



**EVALUATION OF CONSUMER PREFERENCE AND NUTRITIVE VALUES OF GLUTEN-FREE COOKIES FROM ARROWROOT (*Maranta arundinaceae* L.) STARCH AND RICE FLOUR**

*Evaluasi Preferensi Konsumen dan Nilai Gizi Cookies Bebas Gluten dari Pati Garut (*Maranta arundinaceae* L.) dan Tepung Beras*

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**ABSTRACT**

Cookies are a type of biscuit (dry cake) with a crunchy texture and various shapes, sizes, and flavors. Product development, especially cookies made with arrowroot starch and rice flour as substitutes for wheat flour, serves not only to diversify but also to provide an alternative to gluten-free cookies. This study aimed to determine the effects of arrowroot starch and rice flour on consumer preferences for cookie formulations and to evaluate the nutritional value of the chosen cookies. This study consisted of five treatments of arrowroot starch and rice flour ratios, namely F1 (100% arrowroot starch), F2 (75% arrowroot starch: 25% rice flour), F3 (50% arrowroot starch: 50% rice flour), F4 (25% arrowroot starch: 75% rice flour) and F5 (100% rice flour). The study data were analyzed using the Kruskal-Wallis test and, if significant differences were found ( $p < 0,05$ ), the Mann-Whitney test was used. The results showed that the most preferred treatment was a 25:75 ratio of arrowroot starch and rice flour. Based on the results of nutritive values, cookies in treatment F4 had a water content of 5.52 percent, ash content of 1.34 percent, protein content of 4.74 percent, fat content of 25.49 percent, and carbohydrate content of 62.92 percent. It can be concluded that cookies made from 25 percent arrowroot starch and 75 percent rice flour were the most preferred and can be an alternative as healthy cookies for some dietary concerns.

**Keywords:** digestive disorder, healthy cookies, hedonic test, nutritional, sensory analysis

**ABSTRAK**

Cookies adalah salah satu jenis biskuit (kue kering) yang memiliki tekstur renyah serta berbagai bentuk, ukuran, dan rasa. Pengembangan produk, khususnya cookies yang menggunakan pati garut dan tepung beras sebagai pengganti tepung terigu, selain sebagai upaya diversifikasi juga memberikan alternatif cookies bebas gluten. Penelitian ini bertujuan untuk mengetahui formulasi cookies menggunakan pati garut dan tepung beras, yaitu F1 (100% pati garut), F2 (75% pati garut : 25% tepung beras), F3 (50% pati garut : 50% tepung beras), F4 (25% pati garut : 75% tepung beras), dan F5 (100% tepung beras). Data penelitian dianalisis menggunakan *Kruskal Wallis* dan dilanjutkan dengan uji *Mann Whitney* jika terdapat perbedaan signifikan ( $p < 0,05$ ). Hasil penelitian menunjukkan bahwa perlakuan yang paling disukai adalah dengan perbandingan pati garut dan tepung beras yaitu 25 persen : 75 persen. Berdasarkan hasil nilai gizi, cookies pada perlakuan F4 memiliki kadar air 5,52 persen, kadar abu 1,34 persen, kadar protein 4,74 persen, kadar lemak 25,49 persen, dan kadar kabohidrat 62,92 persen. Dapat disimpulkan bahwa cookies yang dibuat dari 25 persen pati garut dan 75 persen tepung beras merupakan yang paling disukai dan dapat menjadi alternatif cookies sehat bagi beberapa kebutuhan diet tertentu.

**Kata kunci:** gangguan pencernaan, cookies sehat, uji hedonik, nilai gizi, analisis sensori

## INTRODUCTION

The arrowroot starch contained starch of 98.10 percent and in vitro starch digestibility of 84.35 percent. The high digestibility of starch shows that starch is easy to digest. Arrowroot starch can be classified as easily digestible starch, so it can be used as baby food or food for people with digestive disorders.<sup>1,2</sup> The high amylopectin content in arrowroot starch is responsible for its high digestibility. Amylopectin, the branched form of starch, is more easily broken down and absorbed by the body compared to amylose, the linear form of starch. This property makes arrowroot starch a suitable ingredient for individuals with digestive disorders or infants, as it can be readily digested.<sup>3</sup>

Celiac disease (CD) is one of the digestive disorders that can damage the small intestine. Symptoms of CD include diarrhea, abdominal pain, bloating, gas, anemia, bone disease, and also skin disorders. People with CD cannot eat gluten, a protein found in wheat, barley and rye.<sup>4-6</sup> One of the treatments for CD patients until now is to follow a gluten-free (GF) diet.<sup>7,8</sup> The development of gluten-free food products has gained significant attention in recent years due to the increasing prevalence of gluten-related disorders, such as celiac disease. As more individuals require gluten-free diets, the food industry has focused on creating high-quality, tasty, and nutritious gluten-free alternatives to traditional wheat-based products.<sup>9</sup> Sensory evaluation is essential in developing gluten-free products, as attributes like taste, aroma, and texture greatly influence consumer acceptance. Studies show that gluten-free foods often have inferior sensory qualities compared to regular products, making sensory testing crucial to identify acceptable formulations.<sup>10,11</sup>

Rice flour is the most commonly used gluten-free flour. Rice flour is frequently combined with flours, starches, and proteins from cereals, pulses, pseudocereals, and other plant materials to get the best batter or dough characteristics and improve the bakery product quality.<sup>12,13</sup> In recent years, the development of gluten-free cookies has been a growing trend, as they provide a tasty and nutritious alternative to traditional wheat-based cookies for

individuals with gluten-related disorders.<sup>14</sup> Nutritionally, rice flour is naturally gluten-free and provides easily digestible carbohydrates, moderate protein, and essential micronutrients, making it suitable for individuals with celiac disease. Arrowroot starch is also gluten-free and contains high levels of digestible carbohydrates with low allergenic potential, which further supports its use in gluten-free diets. Studies confirm that both rice flour and arrowroot starch can be safely consumed by gluten-sensitive and CD populations.<sup>6,15</sup> Arrowroot starch has great functional properties, so it has a high potential to be used in the food industry.<sup>1,16,17</sup> The color of arrowroot starch was almost exactly like the color of wheat flour, suggesting that when wheat flour is substituted, color has little effect.<sup>16,18</sup> Arrowroot starch has a better gel-forming ability, high viscosity and high swelling power and solubility. These properties indicate that arrowroot can be used as thickener or gelling agent. Arrowroot starch can be used in the pharmaceutical industry due to its densities.<sup>3,18,19</sup>

The previous studies of arrowroot cookies had been conducted by several researchers. Cookies made of 16-17 percent arrowroot starch could provide a mucosal immune response similar to wheat cookies, and improve the texture of faeces become softer.<sup>20</sup> Arrowroot starch was also studied for making Philippine butter cookies with better sensory attributes than the original cookies made from all-purpose flour and rice flour.<sup>21</sup> The objective of this study is to evaluate the preference acceptance of gluten-free (GF) cookies and to determine the nutritional value of the chosen cookies based on panelist preferences. This study used arrowroot starch as a substitute for the original rice flour (RF) cookies as gluten-free cookie development. Moreover, the development of gluten-free cookies using local ingredients such as arrowroot starch and rice flour can support food diversification and reduce dependency on imported wheat. These cookies also offer practical, shelf-stable, and accessible snack options that meet the dietary needs of individuals with celiac disease or gluten sensitivity. Both rice flour and arrowroot starch are well-tolerated by individuals with celiac disease, and studies have reported that incorporating diverse gluten-free starch sources may improve nutrient balance, digestibility, and

consumer acceptability.<sup>22,23</sup> Therefore, the tested ratios were designed to assess both functional and nutritional synergy for gluten-sensitive populations.

## METHODS

This research was held into two steps, that were cookies preparation and sensory evaluation. The gluten-free (GF) cookies used the arrowroot starch as a substitute of rice flour was purchased in the local market. The all other ingredients, including butter, powdered milk, sugar, baking powder and eggs, were acquired from a local supermarket, ensuring uniformity in component quality.

### Preparation of cookies

The gluten-free (GF) cookies in this study were used five formulas (F) of arrowroot starch (AS) and rice flour (RF) ratio. F1 used 100 percent arrowroot starch (AS), and the ratio of AS:RF in F2, F3, F4 were 75:25, 50:50, 25:75, respectively. The cookies was compared to 100 percent RF (F5) as an original cookies of rice flour.

For the cookie preparation, first, 70 g butter, 20 g egg, 1 g baking powder, 5 g powdered milk, and 40 g sugar were creamed together until light and fluffy. This creaming process helped to incorporate air into the mixture, creating a light and airy texture in the final cookies. Then, the arrowroot starch and rice flour mixtures were added and mixed well, ensuring the dry ingredients were fully incorporated into the wet ingredients. The dough was then rolled out to the desired thickness and cut into round shapes using a cookie cutter. Finally, the shaped cookies were baked at 180°C for 12-15 minutes, allowing them to develop a crisp and golden-brown exterior while maintaining a soft and tender interior.<sup>24</sup>

### Sensory Evaluation

The sensory evaluation was conducted in the sensory laboratory to determine consumer acceptability of the gluten-free cookies based on color, aroma, texture, taste, and overall liking. This assay used a 7-point hedonic scale for the evaluation, where 1 = dislike extremely, 2 =

dislike very much, 3 = dislike moderately, 4 = neutral, 5 = like moderately, 6 = like very much, and 7 = like extremely. The 7-point scale is widely used in sensory analysis for its balance between sensitivity and simplicity, allowing panelists to express degrees of preference without cognitive overload.<sup>25,26</sup> A total of 30 untrained panelists, consisting of both male and female adults aged 16 to 45 years, participated in the evaluation. These panelists represented general consumers without specific dietary restrictions such as celiac disease, to assess general market acceptability of the gluten-free cookie formulations.

### Nutritional Analysis

The proximate analysis of the selected cookie's formula was performed to comprehensively determine its nutritional composition. The parameters analyzed included the content of moisture, protein, fat, ash, and carbohydrates, providing a detailed evaluation of the cookie's nutritional profile. The laboratory analysis was conducted at PT. Saraswanti Indo Genetech (SIG Laboratory) Semarang, Central Java. This study refer to standard methodologies of the Association of Official Analytical Chemists for the determination of moisture content, ash, protein, and fat. The carbohydrate content were calculated by difference, which assumed that the total composition of a food sample is 100 percent. Then the carbohydrate content was estimated by subtract the amounts of moisture, ash, protein and fat content from this total. The remaining portion is considered to be carbohydrates.<sup>27</sup>

### Data Analysis

The data from the sensory evaluation were analyzed using Kruskal Wallis non-parametric analysis of variance. If there were any significant differences among the cookie samples, the post-hoc analysis was carried out using the Mann-Whitney test.<sup>28</sup> The best formula based on panelists' overall liking for all attributes (such as color, aroma, texture, taste, and overall preference), the approach typically used is to gather sensory data from panelists, calculate average scores for each attribute, and then determine the best formula based on the highest cumulative score. The nutrient content of the selected cookie was calculated and presented descriptively.<sup>29</sup>

## RESULT

### Sensory Evaluation

The results of the sensory evaluation are shown in Table 1. The color, aroma, texture, taste, and overall liking scores were significantly different among the cookie samples ( $p < 0.05$ ). Based on the sensory evaluation, the cookie with the highest score for overall liking was F2, which used a 75:25 ratio of arrowroot starch to rice flour.

### Nutritional Composition

The nutritional composition was analyzed based on the selected formula by panelist preferences score, that was found in formula fourth (F4). The result of the nutritional composition of selected cookies is shown in Table 2. However, to provide scientific relevance, the study included comparisons with other gluten-free cookie studies from the prior research.

Table 1  
The Aroma, Color, Taste, Texture, and General Acceptability of the GF-Cookies

GF-Cookies	Color	Aroma	Taste	Texture	Overall
F1	5.30 ± 0.88 <sup>a</sup>	5.40 ± 0.89 <sup>bc</sup>	5.77 ± 0.94 <sup>c</sup>	5.73 ± 0.75 <sup>b</sup>	5.83 ± 0.75 <sup>c</sup>
F2	5.07 ± 1.08 <sup>a</sup>	4.83 ± 1.21 <sup>b</sup>	4.83 ± 1.29 <sup>a</sup>	4.63 ± 1.35 <sup>c</sup>	5.13 ± 0.90 <sup>a</sup>
F3	5.20 ± 0.96 <sup>a</sup>	4.77 ± 1.28 <sup>ab</sup>	5.03 ± 0.89 <sup>ab</sup>	5.00 ± 1.17 <sup>ac</sup>	5.20 ± 1.13 <sup>ab</sup>
F4	5.77 ± 0.82 <sup>c</sup>	5.60 ± 0.72 <sup>c</sup>	5.57 ± 0.82 <sup>cd</sup>	5.77 ± 0.77 <sup>b</sup>	5.70 ± 0.95 <sup>bc</sup>
F5	4.90 ± 1.37 <sup>ab</sup>	4.97 ± 0.93 <sup>ab</sup>	5.07 ± 1.05 <sup>ab</sup>	5.20 ± 0.92 <sup>ac</sup>	5.33 ± 1.03 <sup>abc</sup>

Values with different superscript letters on the same rows differ significantly ( $p < 0.05$ ). All values are mean with different superscripts based on Kruskal Wallis with Mann-Whitney test.

Table 2  
Comparison of Nutritional Information of Selected Gluten-Free Cookies (F4) and Rice-Based Flour Blends from Previous Study

Nutrient	F4 Cookie (25:75 AS:RF) <sup>1</sup>	Rice Flour <sup>2</sup>	Chickpea Flour <sup>2</sup>	Rice-Chickpea Composite <sup>2</sup>
Energy:				
Total (kcal)	500.05	364.3	374.2	364.7
Energy of fat (kcal)	229.42	9.9	34.2	17.1
Moisture (g/100g)	5.52	9.2 ± 0.3 <sup>a</sup>	10.0 ± 0.5 <sup>a</sup>	9.8 ± 0.3 <sup>a</sup>
Ash (g/100g)	1.34	1.0 ± 0.1 <sup>a</sup>	1.5 ± 0.4 <sup>c</sup>	1.1 ± 0.1 <sup>b</sup>
Protein (g/100g)	4.74	3.6 ± 0.2 <sup>a</sup>	24.0 ± 1.0 <sup>c</sup>	7.9 ± 0.1 <sup>b</sup>
Fat (g/100g)	25.49	1.1 ± 0.1 <sup>a</sup>	3.8 ± 0.3 <sup>c</sup>	1.9 ± 0.1 <sup>b</sup>
Carbohydrate (g/100g)	62.92	85.0 ± 0.4 <sup>c</sup>	61.0 ± 0.3 <sup>a</sup>	79.0 ± 0.2 <sup>b</sup>

<sup>1</sup> Analyzed in current study (F4 formulation with 25% arrowroot starch and 75% rice flour).

<sup>2</sup> Nutritional values for rice flour, chickpea flour, and rice-chickpea composite flour were adapted from Hamdani *et al.*<sup>30</sup>. Values followed by same letter in a row do not differ significantly ( $p > 0.05$ ).

## DISCUSSION

### Color

The differences in the sensory scores may be attributed to the varying ratios of arrowroot starch and rice flour. The color of the F4 cookie, which contained the highest proportion of rice flour at 75 percent compared to the other formulations, was rated the highest by the panelists in the sensory evaluation. This suggests that the higher rice flour content contributed to a more familiar and appealing color for the gluten-free cookie, likely resembling the color of traditional wheat-based cookies.<sup>31</sup> The panelists seemed to prefer the cookie with a higher proportion of rice flour, as it provided a more recognizable appearance that was similar to the color of conventional wheat-based cookies they were accustomed to. This indicates that the visual appeal of the gluten-free cookie was an important factor in its overall acceptability, and the formulation with a greater rice flour content was able to better mimic the appearance of traditional cookies, which the panelists found more desirable.<sup>32,33</sup> Rice flour is known for its light, uniform appearance, which may enhance the visual acceptability of gluten-free products.<sup>34</sup> In contrast, formulations with higher arrowroot starch content (F1–F3) tended to have a duller or less familiar color, which may have affected panelists' perception. The findings indicate that visual similarity to traditional cookies plays a significant role in consumer preference, especially in gluten-free products, where appearance can influence perceived quality and acceptability.

### Aroma and Taste

The aroma and taste scores were also highest for the F4 cookie, which contained the highest proportion of rice flour at 75 percent compared to the other formulations. This means that the increased rice flour added contributed to a more familiar and appealing flavor profile that the panelists found desirable, likely resembling the aroma and taste characteristics of traditional wheat-based cookies they were accustomed to. The distinct flavor and aromas associated with rice flour, such as its nutty and slightly sweet notes, were likely more prominent in the F4 cookie formulation compared to the other samples with higher arrowroot starch

content.<sup>35,36</sup> This allowed the panelists to perceive a flavor profile that was more analogous to the conventional cookies they were familiar with, which enhanced the overall acceptability and liking of the F4 gluten-free cookie.<sup>31,33</sup> This may be attributed to the distinctive flavor of rice flour, which was more prominent in the F4 cookie compared to the other formulations with higher arrowroot starch content.<sup>32,37</sup> These findings suggest that both rice flour and arrowroot starch can support desirable aroma and taste characteristics in gluten-free cookies, with variations likely influenced by the subtle interactions of ingredients rather than by flour type alone. Therefore, while F4 may offer a more familiar flavor to consumers, formulations like F1 also demonstrate promising sensory qualities that warrant further exploration in gluten-free product development.

### Texture

The texture of the gluten-free cookies was also an important factor in consumer acceptance. The value of texture in F1 (100% arrowroot starch) and F4 (75% rice flour) had a similar score (but not significant), indicating that the high arrowroot starch (100%) or high rice flour (75%) ratio produced cookies with desirable textures. The textural attributes, such as crispiness, chewiness, and overall mouthfeel, were likely well-balanced in the F1 and F4 cookie formulations, leading to positive ratings from the panelists. The high arrowroot starch content in F1 and the higher rice flour proportion in F4 seemed to contribute to desirable textural qualities that the sensory panelists found appealing. The arrowroot starch likely provided a crisp and crunchy texture, while the rice flour helped create a more tender and soft mouthfeel. The combination of these textural characteristics, where no single attribute overwhelmed the others, resulted in a satisfying and well-received cookie texture that the panelists found enjoyable and preferable compared to the other formulations.<sup>38,39</sup> In contrast, the cookie with a 75:25 ratio of arrowroot starch to rice flour (F2) received the lowest texture score, suggesting that this particular formulation did not achieve the optimal textural properties preferred by the panelists. This finding aligns with previous research showing that high-amylopectin starches like arrowroot contribute to a crisp

texture upon baking, while rice flour improves tenderness due to its fine granule size and low gelatinization temperature.<sup>40,41</sup> Moreover, the lack of gluten can often result in dense or crumbly textures in cookies, but the right balance of starches as seen in F1 and F4, appears to support structural integrity despite this absence while maintaining palatability. The fact that two very different formulations (F1 and F4) yielded similarly acceptable textures also highlights the potential flexibility in gluten-free formulation strategies, depending on the desired sensory profile.

### Overall

The overall liking score for the F1 and F4 cookie was similar, which had the highest score of preferences. The formula which had 75 percent rice flour, was the most acceptable to the panelists based on all attributes, likely due to its similarity to traditional wheat-based cookies.<sup>42</sup> This means that the panelists mostly liked this formulation and it was the most preferred among the gluten free cookie samples. This factor could have been attributed to the combined impression of the cookie appearance, aroma, taste and texture liked by the panelists who were used to the grain-based cookies, which were similar to the ones they were used to. It is likely that the relative undamaged granular structure and destruction of starch in arrowroot starch contributed to the texture of the cookie which was noted to be more tender and crisp compared with those samples which had more rice flour content.<sup>18</sup> It was revealed that the cookie under study was high in fat and carbohydrates and thus serves as a good energy source. Protein content was of medium range and even suggests that these kinds of cookies can be appropriate for snacking for some dietary concerns. This supports the idea that the combination of 25 percent arrowroot starch and 75 percent rice flour may provide an optimal balance between crispness and tenderness. While arrowroot starch contributes to structural lightness and crunch, rice flour enhances softness and familiarity in mouthfeel, which together appear to have maximized consumer acceptance.

### Nutritional Composition

Based on the sensory evaluation, the gluten-free cookie made with a 25:75 ratio of arrowroot starch to rice flour (F4) was the most

preferred formulation. Its favorable acceptability across attributes confirms that partial substitution of rice flour with arrowroot starch can improve product appeal while maintaining desirable sensory properties. The selected cookie had desirable sensory attributes and a favorable nutritional profile, suggesting it could be a viable option for individuals seeking gluten-free alternatives<sup>42</sup> This study shows the potential of using arrowroot starch as a partial substitute for rice flour in the development of gluten-free cookies with improved acceptability and nutritional value. The selected gluten-free cookie showed that a balanced nutritional profile, with a significant amount of carbohydrates, moderate protein content, and relatively high-fat content. The high-fat content may be attributed to the use of butter in the cookie formulation.

The nutritional profile (Table 2) of the F4 cookie revealed a high carbohydrate content (62.92 g/100g), moderate protein (4.74 g/100g), and relatively high fat (25.49 g/100g), which contributed to an energy value of 500.05 kcal per 100 grams. This energy density is notably higher than that of raw rice flour (364.3 kcal) or rice–chickpea composite flour (364.7 kcal) as reported by Hamdani *et al*<sup>30</sup>, primarily due to the inclusion of butter in the cookie formulation. Specifically, fat contributed approximately 229.4 kcal, or nearly 46 percent of the total energy, which is significantly greater than the energy contribution from fat in chickpea or rice-based flour blends. These findings suggest that the gluten-free cookie made with a 25:75 ratio of arrowroot starch to rice flour ratio may be relatively suitable for celiac disease or gluten intolerant patients with satisfying sensory characteristics and adequate nutritional value. Overall the present study analysed the organoleptic characteristics and proximate composition of the cookies prepared from gluten-free arrowroot starch and rice flour. The cookie with the highest overall liking score was the F4 formulation, which used a 25:75 concentration ratio of arrowroot starch to rice flour. The selected cookie contained an adequate provision of nutrients in terms of carbohydrates and moderate protein content in addition to a high proportion of the fat content. In the context of celiac disease, the macronutrient profile of the selected cookie may offer practical benefits. The high carbohydrate

content provides an accessible energy source suitable for individuals with malabsorption issues, while the moderate protein and fat content contribute to satiety and energy density, which are often needed in gluten-free diets. Importantly, both rice flour and arrowroot starch are naturally gluten-free and considered hypoallergenic, further supporting the suitability of this formulation for CD populations.<sup>43,44</sup>

## CONCLUSIONS

Based on the findings of this study, it can be concluded that the gluten-free cookie formulated with a 25 percent arrowroot starch and 75 percent rice flour ratio (F4) was the most preferred by the panelists. This formulation demonstrated superior texture and taste compared to the other variations. Nutritional analysis also revealed that the selected cookie had a balanced profile, with moderate protein content and high carbohydrate levels. Furthermore, the comparable sensory performance of the 100 percent arrowroot starch cookie (F1) suggests that full substitution is also feasible, highlighting the versatility of arrowroot starch in gluten-free product development. Overall, this research confirms the potential of arrowroot starch as a valuable ingredient in gluten-free bakery products and contributes to expanding safe dietary options for individuals sensitive to gluten.

## RECOMMENDATION

In light of these results, it is recommended that the arrowroot starch and rice flour formulation be further developed as a safe, palatable, and nutritious gluten-free alternative, particularly for individuals with gluten intolerance or celiac disease. Future research should explore variations in formulation, processing techniques, and shelf-life stability to ensure consistent product quality. Additionally, public education on the benefits and safety of gluten-free products is essential to increase consumer acceptance and encourage wider adoption of such alternatives in daily diets.

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