

The Effect of Corn Flour Substitution on Moisture Content and Organoleptic Properties in Cookies (*Zea Mays L*)

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ABSTRACT

*This study aimed to determine the effect of corn flour (*Zea mays L.*) substitution on the moisture content and organoleptic characteristics of cookies, including color, aroma, texture, and taste. The study employed an experimental method with a quantitative approach using a Completely Randomized Design (CRD) consisting of four treatments: A0 (0%), A01 (15%), A02 (25%), and A03 (35%), each with three replicates, resulting in 12 experimental units. The cookie production process involved substituting corn flour for wheat flour; moisture content was then analyzed using the oven method, and organoleptic testing was conducted with 15 panelists using a 1–5 hedonic scale. The results indicated that corn flour substitution influenced the moisture content and organoleptic characteristics of the cookies. The highest moisture content was obtained in treatment A0 at 4.56%, while the lowest moisture content was found in treatment A01 at 2.46%. The organoleptic test results showed that treatment A02 received the highest score for color at 3.80, while the highest scores for aroma, texture, and taste were obtained in treatment A0 at 4.00, 3.93, and 4.00, respectively. In general, increasing corn flour substitution caused the color to change to a more yellowish-brown and made the cookies more brittle due to the absence of gluten in corn flour. Based on all test parameters, treatment A02 with 25% corn flour substitution showed the most balanced results and was still acceptable to the panelists. This study indicates that corn flour has the potential to be used as a wheat flour substitute in the development of cookies based on local food ingredients.*

Keywords: *Corn Flour, Cookies, Moisture Content, Organoleptic, Flour Substitution*

INTRODUCTION

Corn is a strategic local food commodity in Indonesia that plays a vital role in supporting national food security and the development of a food industry based on local resources. In addition to being the primary source of carbohydrates in several regions, corn also holds potential as a raw material for various value-added processed products. The development of corn-based products is increasing in line with the need for healthier and more affordable food diversification. Rosyada and Mulyatiningsih (2020) state that the utilization of corn in the form of processed products such as cookies can strengthen food security through the diversification of public consumption. Meanwhile, Kumalasari and Devira (2024) emphasize that corn flour has the potential to serve as a substitute for wheat flour in bakery products due to its high availability and functional characteristics that support sustainable local food innovation and the continuous improvement of economic value for local farmers in Indonesia.

Corn-based food diversification is a key strategy in reducing dependence on imported food ingredients such as wheat flour. This effort aligns with national food security policies that emphasize the optimal utilization of local resources. The development of various corn-based processed products offers opportunities to increase value-added and expand consumer choices. Kumalasari and Devira (2024) state that corn flour can be utilized as a substitute ingredient in bakery products due to its properties that support food processing. Furthermore, food innovations based on local ingredients can enhance product diversity and support national food self-reliance. Thus, the development of corn-based products focuses not only on economic aspects but also on sustainably improving the quality of public consumption. This reinforces corn's role as a strategic commodity within Indonesia's sustainable national food system moving forward.

Corn flour is one of the processed forms of corn widely used in the food industry as an alternative raw material to replace wheat flour. This flour is high in carbohydrates, dietary fiber, and bioactive compounds such as carotenoids, which act as antioxidants. In food processing, corn flour is gluten-free, giving it a different texture compared to wheat flour (). Sachriani and Mariani (2024) explain that these compositional differences can influence the physical, chemical, and organoleptic properties of the final product. Nevertheless, corn flour

holds great potential for the development of healthier functional food products based on local ingredients. Therefore, the use of corn flour in the food industry must be properly formulated to produce products of optimal quality that are acceptable to consumers and support sustainable and innovative national food diversification.

Cookies are a popular bakery product among the public due to their sweet taste, crisp texture, and relatively long shelf life. In the manufacturing process, flour serves as the primary ingredient that forms the product's structure. The use of corn flour as a substitute for wheat flour has been extensively studied in the development of locally sourced cookies. Hardiyanti, Kadirman, and Rais (2021) state that substituting corn flour in cookie production can affect physical characteristics and consumer acceptance levels. Additionally, Saputra, Rusilanti, and Mariani (2020) also demonstrated that corn flour-based cookies are well-received when formulated appropriately. Therefore, the use of local ingredients in cookie production serves as a potential food innovation alternative to enhance the value of agricultural commodities. Agniya Fadiati and Cahyana (2025) further noted a significant increase in the nutritional value of locally sourced cookies.

The use of corn flour as a substitute for wheat flour in cookie production presents several challenges, particularly regarding the absence of gluten, which plays a crucial role in forming the elastic structure of baked goods. This condition can result in a more brittle cookie texture if the formulation is not properly adjusted. Putri (2024) states that an excessively high corn flour substitution rate can reduce consumer acceptance of the product. Additionally, Purwanti and Pratami (2024) explain that the addition of other ingredients is necessary to improve the texture and physical characteristics of the product. Oktaviana et al. (2023) also emphasize that ingredient formulation significantly influences the physical and organoleptic quality of processed food products. Therefore, an appropriate formulation is required to ensure that corn flour-based cookies achieve optimal quality. Furthermore, moisture content also affects the shelf life and quality of the cookies.

Based on the above discussion, the development of corn-flour-based cookies represents a local food innovation with the potential to enhance the value of corn as a commodity in Indonesia. The utilization of this local ingredient also supports the national sustainable food diversification program. However, further research is needed regarding the appropriate level of

corn-flour substitution to achieve products with optimal physical, chemical, and organoleptic characteristics. Previous research by Hardiyanti et al. (2021) and Putri (2024) indicates that ingredient formulation significantly influences product quality and consumer acceptance. Therefore, the development of corn flour-based cookie products must be conducted in a measured and scientific manner to produce products that are popular with the public and have good nutritional value. This is also expected to strengthen the sustainable local corn-based food industry in Indonesia in the future.

METHODS

2.1 Research Method and Type

The type of research used is experimental research with a quantitative approach aimed at determining the effect of corn flour substitution on the moisture content and organoleptic test of cookies under controlled conditions. The research design used was a Completely Randomized Design (CRD) with four treatments: A0 (0%), A01 (15%), A02 (25%), and A03 (35%), each repeated three times, resulting in 12 experimental units. A Completely Randomized Design was used because it can control experimental variation and provide more objective results when comparing treatments in food research based on the substitution of local ingredients.

2.2 Research Location and Time

This study was conducted at the Integrated Laboratory of the Faculty of Agricultural Product Technology, University of Southeast Sulawesi, while moisture content analysis was performed at Halu Oleo University in Kendari, which possesses adequate food testing facilities. The study was carried out in several stages, namely ingredient preparation, cookie production, moisture content analysis, and organoleptic testing, until all data were collected. Moisture content testing was performed using standard laboratory methods to ensure accurate, valid, and scientifically accountable results in food product quality analysis.

2.3 Equipment and Materials

The equipment used in this study included an oven, a microwave, a mixer, baking pans, a spatula, molds, an analytical balance, aluminum cups, a desiccator, and tongs used in the production process and for analyzing the moisture content of the cookies. The use of standard laboratory equipment is crucial to ensure the precision and accuracy of test results. The

ingredients used include corn flour, wheat flour, chicken eggs, granulated sugar, margarine, butter, powdered milk, baking powder, and vanilla powder, as well as distilled water and silica gel for moisture content analysis, which play a role in determining the texture, flavor, and final quality of the cookies.

2.4 Production Procedure and Analysis Parameters

The cookie production process involves mixing eggs, sugar, margarine, butter, vanilla, and baking powder until homogeneous, then adding wheat flour and cornstarch according to the treatment (15%, 25%, 35%) along with powdered milk until the dough is smooth. The dough is shaped uniformly and baked at 150°C for 30 minutes, then cooled to room temperature. The formulation of ingredients in baked goods significantly influences sensory characteristics such as texture, taste, aroma, and color, so it must be executed precisely. The analyzed parameters include moisture content and organoleptic testing using 15 panelists on a 1–5 hedonic scale.

2.5 Data Analysis

The research data were analyzed using Analysis of Variance (ANOVA) in a Completely Randomized Design (CRD) to determine the effect of corn flour substitution on the moisture content and organoleptic evaluation of the cookies. ANOVA was used to test differences among more than two treatments simultaneously in the experimental study. If significant differences were found, the Honest Significant Differences (HSD) test was conducted to determine the best treatment among the groups. The statistical model used was $Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$, indicating that the observed results were influenced by the mean, treatment, and experimental error.

RESULTS AND DISCUSSION

RESULTS

3.1 Description of Cookie Products

The results of the study indicate that corn flour (*Zea mays L.*)-based cookies produced under each treatment exhibit distinct physical characteristics, including color, aroma, texture, and brittleness. The cookies generally have a flat, round shape with a crisp texture and a light brown color. Differences in the corn flour substitution levels (0%, 15%, 25%, and 35%) resulted in variations in the final product characteristics. In treatment A0 (no substitution), the cookies have a paler color and a more compact texture, whereas in treatments with added corn

flour, the color tends to be darker and the texture becomes more brittle. This indicates that corn flour contributes to changes in the physical properties of the resulting cookies.

3.2 Moisture Content of Cookies

The results of the moisture content analysis showed variations in values across each corn flour substitution treatment. Treatment A0 (0%) had the highest moisture content at 4.56%. This value indicates that cookies without corn flour substitution have a higher water-holding capacity compared to the other treatments. Treatment A01 (15%) showed a significant decrease in moisture content to 2.46%, which was the lowest value in this study. Furthermore, treatment A02 (25%) had a moisture content of 2.95%, while A03 (35%) showed an increase back to 3.46%.

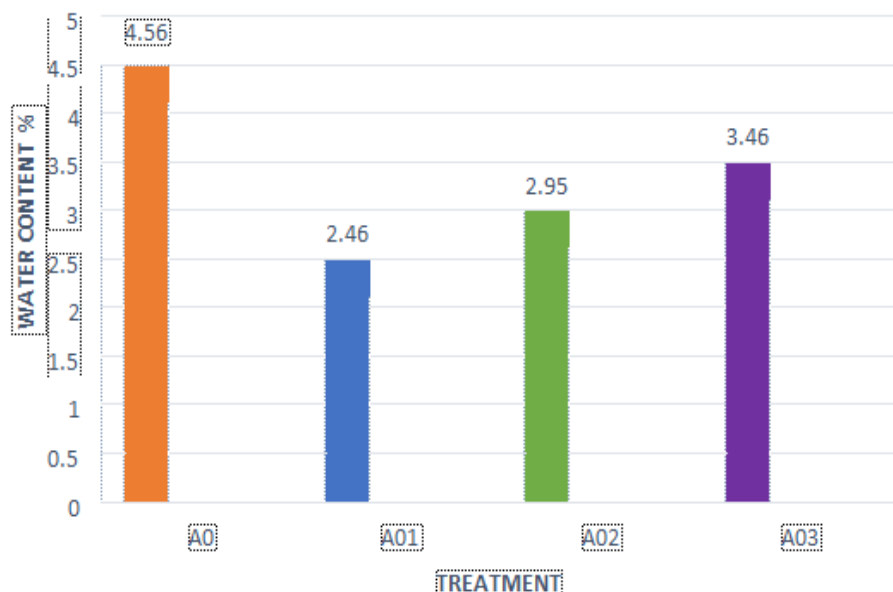


Figure 1. Graph of the Effect of Corn Flour Substitution on Cookie Moisture Content

In general, the results indicate that the moisture content of the cookies fluctuates as the level of corn flour substitution increases. These changes in moisture content are not linear but exhibit an alternating pattern of increases and decreases across the different treatments. This suggests that variations in ingredient composition have distinct effects on the physical properties of the dough, particularly regarding the ability of to bind and retain water during processing. The differences in characteristics between wheat flour, which contains gluten, and corn flour, which does not contain gluten, are the primary factors influencing these results.

Additionally, the baking process at high temperatures plays a role in reducing moisture content through evaporation, resulting in varying levels of water loss for each formulation. Thus, it can be concluded that ingredient composition significantly determines the stability of moisture content in the final cookie product, both during the baking process and after cooling.

3.3 Organoleptic Test

3.3.1 Color

The results of the color organoleptic test indicate that panelists' overall preference for the cookies generally fell within the "somewhat liked" to "liked" categories. This suggests that the color of the cookies produced from various corn flour substitution treatments was still acceptable to panelists, despite differences in color intensity across formulations. Treatment A02 (25% corn flour substitution) received the highest average score of 3.80, indicating that at this substitution level, the cookies' color was rated as the most appealing and consistent with typical cookie characteristics. Furthermore, treatment A01 (15%) had a score of 3.73, which still falls within the "like" category, while treatments A0 (0%) and A03 (35%) each received the lowest score of 3.60. The relatively similar scores for these two treatments indicate that the panelists had nearly identical levels of acceptance regarding the cookies' color, despite the differing visual characteristics resulting from variations in ingredient composition.

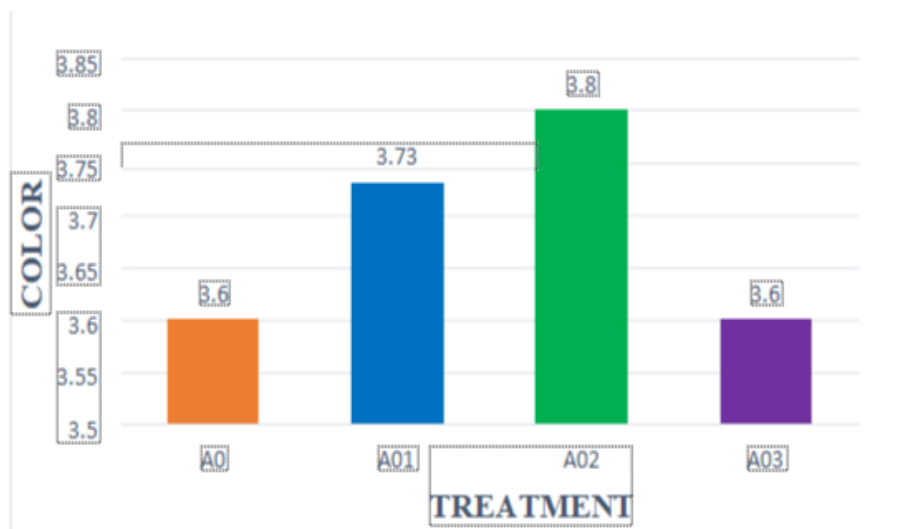


Figure 2. Graph of the Effect of Corn Flour Substitution on Cookie Color

These results indicate that the color of the cookies undergoes a fairly noticeable change as the level of corn flour substitution increases in each treatment. This color change is

characterized by a trend toward increasingly yellow to light brown hues compared to the control treatment without substitution. This phenomenon is influenced by the presence of natural pigments in corn flour, particularly carotenoids, which impart a distinctive color to the final product. Additionally, the heating process during baking plays a significant role in color formation through the Maillard reaction between sugars and proteins in the dough. As the corn flour substitution increases, the intensity of the color in the resulting cookies becomes more pronounced, creating visual differences that may influence panelists' acceptance of the product.

3.3.2 Aroma

The results of the aroma organoleptic test showed that the panelists' preference for the cookies' aroma fell into the "like" to "somewhat like" categories. Treatment A0 (without corn flour substitution) received the highest average score of 4.00 in the "like" category, indicating that the aroma of the cookies in this treatment was most preferred by the panelists. Treatment A03 with a 35% corn flour substitution received a score of 3.93, followed by treatment A02 at 3.73, while treatment A01 received the lowest score of 3.60. These score differences indicate that the addition of corn flour affects the aroma of the resulting cookies. The higher the corn flour substitution level, the more pronounced the characteristic corn aroma in the cookies becomes, resulting in distinct aroma characteristics for each treatment. Additionally, the baking process also influences the formation of the characteristic cookie aroma due to the heating reactions of the ingredients during processing.

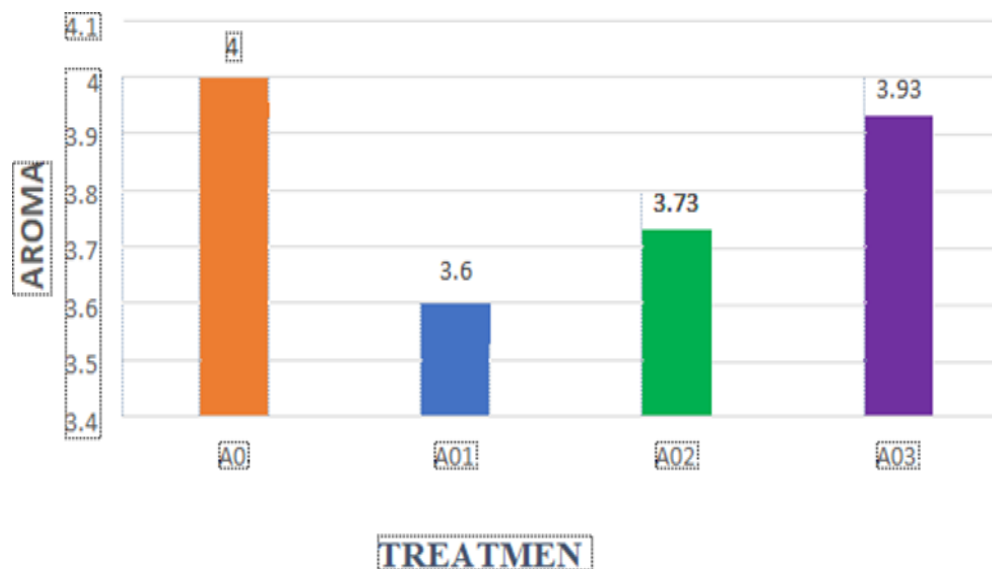


Figure 3. Graph of the Effect of Corn Flour Substitution on Cookie Aroma

These results indicate that the aroma of the cookies is significantly influenced by the composition of ingredients used in each treatment. Cookies without corn flour substitution (A0) have a more dominant aroma derived from butter, milk, and wheat flour, resulting in a more familiar and preferred cookie aroma among the panelists. Meanwhile, the addition of corn flour in treatments A01, A02, and A03 altered the product's aroma characteristics. The higher the concentration of corn flour used, the more pronounced the characteristic corn aroma in the cookies becomes, creating a distinct aroma difference compared to cookies without substitution. In addition to being influenced by raw materials, the aroma of cookies is also formed during the baking process due to heating reactions between sugar, fat, and protein, which produce the characteristic aroma of baked goods. Therefore, differences in ingredient formulations affect the intensity and character of the aroma produced in each treatment.

3.3.3 Texture

The results of the texture organoleptic test showed that the panelists' preference for the cookies' texture fell into the "somewhat liked" to "liked" categories. Treatment A0 (without corn flour substitution) received the highest average score of 3.93, indicating that the texture of the cookies in this treatment was most preferred by the panelists. Treatment A02 with 25% corn flour substitution received a score of 3.86, followed by treatment A03 at 3.80, while treatment A01 with 15% substitution received the lowest score of 3.40. These score differences indicate that corn flour substitution affects the texture characteristics of the resulting cookies. In general, the panelists rated the texture of the cookies in each treatment as acceptable, although there were differences in the levels of crispness, brittleness, and density of texture between treatments due to variations in the composition of the ingredients used.

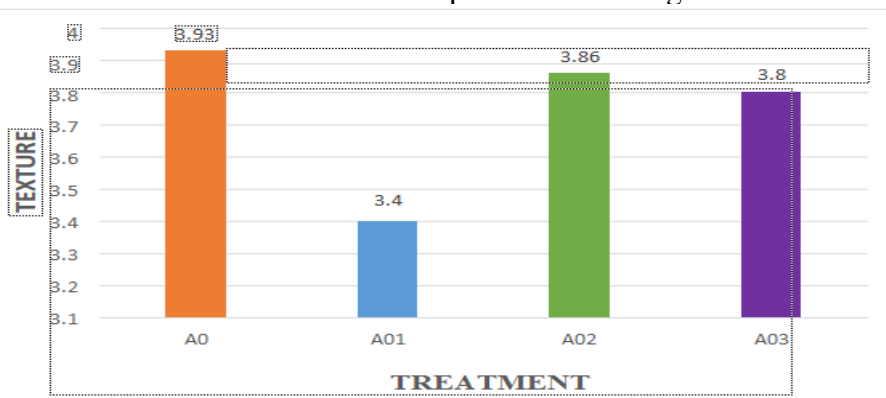


Figure 4. Graph of the Effect of Corn Flour Substitution on Cookie Texture

These results indicate that the texture of the cookies changed as the level of corn flour substitution increased in each treatment. These changes were evident in the differences in the crispness, brittleness, and density of the resulting cookies. The decrease in texture values in treatments with higher corn flour concentrations suggests that the addition of corn flour affects the dough structure during the mixing and baking processes. Gluten-free corn flour reduces the dough's ability to form a compact structure compared to wheat flour. Consequently, the resulting cookies tend to be more brittle and less dense. Additionally, the baking process also influences the formation of the final product's texture due to water evaporation and changes in starch structure during heating.

3.3.4 Taste

The results of the organoleptic taste test indicate that the panelists' preference for the cookies' taste falls into the "like" category. Treatment A0 (without corn flour substitution) received the highest average score of 4.00, indicating that the cookies in this treatment were most preferred by the panelists. Meanwhile, treatments A01, A02, and A03 each received the same score of 3.93. This score indicates that the addition of corn flour up to a 35% substitution level is still acceptable to the panelists and does not result in a significant difference in the flavor of the resulting cookies. Although there was a slight decrease in scores compared to the treatment without substitution, overall, all treatments were still in the "preferred by panelists" category based on the results of the taste organoleptic test.

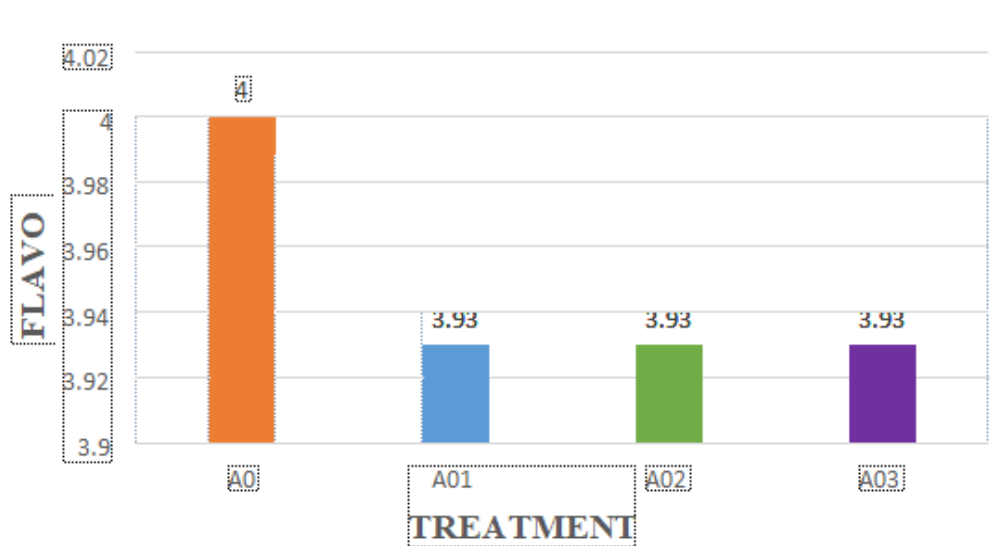


Figure 5. Graph of the Effect of Corn Flour Substitution on Cookie Flavor

These results indicate that differences in the level of corn flour substitution do not cause significant changes in the taste of the resulting cookies. This is evident from the relatively similar average scores for each treatment, which all remain in the "preferred by panelists" category. However, there is a slight decrease in the level of preference for treatments with added corn flour compared to the control treatment. This decrease is likely due to changes in flavor characteristics resulting from the use of corn flour, which has a distinct flavor profile different from wheat flour. As the corn flour substitution level increases, the characteristic corn flavor in the cookies becomes more pronounced, thereby affecting the panelists' perception of the balance between sweet and savory flavors in the product. However, overall, adding corn flour up to 35% still produces cookies with a flavor that is acceptable and preferred by the panelists.

Overall, the research results indicate that corn flour substitution affects the physical and organoleptic characteristics of the resulting cookies. These effects are evident in changes to several test parameters, particularly moisture content, color, and product texture across each substitution treatment. Changes in moisture content indicate differences in the ingredients' ability to bind and retain water during the baking process, while changes in color are influenced by the natural pigments in corn and the browning process during heating. Additionally, the texture of the cookies also changed due to differences in the characteristics of corn flour and wheat flour in forming the dough structure. Meanwhile, the taste and aroma parameters showed relatively small differences between treatments, so they were generally still acceptable to the panelists. Based on the results of all test parameters, the treatment with 25% corn flour substitution (A02) showed relatively more stable and balanced results because it had a fairly good level of panelist acceptance in terms of color, aroma, texture, and taste, and produced cookie physical characteristics that were still in line with the expected product quality.

DISCUSSION

The research results indicate that corn flour substitution affects the moisture content of the resulting cookies. The treatment without corn flour substitution had a higher moisture content compared to the treatment with added corn flour. This condition suggests that differences in ingredient composition affect the dough's ability to bind water during the mixing

and baking processes. Corn flour has a lower gluten content compared to wheat flour, so the water retention capacity of the product also decreases. The reduction in moisture content in the cookies is influenced by the baking process, which causes water to evaporate more quickly during heating. These findings align with the research by Paesani et al. (2020), which states that the use of corn flour in gluten-free cookies affects the moisture content and physical characteristics of the product due to changes in starch structure during baking. Additionally, Mancebo, Picón, and Gómez (2015) explain that differences in flour types in cookies can affect the stability of moisture content and the crispness of the final product.

The color of the cookies in this study showed a shift toward a more yellowish-brown hue as the percentage of corn flour substitution increased. This color change was influenced by the carotenoid pigment content in corn, which imparts a natural color to the cookie products. Furthermore, the high-temperature baking process triggers the Maillard reaction, resulting in a darker color compared to the treatment without substitution. Treatment A02 received the highest panelist preference because the resulting color was considered more appealing and consistent with the typical characteristics of cookies. These findings are supported by the research of Belorio, Sahagún, and Gómez (2019), which explains that the use of corn flour can enhance the color intensity of baked goods due to the presence of natural pigments and the effects of the heating process. Research by Roman et al. (2019) also noted that color changes in cookies are significantly influenced by the composition of starch and sugar during the baking process.

The aroma of the cookies in this study was influenced by the level of corn flour substitution used in the product formulation. Cookies without substitution had a more dominant aroma derived from butter and wheat flour, whereas the addition of corn flour produced a distinct corn aroma that became more pronounced at higher concentrations. The aroma of baked goods is formed from a combination of ingredients and the baking process, which produces volatile compounds. Reactions between sugar, protein, and fat during baking generate characteristic aromas that influence panelists' preference for the product. The study results indicate that the aroma of cookies with corn flour substitution remains acceptable to panelists up to a 35% substitution level. Research by Hamdani, Wani, and Bhat (2021) explains that the use of non-wheat flours in bakery products can affect aroma due to changes in volatile

components during the baking process. Additionally, Culetu et al. (2021) state that the aroma characteristics of gluten-free products are significantly influenced by the type of flour used in the product formulation.

Cookie texture is one of the key parameters in determining consumer acceptance of the product. The results of the study indicate that increasing corn flour substitution affects the resulting cookie texture. The treatment without substitution produced a crispier and more compact texture compared to the treatment with added corn flour. Since corn flour contains no gluten, the dough structure becomes more brittle and less elastic during the cookie forming process. Texture changes are also influenced by starch content and moisture levels in the product during baking. Nevertheless, treatment A02 still demonstrated a fairly good level of panelist acceptance compared to the other treatments. These results align with the study by Mancebo, Rodríguez, and Gómez (2016), which stated that the use of non-wheat flour in cookies can affect texture due to changes in the protein and starch structure of the dough. The study by Paesani et al. (2020) also showed that corn flour substitution affects the crispness and structural stability of gluten-free cookies.

Overall, the study results indicate that corn flour substitution affects the physical and organoleptic characteristics of cookies. The most noticeable changes were observed in moisture content, color, and texture, while aroma and taste showed relatively minor differences across treatments. Treatment A02, with a 25% corn flour substitution, yielded the most balanced results across all testing parameters, as it produced an appealing color, a texture that remained crisp, and flavor and aroma that were still preferred by the panelists. These findings suggest that corn flour has potential as a wheat flour substitute in cookies made with local ingredients. The study by Culetu et al. (2021) explains that the use of local flours in gluten-free bakery products can enhance functional value and food diversification. Additionally, Belorio et al. (2019) state that the use of corn flour in bakery products can yield sensory characteristics that remain acceptable to consumers when used in appropriate formulations.

CONCLUSION AND IMPLICATIONS

Based on the research results, it can be concluded that the substitution of corn flour (*Zea mays L.*) affects the moisture content and organoleptic characteristics of cookies, including

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color, aroma, texture, and taste. Differences in the level of corn flour substitution cause changes in the physical characteristics of the product, particularly in moisture content, color, and texture. The highest moisture content was obtained in the treatment without corn flour substitution, while the addition of corn flour tended to reduce moisture content due to the low gluten content in corn flour. Regarding organoleptic parameters, the color of the cookies became more yellowish-brown as the corn flour substitution increased due to the influence of carotenoid pigments and the browning process during baking. The aroma and taste of the cookies remained acceptable to the panelists up to a 35% substitution level, although there was a slight decrease in likability compared to the treatment without substitution. Meanwhile, the texture of the cookies became more brittle at higher substitution levels because corn flour lacks gluten, which plays a role in dough structure formation. Based on all test parameters, treatment A02 with a 25% corn flour substitution showed the best results because it produced more balanced physical and organoleptic characteristics and had a fairly good level of panelist acceptance.

The results of this study indicate that corn flour has good potential as a substitute for wheat flour in the production of cookies made from local ingredients. The use of corn flour can support food diversification programs, reduce dependence on imported wheat flour, and increase the utilization of economically valuable local commodities. Furthermore, a 25% corn flour substitution formulation can serve as an alternative in bakery product development, as it produces cookies with physical and organoleptic qualities that remain acceptable to consumers. This study can also serve as a reference for the local food industry in developing innovative, value-added, and competitive corn-based products for the market.

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