

Gluten-Free Cookies Innovation Made from Arrowroot Flour (*Maranta arundinacea L.*) with the Addition of Spinach (*Amaranthus sp.*)

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Abstract: Cookies are generally high in calories and contain wheat flour, which contains gluten, making them unsuitable for individuals with gluten intolerance. This study developed gluten-free cookies using arrowroot flour (*Maranta arundinacea L.*) and spinach (*Amaranthus sp.*) as sources of iron and natural pigments. This study aims to determine the panelists' acceptance level of cookies made from arrowroot flour with added amaranth. This is an experimental study to evaluate sensory acceptance through a hedonic organoleptic test using a scale of 1–5 for the parameters of appearance, color, aroma, taste, and texture. Thirty untrained panelists aged 19–22 years old were selected to represent general consumers. Appearance received an average score of 4.57; color 4.33; aroma 4.00; taste 3.90; and texture 4.03. These scores indicate that the panelists' level of liking ranged from like to very like. This product has the potential to be an alternative gluten-free cookie made from local foods enriched with iron.

1 INTRODUCTION

Consumption of high-calorie snacks such as cookies, packaged cakes, or various ultra-processed sweet and salty snacks is associated with the risk of obesity, metabolic syndrome, and other metabolic disorders (Poti, Braga, and Qin, 2017). Research conducted by Rauber et al. (2021) explains that consumption of ultra-processed foods is a significant factor in obesity and abdominal obesity (hazard ratio up to 1.79). Additionally, other studies have shown that biscuit and cookie snacks contribute up to 11.8% of snack energy intake among adolescents (Lopes et al., 2022). Therefore, there is a need for

innovative snack products that are not only delicious but also healthier and more nutritious.

As awareness of health issues in the food industry increases, there has been a growing trend toward diversifying functional food products that not only offer great taste but also provide health benefits. Gluten-free products used to be attractive only to people with gluten intolerance and allergies, such as children with autism. Many children with autism are known to have allergies or intolerances to gluten and casein. This is because both substances can trigger negative reactions, such as increasing hyperactive and aggressive behavior, causing

intolerance, and triggering opioid reactions that can potentially lead to leaky gut syndrome (Riski Ayu A and Sri Winarti, 2021). Nowadays, gluten-free products are widely sought after by the general public and have become a new lifestyle trend. Gluten-free products are a potential alternative because they can reduce the risk of digestive disorders commonly found in vulnerable groups, while also serving as a more friendly food option.

Indonesia's diverse local food sources have the potential to become gluten-free ingredients, such as arrowroot flour (*Maranta arundinacea L.*). Arrowroot flour has the advantages of being easy to digest, smooth in texture, and gluten-free. The advantages of arrowroot flour make it a healthier alternative to wheat flour for consumers who need safe and healthy flour alternatives (Fidianingsih et al., 2022). In addition, it can support efforts to utilize local food resources. The low glycemic index of arrowroot makes it relatively safer for consumption by individuals with intolerances, presenting significant potential for development into modern food products.

On the other hand, spinach (*Amaranthus sp.*) is a green vegetable that is abundant and easily accessible to the public. Dehydrating spinach produces spinach powder containing approximately 19.2% protein, 8.2% crude fiber, 1,304 mg/100g calcium, and 40.4 mg/100g iron, making it a functional ingredient choice to enrich the nutritional content of staple foods such as chappati or other baked goods (Waseem et al.,

2021). The addition of spinach not only increases the nutritional value but also provides an appealing visual appearance through its natural green pigment.

Cookies are a popular snack among people of all ages due to their sweet taste, crunchy texture, and convenience, making them ideal for innovation. A number of studies have shown that cookies are one of the most commonly used bakery products for research on ingredient substitution, both to increase nutritional value and health benefits. In addition, the manufacturing process is easy and can use a variety of local ingredients (Galla et al., 2017). Replacing wheat flour with gluten-free arrowroot flour and adding spinach is expected to produce functional cookies that are not only high in nutritional value but also have good marketability. Thus, cookies can be an appropriate means to support national food diversification and bring about healthy food innovations based on local ingredients.

Based on this background, the researchers aimed to innovate gluten-free cookies made from arrowroot flour with added spinach, test their organoleptic acceptance, and calculate their contribution to the Nutrient Adequacy Rate (NAR). This study is expected to provide an innovative alternative in the development of gluten-free food products based on local resources by combining health values.

2 METHOD

This study is an experimental study that aims to develop gluten-free cookies made from arrowroot flour with added spinach, as well as to evaluate their sensory acceptance through hedonic organoleptic testing. Organoleptic testing was conducted cross-sectionally in a single testing session after the products were produced.

The ingredients used in making Baygar Crunchies cookies include arrowroot flour, butter/margarine, spinach powder, milk powder, caster sugar, eggs, raisins, and vanilla. The manufacturing process is carried out with the help of various tools, including: a mixing bowl, oven, baking pan, mixer, mixing utensil, bowl, strainer, digital scale, plastic gloves, spoon, pastry brush, and cloth.

The cookie-making process begins with preparing all the necessary tools and ingredients. Next, egg yolks, butter or margarine, and powdered sugar are mixed using a mixer until smooth. Then powdered milk and vanilla powder are added and mixed again. After that, arrowroot flour and spinach powder are added to the dough and mixed until well blended. Grease a baking sheet with margarine or butter, then weigh the dough according to the desired weight, shape it into flat rounds, and place them on the baking sheet before sprinkling raisins on top. The dough is then baked in the oven at the lowest temperature for about 40 minutes until cooked and hardened. After baking, the cookies are removed from the oven and are ready to be packaged and enjoyed.

In this study, organoleptic testing was conducted involving 30 untrained panelists from the general consumer population aged 19–22 years, selected using convenience sampling, i.e., based on availability and willingness to participate as respondents. All panelists had no allergies to cookie ingredients, were not experiencing any smell or speech impairments, and were willing to participate in the organoleptic test and fill out the assessment sheet honestly. Untrained panelists were chosen so that the research results could represent consumer perceptions of product acceptance in the market.

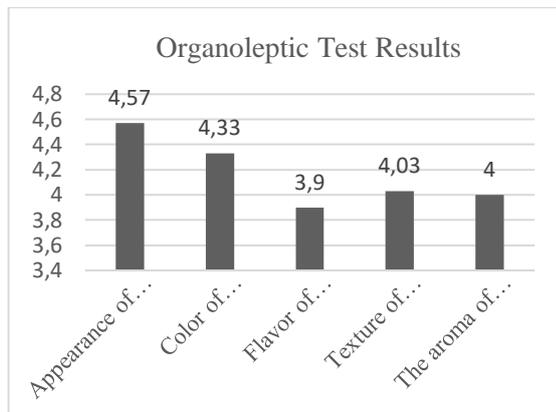
The assessment process was conducted in one session, where each panelist received a sample of Baygar Crunchies cookies and was asked to fill out a hedonic assessment sheet via Google Form. The parameters measured included appearance, color, aroma, taste, and texture. The instrument used was a hedonic rating sheet with a 5-point scale, where 1 = strongly dislike, 2 = dislike, 3 = neutral, 4 = like, and 5 = strongly like. Each parameter was assessed separately by the panelists, so that the results obtained could describe the level of consumer acceptance of each aspect of the cookies.

The calculation of the nutritional content of the product is based on the composition of the ingredients used in the formulation. The nutritional value obtained is then compared with the Nutrient Adequacy Rate (NAR) according to the 2019 Indonesian Ministry of Health standards to assess the product's contribution to meeting daily nutritional requirements.

The organoleptic test data obtained from the panelists' hedonic scores were processed by calculating the mean and standard deviation (SD) for each parameter, including appearance, color, aroma, taste, and texture. The results of the analysis were then presented in tables and graphs to facilitate interpretation.

3 RESULT

The organoleptic test results for Baygar Crunchies cookies were conducted by assessing five parameters, namely appearance, color, aroma, taste, and texture using a 1-5 hedonic scale. The panelists' assessment data was then averaged and presented in the following graph to show the level of consumer acceptance for each sensory assessment.



Based on the results table above, the appearance parameter obtained the highest score of 4.97 ± 0.50 , indicating that the panelists really liked the visual appearance of the cookies with their natural green color from spinach. The color parameter also received a high score of 4.33 ± 0.66 , showing that the addition of spinach contributed positively to the visual aspect of the product. For the aroma and texture parameters, the

average scores were 4.00 ± 0.87 and 4.03 ± 0.85 , respectively, indicating the “like” category. This shows that the use of arrowroot flour and spinach did not reduce the panelists' acceptance of the product's sensory characteristics. Meanwhile, the taste parameter obtained the lowest average score of 3.90 ± 0.92 , although it was still in the “like” category. This variation may be due to differences in panelists' preferences for the distinctive taste of arrowroot flour and spinach used in the formulation. Overall, the organoleptic test results show that cookies made from arrowroot flour with added spinach were well received by the panelists, indicating their potential for further development as functional cookies made from local ingredients.

In addition to the organoleptic test, an analysis of the nutritional content of Baygar Crunchies cookies was conducted in relation to daily nutritional requirements. The calculations were based on the energy, protein, fat, carbohydrate content, and estimated iron content. The results of the analysis were compared with the Nutrient Adequacy Rate (NAR) for adolescent girls aged 16-18 years. The results of the calculations are presented in the table below.

Nutritional results table & %RDA

Nutrients	.p	RDA	for %RDA
		Women (16-18 years old)	
Energy (kcal)	29.5 kcal	2100 kcal	1.40%
Protein (g)	0.17 g	65 g	0.26%
Fat (g)	1.70 g	70 g	2.42%
Carbohydrates (g)	3.40 g	300 g	1.13%
Iron (mg)	0.6 mg	15 mg	4%

Based on the table above, each 5 g cookie provides 29.5 kcal of energy, or about 1.4% of the RDA for adolescent girls. The protein, fat, and carbohydrate content is relatively small, but it can still be an additional source of energy from daily snacks. These cookies also contain about 0.6 mg of iron, which is equivalent to 4% of the daily RDA.

4 DISCUSSION

The discussion of the research results focuses on organoleptic testing and nutritional analysis of Baygar Crunchies cookies made from arrowroot flour fortified with spinach. Each sensory parameter, ranging from appearance, color, aroma, taste, to texture, plays an important role in determining the overall acceptability of the product. In addition, nutritional analysis also shows the extent to which this product can contribute to daily energy and nutritional needs, especially for the target group of adolescent girls.

Appearance received the highest score 4.57 ± 0.50 , indicating that the visual appearance of the product was considered attractive by the panelists. Visual appearance is a strong initial acceptance indicator because it influences taste expectations and the decision to try the product. This is in line with a study on the fortification of bread products with vegetables, which reported an increase in visual acceptance when the addition of vegetables produced attractive natural colors (Jyoti, Sangwan and Jood, 2022; Galla *et al.*, 2017)

Color received a high score 4.33 ± 0.66 . The green color produced by chlorophyll pigments in spinach tends to give a natural and healthy impression to functional products based on local ingredients, thereby increasing consumer interest. Literature on natural colorants and consumer acceptance explains that natural pigments such as chlorophyll can enhance visual appeal, especially if the color remains stable during processing and product presentation. However, chlorophyll is sensitive to heat, light, oxygen, and temperature, so the formulation process must be regulated to maintain the green color's appeal (Vega *et al.*, 2023; Magalhães *et al.*, 2024).

The aroma scored 4.00 ± 0.87 , indicating a favorable category. The addition of spinach generally produces a relatively neutral or mild aroma when used in reasonable amounts, either in pure or powdered form. Thus, the main aroma of the cookies, which comes from vanilla, margarine/butter, and sugar, remains dominant. These findings are in line with previous studies that found that the addition of vegetables to bakery products does not interfere with the aroma of the product, as long as their use is not excessive and they undergo processing stages such as blanching or dehydration, which can reduce the aroma of raw vegetables (Khan *et al.*, 2015; Jyoti, Sangwan and Jood, 2022)

The taste received the lowest score (3.90 ± 0.92) even though it was still in the likeable category. This decrease in score may be influenced by the vegetal or bitter taste of spinach, especially when used fresh or in high proportions, interactions between sugar or salt flavors and spinach compounds, and individual preferences for combinations of sweet and bitter flavors. Previous studies have shown that

the taste is well accepted when 5-10% spinach powder is used. Therefore, optimizing the proportion of spinach to around 5-10% while balancing the taste, for example through sugar, the addition of vanillin, or natural ingredients that can enhance the taste, has the potential to increase the taste score without reducing the nutritional value. (Galla *et al.*, 2017; Jyoti, Sangwan and Jood, 2022)

Texture obtained a score of 4.03 ± 0.85 , indicating a “like” category. The difference in texture compared to wheat flour-based cookies is influenced by the characteristics of arrowroot flour starch, which differs from wheat flour. Arrowroot flour has a high starch content with gelatinization characteristics that differ from wheat flour, which contains gluten, so arrowroot flour-based products tend to be more brittle and less elastic (Malki *et al.*, 2023). This characteristic actually supports the crispness of cookies. However, the formulation still needs to be optimized so that the texture is not too brittle or easily crumbled during processing and storage. Based on previous research, arrowroot flour is considered suitable for use in gluten-free products and produces a distinctive texture when processed properly (Lestari, Huriyati, and Marsono, 2017).

Overall, the organoleptic test results for Baygar Crunchies cookies are consistent with previous studies on cookies or biscuits fortified with vegetable powder or puree. Visual acceptance and color improve when natural colors are retained, while aroma and texture remain acceptable through appropriate processing methods. However, taste needs to be optimized at certain substitution levels. Several studies show that adding spinach at around 5-10% results in an optimal combination of nutritional

value and sensory acceptance (Jyoti, Sangwan and Jood, 2022), while adding more than this amount has the potential to reduce flavor and texture scores (Galla *et al.*, 2017).

In addition to sensory aspects, it is also important to evaluate products based on their nutritional content. Nutritional analysis of Baygar Crunchies cookies provides information about the product's contribution to daily energy and nutritional needs, especially for adolescent girls as the main target group. Each 5 g cookie provides 29.5 kcal of energy, or about 1.4% of the RDA for energy for girls aged 16-18 years, which is 2100 kcal/day. The macronutrient content is relatively small, namely 0.17 grams of protein, which meets 0.26% of the RDA, 1.70 grams of fat, which meets 2.43% of the RDA, and 3.40 grams of carbohydrates, which meets 1.13% of the RDA. Thus, these cookies can serve as an additional energy snack in the daily diet but not as a primary source of macronutrients. Interestingly, this product contributes 0.6 mg of iron, which meets 4% of the RDA for iron for adolescent girls, which is 15 mg/day. This value is quite significant, considering that one cookie can meet part of the daily iron requirement.

5 CONCLUSIONS

This cookie product is innovative because it uses arrowroot flour (*Maranta arundinacea L.*) as a substitute for wheat flour, resulting in a gluten-free product that also supports local food diversification. The addition of amaranth (*Amaranthus sp.*) as a source of iron, fiber, vitamins, and antioxidants makes these cookies not just a snack but also a

functional food with health benefits. Organoleptic test results show that these cookies are well accepted by panelists, with average scores ranging from like to very like across all parameters. Appearance received the highest score, indicating strong visual appeal, while taste received a relatively lower score, although it was still within the acceptable range for panelists. Therefore, Baygar Crunchies has the potential to be further developed as a functional snack based on local foods that supports nutritional needs, especially for groups vulnerable to anemia, such as adolescent girls.

Further research is still needed to analyze the nutritional content of the product comprehensively, including proximate analysis, vitamins, minerals, and testing product stability during storage. In addition, formula optimization is needed to improve taste acceptance, for example by adjusting the proportion of spinach, sugar content, and adding natural flavors. Consumer testing with a wider coverage is also important to determine public preferences, especially among teenage girls who are vulnerable to anemia. With these various potentials, Baygar Crunchies cookies have great opportunities to be developed into commercial functional snacks with healthy food claims, while supporting efforts to diversify food based on local Indonesian ingredients.

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