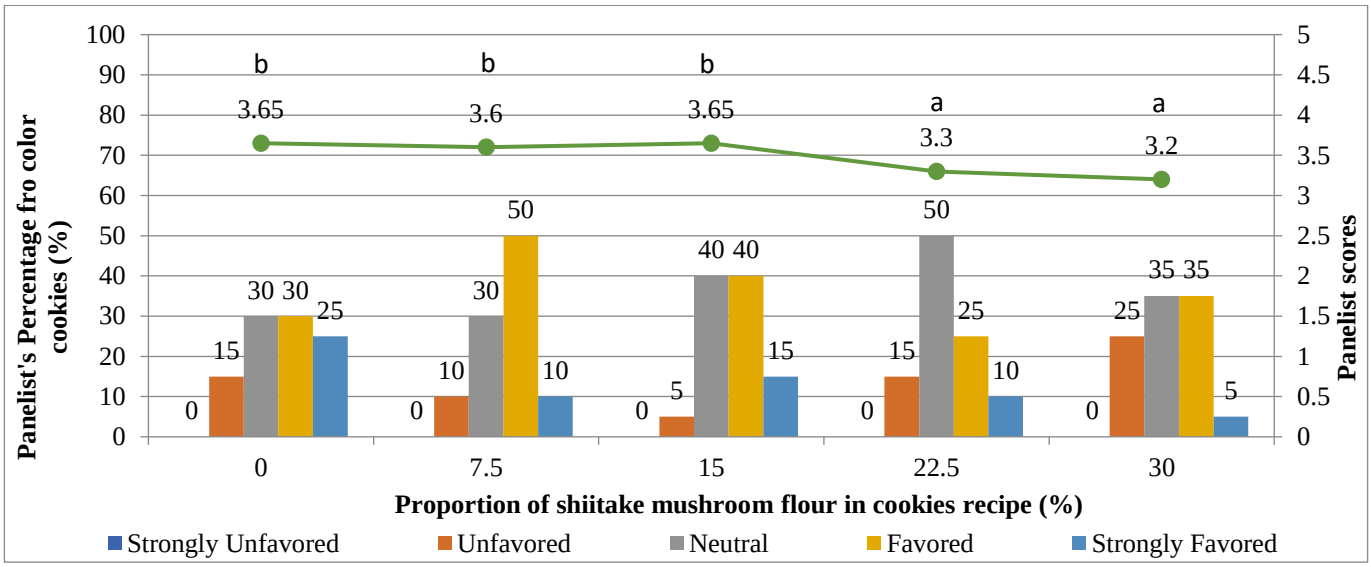

Fig. 2 The level of panelists' preference for color cookies when wheat flour is substituted with shiitake mushroom flour, mean values of panelist scores marked with different superscript letters indicate significant differences (P<0.05)

3.2. Color of Cookies

This study (Figure 2) shows that substituting wheat flour with shiitake mushroom flour in a proportion of 7.5-15% in the recipe does not reduce the level of panelists' preference for the color of cookies but decreases when the substitution is above 15%. The decrease in the panelists' preference for the color of cookies when replacing shiitake mushroom flour in high proportions (22.5-30%) in the recipe is thought to be due to the influence of heat during baking, which causes the color of the shiitake mushrooms to become darker and at high proportions the color of the cookies also becomes darker. Jiménez-Zamora et al. [29] reported that the color of raw shiitake mushrooms is bright. After cooking, the color becomes darker due to the formation of brown pigments in the Maillard reaction during cooking. In addition, Bojarska et al. [30] also reported that the brightness of boiled shiitake mushrooms decreased, which is thought to be due to the high water content in shiitake mushrooms, causing light to penetrate deeper into the tissue, resulting in a darker shiitake mushroom surface. The current study is aligned with Eissa et al. [31], who reported that replacing wheat flour with mushroom flour by 15% can increase the brown color of bread and biscuits. Singh et al. [32] reported that substituting wheat flour with shiitake mushroom flour increased protein and mineral content but suggested using a proportion of 10% in biscuit recipes.

3.3. Aroma of Cookies

This study (Figure 3) shows that the substitution of wheat flour with shiitake mushroom flour in a proportion of 7.5-15% in the recipe does not reduce the level of panelists' preference for the aroma of cookies, but decreases when the substitution is above 15%. The decrease in panelists' preference for the taste of cookies when replacing shiitake mushroom flour with a high proportion (22.5-30%) in the recipe is thought to be due to the presence of volatile components from shiitake mushrooms remaining in the cookies after cooking. Xiaokang et al. [33] reported that most of the volatile substances

detected in shiitake mushrooms were alcohols, followed by aldehydes and ketones. Lin et al. [34] reported that compounds with 8 carbons, such as 1-octen-3-one, 1-octene-3-ol, and 3-octanol, contribute to the mushroom aroma. The cooking process plays a crucial role in the aroma of shiitake mushrooms substituted in the cookie-making process. The cooking process contributes to the distinctive smell of shiitake mushrooms. The reduction in aroma in cooked shiitake mushrooms is significantly influenced by volatile compounds that are lost by evaporation during the cooking process. Tian et al. [35] reported that boiling and oven roasting caused a decrease in volatile compounds in shiitake mushrooms. Yao et al. [36] reported that 5-20 minutes of cooking decreased volatile compounds in shiitake mushrooms.

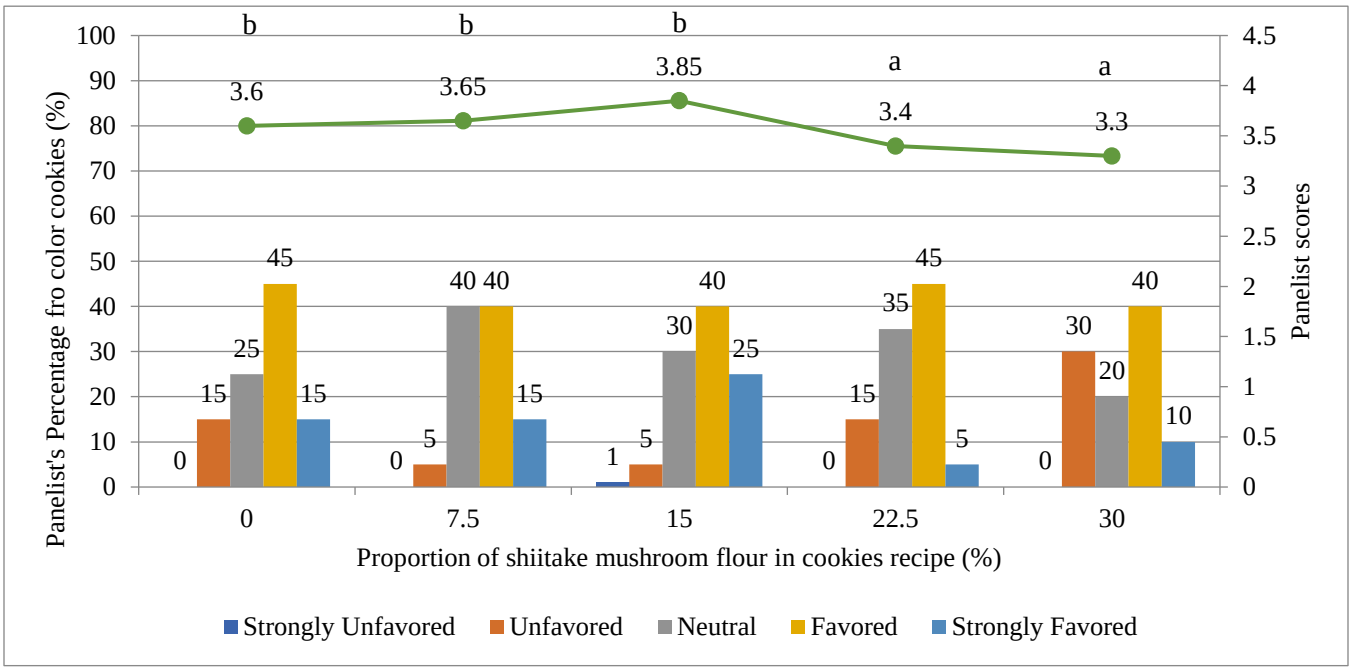

Fig. 3. The level of panelists' preference for aroma cookies when wheat flour is substituted with shiitake mushroom flour, mean values of panelist scores marked with different superscript letters indicate significant differences (P<0.05)

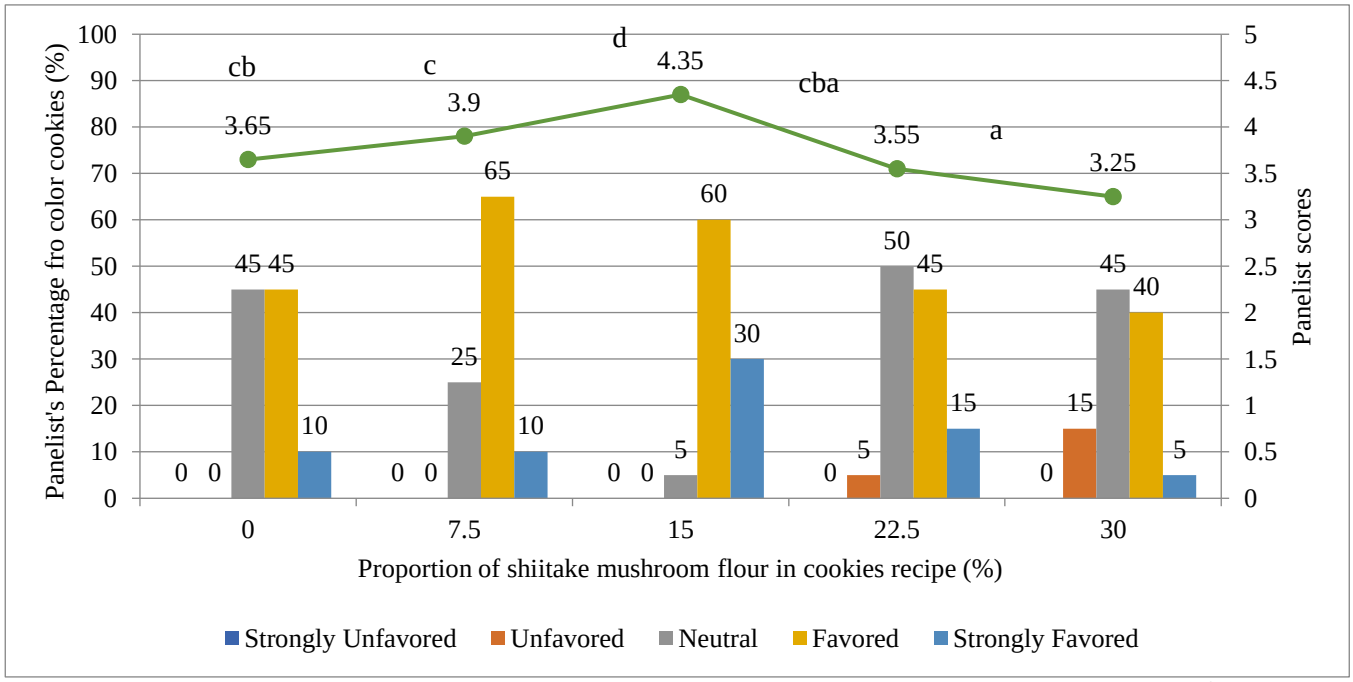

Fig. 4 The level of panelists' preference for taste cookies when wheat flour is substituted with shiitake mushroom flour, mean values of panelist scores marked with different superscript letters indicate significant differences (P<0.05)

3.4. Taste of Cookies

This study (Figure 4) shows that substituting wheat flour with shiitake mushroom flour in a proportion of 7.5-15% in the recipe increases the panelists' preference for the taste of cookies. Substituting wheat flour with 15% shiitake mushroom flour is the optimum proportion in the cookie-making recipe. The panelists' preference for the taste of cookies decreased by 22.5-30%, which is thought to be because the high umami content is not preferred. Hou et al. [37] reported that shiitake mushrooms have a savory taste, slightly earthy, sweet, and smoky taste, often described as umami. Umami can be perceived as a taste sensation caused by glutamic acid. Umami is an ingredient that enriches the flavor of shiitake mushrooms because it contains L- glutamic acid (L - Glu), monosodium glutamate (MSG), L - aspartic acid (L - Asp), and 5′- nucleotides, including 5′- guanosine monophosphate (5′- GMP), 5′- inosine monophosphate (5′- IMP), 5′- adenosine monophosphate (5′- AMP) and 5′- xanthosine monophosphate (5′- XMP) [22].

The caps of shiitake mushrooms are known to contain 5' GMP (Guanosine 5-monophosphate) and 5' IMP (Inosine 5-monophosphate) at levels of 4.13 g/kg and 0.04 g/kg, respectively. The EUC (Equivalent Umami Concentration) value in the caps of the mushrooms is 728.54 g MSG/100 g, indicating that shiitake mushrooms can be utilized as a source of flavor-enhancing components [38].Based on the results of observations of the characteristics of crispiness, color, aroma, and taste of cookies, this study indicates that substituting wheat flour with shiitake mushroom flour can produce cookies with a low glycemic index and reduce the use of wheat flour.

The glycemic index of wheat flour is around 85.0, the glycemic index of shiitake mushroom flour is 10-15, and the glycemic index of cookies is 70.0 [39]. Reducing the glycemic index in recipes using mushroom flour is a good approach to obtaining functional cookies. This study also indicates that shiitake mushroom flour is a natural ingredient that has the potential to enhance the taste of food products, especially cookies, to be developed as a healthy food additive but still provide good sensory quality. This study's results align with those of several researchers who published the effects of using mushrooms in bakery products. Sheikh et al. [40] reported that cakes containing 15% oyster mushroom powder showed better color, taste, texture, and overall acceptability.

4. Conclusion

Substituting shiitake mushroom flour (*Lentinula edodes*) can affect cookies' crispness, color, aroma, and taste. Shiitake mushroom flour has a soft texture, which can enhance the crispness of cookies. As the substitution of shiitake mushroom flour increases, the crispness of the cookies also increases. Substitutions of white flour with 15% shiitake mushroom flour result in cookie colors that the panelists prefer. Shiitake mushrooms are natural ingredients that have the potential to enhance crispness, color, aroma, and taste in food products. Therefore, shiitake mushrooms can be used as natural additives, making them suitable for development as healthier food additives while maintaining good sensory quality.

Authors' Contribution

Wardah: Conceptualization and methodology, data collection, article preparation.
Rini Rahayu Sihmawati: Data collection and article preparation.
Tatang Sopandi: Data collection and analysis, article preparation and editing.

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