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Influence of Bamboo Shoots (*Dendrocalamus asper*) Flour Addition and Baking Temperatures on the Sensory and Physical Characteristics of Cookies

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ABSTRACT

This study examines the effects of incorporating bamboo shoot flour and varying baking temperatures on the quality of cookies, in an effort to enhance their palatability and consumer acceptability. Utilizing a factorial randomized block design, this investigation was carried out in triplicate, considering two key factors: the proportion of bamboo shoot flour incorporated (A) and the baking temperature (B) at three different levels (140°C, 145°C, and 150°C). It was found that the use of bamboo shoot flour in cookie production is safe, with a recorded HCN content of 4.86 ppm, well beneath the maximum safety standard for consumption. However, bamboo shoot flour demonstrated mild antioxidant activity, attributed to the high temperatures and prolonged processing times employed in preparation, which likely diminished the antioxidant content. Significant effects of both bamboo shoot flour incorporation and baking temperature on the sensory and physical properties of the cookies were observed. The most desirable ratio of bamboo shoot flour to wheat flour was found to be 1:2, and the optimal baking temperature range was between 140°C to 145°C. These parameters were found to yield the highest preference across nearly all evaluated metrics, suggesting a potential strategy for enhancing the use of underutilized bamboo shoots in snack foods.

1. INTRODUCTION

Cookies, being the most consumed bakery product, offer a wide variety of flavors, and are characterized by a high-fat, crunchy texture derived from a soft dough [1]. Their extended shelf life, when properly packaged, further contributes to their popularity [2]. However, the high sucrose content, typical of these cereal-based foods, is associated with health problems such as obesity, diabetes, and tooth decay [3]. Thus, strategies aimed at enhancing the nutritional profile of cookies are warranted. One such approach entails the use of composite flours. Yet, replacement of fundamental ingredients can significantly alter the sensory properties of the cookies.

Wheat flour, commonly known as cake flour, is a primary ingredient in cookie production. Its high starch content, a complex carbohydrate insoluble in water, combined with gluten, a protein responsible for dough elasticity, make it an integral component of cookies [4]. The gluten formation is proportional to the protein content of the flour, with an increased protein content leading to enhanced gluten production [5]. Consequently, cookies made with alternative flours, such as non-cake flour, tend to fall under the category of soft dough cookies.

The baking process, essential in cookie production, influences the ingredients' color, texture, aroma, and flavor. Baking serves the dual purpose of maturing ingredients and imparting a characteristic aroma [6]. The choice of flour and baking conditions play a crucial role in determining the crunchiness of cookies. Despite its significance, the baking process can adversely impact the nutritional value of the ingredients due to the heat exposure and the type of ingredients used [6]. A typical baking process is performed at 175°C [7]. However, this heat exposure can damage nutrients such as proteins and antioxidants. To minimize nutritional loss while ensuring the cookies' desired characteristics, lower baking temperatures between 140°C – 150°C are proposed in this study.

Bamboo shoots, the young offshoots of bamboo plants, present an opportunity to diversify food product development [8]. They are low in fat content and high in carbohydrates, potassium, dietary fibers, vitamins, amino acids, and antioxidants such as flavones, phenols, and steroids [9]. Nevertheless, they contain the toxic compound cyanide acid (HCN), which imparts a bitter taste and can pose health risks if consumed above safety thresholds [10]. HCN levels deemed safe for food ingredients are less than 50 mg/kg fresh ingredients [11, 12]. Thus, preparatory measures are required to ensure the HCN content in bamboo shoot flour is within permissible levels.

Rich in fiber, ranging between 0.4 to 3.97 g /100 g, bamboo shoots offer health benefits such as improved bowel movements, colon stability, detoxification, and disease prevention [10]. This study aims to harness their potential by incorporating bamboo shoot flour into cookies, thereby increasing their economic value and diversifying their use. However, the addition of bamboo shoot flour to cookies may introduce a bitter taste, necessitating optimal utilization ratios to maintain consumer acceptability.

This research, therefore, investigates the impact of incorporating bamboo shoot flour and varying baking temperatures on the sensory and physical attributes of cookies. The goal is to enhance the utilization of bamboo shoots, a local food substitute for wheat flour in cookie production, thereby reducing reliance on wheat flour. This approach is expected to increase the usage and economic value of bamboo shoots.

2. MATERIALS AND METHODS

2.1 Bamboo shoots raw materials

The bamboo shoots used in this study were *Betung* bamboo shoots variety obtained from Bogor, West Java, Indonesia. The bamboo shoots raw material was fresh bamboo shoots in the form of cone shape, without preservation or temporary storage. The preparation of bamboo shoot flour began by selecting healthy bamboo shoots without any defects or disease, then washing and trimming to remove the skin and fine hairs. The bamboo shoots were chopped into 2-mm thick pieces, approximately 3 to 4 cm in diameter, and then washed with water and boiled at 80℃ with a 1% salt solution for 10 minutes to reduce the HCN level. The bamboo shoots were then drained, re-boiled with water for 20 minutes to dissolve the salt and cyanide salt bonds, and then drained again. The boiled bamboo shoots were dried in a cabinet dryer at 45℃ for 45 minutes, and then ground into flour using a disk mill. The flour was sieved with a mesh-80 sieve to produce uniform-sized ingredients.

2.2 Cookies preparation

The processing of cookies started with the mixing of margarine, icing sugar, and egg yolk using a mixer. The ingredients were placed into a basin, then blended using the mixer until creamy. Subsequently, milk powder, vanilla, salt, baking powder, and a combination of bamboo shoot flour and cake flour were added and mixed with the mixer until a dough was formed. The proportion of bamboo shoot flour and cake flour was adjusted according to the treatment variation. To make bamboo shoot cookies, for every 250 g of the mixture consisting of: 90 g of mixture flour (the mixture was according to treatment ratio), 57.5 g of margarine, 25 g of egg yolk, 61.25 g of powdered sugar and other ingredients for a total of 250 g.

The dough was shaped into rounds with a diameter of 3 cm and thickness of 0.5 cm and placed on a baking sheet.

The cookies were baked in an oven at temperatures of 140℃, 145℃, and 150℃. After baking, the cookies were left to cool to room temperature and were then subjected to chemical, physical, and sensory evaluations.

2.3 Experimental design

This research used a 3×3 factorial design using randomized block design (RBD) with three replications, resulting in 27 experimental units. Factor A represented the ratio between bamboo shoot flour and cake flour, with three levels: a1 (1:2), a2 (2:1), and a3 (3:1). These ratios were chosen to see how significant character the cookies would have if the ratio of bamboo shoot flour was less and more than wheat flour. Factor B represented the baking temperature, with three levels: b1 (140℃), b2 (145℃), and b3 (150℃). Blocks were represented as repetitions, where each repetition was carried out on a different day. In each replication (block), experiments were carried out on all treatments (9 treatments).

2.4 HCN content analysis of bamboo shoots flour

HCN content analysis was performed on bamboo shoots flour. The analysis was performed using the Titration Method [13]. A refined sample weighing between 5 to 10 grams was taken and placed into an Erlenmeyer flask. 200 mL of distilled water was added, then the flask was tightly closed. The mixture was left to sit for 2 to 3 hours, then transferred to a distillation flask. The distillate was collected in an Erlenmeyer flask containing a 2.5% solution of NaOH. The distillation process was stopped once 150 mL was obtained. The distillate was then mixed with 8 mL of NH_4OH_6N and 2 mL of KI indicator and titrated with $AgNO_3$ solution until a muddy sediment was formed. The HCN content was calculated using Eq. (1):

$$HCN_c = \frac{(V_1-V_2)\times 0.54\times 1000}{w_s} \tag{1}$$

where, HCN_c is HCN content in the sample (ppm), V_1 is volume of $AgNO_3$ at initial condition (mL), V_2 is volume of $AgNO_3$ after finish the titration (mL), 0.54 was conversion value (1 mL of 0.02 N $AgNO_3$=0.54 mg of HCN) and w_s is weight of the sample (g).

2.5 Water content analysis of bamboo shoots flour

Water content analysis was performed on bamboo shoots flour. The water content was analyzed using the Gravimetric Method (AOAC, 1995). The sample was weighed to obtain a weight of 1 to 2 g and placed in a cup. The cup was then placed in an oven with a temperature range of 102 to 105℃ and left for 3 hours. The sample was then cooled in a desiccator for 5 minutes and re-weighed. The process was repeated until a constant weight was obtained. The formula for determining the water content was calculated using Eq. (2):

$$M_c = \frac{(w_i)-w_f}{w_i}\times 100\% \tag{2}$$

where, M_c is moisture content in wet basis (%), w_f is weight of the sample after constant (g), w_i is weight of the initial sample (g).

2.6 Antioxidant activity analysis of bamboo shoots flour

Bamboo shoots flour also been analyzed for the antioxidant activity using DPPH method. The DPPH radical scavenging activity was assessed using the protocol described by previous published papers [14, 15]. 2.5 mg of extract was weighed, then dissolved in a 25 mL methanol volumetric flask, and the volume was marked with a limit of 100 ppm for the main solution. The main solution was pipetted in 0.5 mL increments to create test solution concentrates of 10 ppm, 20 ppm, 30 ppm, 40 ppm, 50 ppm, 60 ppm, and 70 ppm. 1 mL of DPPH solution was added to each volumetric flask, then the volume was completed with methanol to the limit mark. A blank solution was created by pipetting 1 mL of DPPH solution into a 25 mL volumetric flask, then adding methanol until the volume reached the limit mark.

The DPPH absorbance was measured using a visible light spectrophotometer at 517 nm wavelength. The antioxidant ability was determined by measuring the decrease in DPPH solution absorbance due to the addition of samples. The DPPH solution absorbance value before and after the addition of the extract was calculated as percent inhibition using Eq. (3):

$$DPPH_i = \frac{Abs_b - Abs_s}{Abs_b} \times 100\% \quad (3)$$

where, $DPPH_i$ is the ability of the sample to inhibit DPPH (%), Abs_b is absorbance with no sample (unitless), Abs_s is absorbance of sample (unitless).

The parameter used in the DPPH method is the 50% inhibition concentration (IC50), which represents the concentration needed to reduce the activity of free radicals by 50%. The lower the IC50 value, the higher the antioxidant activity of a sample. According to Molyneux [16], if the IC50 value is less than 50 ppm, the antioxidant activity is considered very strong; if it is between 50 to 100 ppm, it is considered strong; if it is between 101 to 150 ppm, it is considered moderate; and if it is above 150 ppm, it is considered weak. Based on this classification, the IC50 value of bamboo shoot flour falls into the weak category.

2.7 Sensory tests of cookies

The sensory evaluation was performed using the hedonic test method as also used in many previous publication [15]. The assessment of brown color and aftertaste was based on a 6-point scale, with ratings of "Very Strong" (score 6), "Strong" (score 5), "Somewhat Strong" (score 4), "Somewhat Weak" (score 3), "Weak" (score 2), and "Very Weak" (score 1). For odor, and texture, preferences were evaluated using the following ratings: "Strongly Dislike" (score 1), "Dislike" (score 2), "Somewhat Dislike" (score 3), "Somewhat Like" (score 4), "Like" (score 5), and "Strongly Like" (score 6).

3. RESULTS AND DISCUSSION

The results of the analysis showed that the water content of bamboo shoot flour was 6.13%. The results of the analysis of the hydrogen cyanide (HCN) content in bamboo shoot flour showed a concentration of 4.86 parts per million (ppm). This concentration is considered safe for human consumption, as the maximum acceptable level of HCN in food ingredients is 10 ppm, according to the Food and Agriculture Organization (FAO) and World Health Organization (WHO) [17, 18]. Another study reported that the maximum threshold of HCN is 40-50 ppm [19]. The HCN content in food can be reduced through various processes such as fermentation, heating, steaming, boiling, soaking, washing, frying, and drying [20, 21].

The cyanogenic glycosides in fresh bamboo shoots can rapidly decompose during boiling, with a temperature of 98℃ for 20 minutes removing approximately 70% of the HCN content. Higher temperatures and longer boiling times can result in the removal of more than 96% of the HCN [22].

The type of cyanogenic glycoside compound present in bamboo shoots is taxiphyllin. Upon boiling, the taxiphyllin undergoes hydrolysis and dissolves in water. The longer the boiling time, the more cyanide acid will be dissolved, resulting in a lower HCN level [23].

Regarding the antioxidant activity (IC50) of bamboo shoot flour, the value obtained using the DPPH method was 2495.73 ppm. This value was categorized as weak category due to the value above 150 ppm. The lower of antioxidant activity was due to the boiling process, which could lead to a decrease in the bioactive component in the bamboo shoots flour. These components are released into the water and dissolve, causing a reduction in antioxidant activity.

3.1 Sensory characteristics of cookies

3.1.1 Brown color

Based on the analysis of variance (ANOVA) on bamboo shoot cookies, the results showed that the factors of flour substitution (A), baking temperature (B), and their interaction (AB) had a significant impact on the panelists' assessment of the brown color of the cookies. The interaction between the addition of bamboo shoot flour and the baking temperature could be seen in Table 1.

Table 1. The effects of the interaction of flour substitution and baking temperature on the brown color preferences

Flour Ratio (Bamboo Shoots Flour: Cake Flour) (A)	Baking Temperature (B)		
	b_1 (140ºC)	b_2 (145ºC)	b_3 (150ºC)
a_1 (1:2)	4.70 B^a	4.88 C^b	4.37 C^a
a_2 (2:1)	4.37 A^b	4.16 B^a	3.77 B^a
a_3 (3:1)	4.17 A^b	3.20 A^a	2.94 A^a

Each different letter shows a significant difference for each treatment by the Duncan post hoc test at the 5% level. The capital letters on the line are read vertically and the lowercase letters on the column are read horizontally.

Table 1 indicates that flour substitution and baking temperature have a significant impact on the sensory evaluation of the brown color in bamboo shoot cookies. The greater the substitution of bamboo shoot flour and the higher the baking temperature, the darker the color of the cookies, as reflected in the lower scores from sensory panelists. For example, the ratio of 3:1 between bamboo shoot flour and cake flour at a baking temperature of 150℃ resulted in a blackish appearance that was less appealing to consumers.

Color is a perceived characteristic that results from the reflection and transmission of light in the visible spectrum. The perception of color is influenced by the presence of light and can vary in different lighting conditions. The brown color of bamboo shoot flour is a result of the oxidation of phenolic compounds by the polyphenol oxidase enzyme. This reaction converts monophenols to diphenols, followed by the oxidation of diphenols to quinones, which contribute to the brown color [24]. This effect was also observed in research on cookies made from soy flour, banana flour and moringa leaf flour, which had a slightly brown color and impacted the overall color of the cookies [25].

The formation of the brown color in cookies is influenced by the Maillard reaction during baking. This reaction is a sequence of events starting with the reaction between amino groups in amino acids, peptides, or proteins and hydroxyl glycosidic groups in sugar, ultimately resulting in the formation of brown nitrogen polymers or melanoidins [26]. The Maillard reaction and caramelization are considered the final steps in baking and the end result of sugar degradation during baking [27].

Complex chemical reactions take place during baking, including the formation of heat-generated toxicants such as acrylamide. Acrylamide is formed through the Maillard reaction between reducing sugars and asparagine at temperatures above 120℃ [28]. The primary components of cookies are cereal flour, sugar, and fat. Conventional cookie dough is baked at high temperatures (205°C) for a short period of time (10 minutes) to obtain a low final water content and a brown surface. According to literature data, it is believed that Maillard reaction and caramelization are responsible for the color differences in cookie samples, starting from the later phase of baking (after the fifth minute when the center of the cookies reaches boiling point) in cookies with the highest initial water content (wet formula) [29]. As a result, samples with higher water content have lower values of total color difference.

3.1.2 Cookies odor

The results of the ANOVA on bamboo shoot cookies indicate that flour substitution (A), baking temperature (B), and their interaction (AB) have a significant impact on the sensory value of the cookies' odor. As shown in Table 2, the interaction between flour substitution and baking temperature significantly affects the sensory value of the odor of the cookies. It was observed that panelists preferred the odor of cookies baked at 140℃ over those baked at 145℃ and 150℃.

Table 2. The effects of the interaction of flour and baking temperature on the odor preferences

Flour Ratio (Bamboo Shoots Flour: Cake Flour) (A)	Baking Temperature (B)		
	b_1 (140ºC)	b_2 (145ºC)	b_3 (150ºC)
a_1 (1:2)	4.86 B^b	4.81 C^b	4.52 C^a
a_2 (2:1)	4.00 A^a	4.08 B^a	4.09 B^a
a_3 (3:1)	3.97 A^c	3.56 A^b	3.23 A^a

Each different letter shows a significant difference for each treatment by the Duncan post hoc test at the 5% level. The capital letters on the line are read vertically and the lowercase letters on the column are read horizontally.

Odor plays an important role in consumer acceptance of a product as it is often the first sensory attribute that consumers perceive. A pleasing odor can attract attention and increase the likelihood of product liking [30]. Odor is produced by the interaction of substances with the olfactory epithelium cells in the nasal cavity. For a substance to produce an odor, it must be volatile, slightly soluble in water, or slightly soluble in oil.

The odor of cookies with a 1:2 substitution of bamboo shoot flour was preferred by the panelists compared to the 2:1 and 3:1 substitution. This is because a higher concentration of bamboo shoot flour results in a stronger odor, decreasing its sensory appeal. The results showed that lower levels of bamboo shoot flour substitution and lower baking temperatures (within a certain range) produced cookies with a more preferred odor according to the panelists.

3.1.3 Crunchiness

The results of the analysis of variance (ANOVA) on bamboo shoot cookies showed that flour substitution (A), baking temperature (B), and the interaction between flour substitution and baking temperature (AB) had a significant impact on the sensory value of the cookies' crunchiness. As indicated in Table 3, the interaction of flour and baking temperature had a noticeable effect on the crunchiness of the cookies. The panelists preferred cookies with a crunchiness value resulting from a baking temperature of 140°C.

Table 3. The effects of the interaction of flour substitution and baking temperature on the crunchiness preferences

Flour Ratio (Bamboo Shoots Flour: Cake Flour) (A)	Baking Temperature (B)		
	b_1 (140ºC)	b_2 (145ºC)	b_3 (150ºC)
a_1 (1:2)	4.29 B^a	4.57 B^a	4.34 B^a
a_2 (2:1)	3.77 A^b	3.63 A^b	3.31 A^a
a_3 (3:1)	4.01 B^b	3.82 A^a	4.07 B^{ab}

Each different letter shows a significant difference for each treatment by the Duncan post hoc test at the 5% level. The capital letters on the line are read vertically and the lowercase letters on the column are read horizontally.

The texture of food is mainly determined by the water, fat, and carbohydrate content (such as starch, cellulose, and protein). The texture of a product is related to the water and protein content, with higher protein content leading to higher water absorption. Changes in texture can occur due to fluid loss, reduced fat, emulsion formation/breakdown, hydrolysis, or carbohydrate and protein polymerization/coagulation.

Crunchiness is a pressure sensation that can be felt in the mouth (when bitten, chewed, and swallowed) or with the fingers [31]. In this study, crunchiness was assessed by determining the sensory texture based on the crunchiness of the cookies when bitten. The results of the sensory test showed that an increase in bamboo shoot flour substitution resulted in a decrease in the crunchiness preferred by the panelists.

The sensory test results for the crunchiness attribute showed fluctuation, likely due to psychological error on the part of the panelists, specifically a central tendency error. This error is characterized by the panelists giving a middle value on the existing value scale and being hesitant to give the highest score. This error results in the panelists perceiving all the samples as being nearly the same.

3.1.4 Sweetness

Based on the results of analysis of variance (ANOVA) on bamboo shoot cookies, flour substitution (A), baking temperature (B), and the interaction between flour substitution and baking temperature (AB) were found to significantly affect the sensory value of sweetness in the cookies. The results of the interaction of flour and baking temperature on the sweet taste value can be seen in Table 4.

Table 4. The effects of the interaction of flour substitution and baking temperature on the sweet taste preferences

Flour Ratio (Bamboo Shoots Flour: Cake Flour) (A)	Baking Temperature (B)		
	b_1 (140ºC)	b_2 (145ºC)	b_3 (150ºC)
a_1 (1:2)	4.90 B^a	4.84 C^a	4.66 C^a
a_2 (2:1)	3.96 A^b	3.69 B^{ab}	3.46 B^a
a_3 (3:1)	3.81 A^b	3.12 A^a	2.88 A^a

Each different letter shows a significant difference for each treatment by the Duncan post hoc test at the 5% level. The capital letters on the line are read vertically and the lowercase letters on the column are read horizontally.

According to Table 4, the substitution of bamboo shoot flour and cake flour (1:2) with different baking temperatures showed no significant effect on sweetness and was preferred by the panelists. This is because the cake flour has a higher concentration than bamboo shoot flour, thus not affecting the sweetness of the cookies.

The sense of taste originates from the primary organ of taste, the tongue, which recognizes four basic tastes: salty, sweet, bitter, and sour. Taste buds, composed of small cells on the tongue, respond to the dissolved substance and send signals to the brain to determine the resulting taste. The main ingredients and supporting ingredients of a food product influence its taste, which is crucial for consumer preference.

A higher concentration of bamboo shoot flour in cookies was found to result in less intense sweetness and lower assessments by the panelists. This is because bamboo shoot flour contains small amounts of cyanide acid, leading to a bitter taste that affects the sweetness of the cookies.

The taste of food products is determined by factors such as odor, ingredients, texture, level of maturity, and temperature acceptance in the mouth. Taste is a sensation that is shaped by the combination of ingredients and their composition in the product [32].

3.1.5 Bitter aftertaste

The results of the analysis of variance (ANOVA) on bamboo shoot cookies indicate that flour substitution (A), baking temperature (B), and their interaction (AB) have a significant impact on the bitter aftertaste of the cookies. Table 5 illustrates the effect of flour substitution and baking temperature on the sensory value of the bitter aftertaste.

Table 5. The effects of the interaction of flour and roasting temperature on the bitter aftertaste

Flour Ratio (Bamboo Shoots Flour: Cake Flour) (A)	Baking Temperature (B)		
	b1 (140ºC)	b2 (145ºC)	b3 (150ºC)
a_1 (1:2)	3.78 A^b	3.47 B^{ab}	3.33 B^a
a_2 (2:1)	3.53 A ^{b}	2.97 A^a	2.68 A^a
a_3 (3:1)	4.86 B^a	4.91 C^b	4.48C^a

Each different letter shows a significant difference for each treatment by the Duncan post hoc test at the 5% level. The capital letters on the line are read vertically and the lowercase letters on the column are read horizontally.

According to the results, the substitution of bamboo shoot flour with cake flour in a ratio of 1:2 is preferred by the panelists as it results in a lesser bitter aftertaste. Bitter aftertaste can occur due to the Maillard Reaction that takes place during baking, causing amino acid hydrolysis [27]. Moreover, bamboo shoot flour still contains cyanide acid, which also contributes to the bitter taste. The higher the baking temperature and concentration of bamboo shoot flour, the more intense the bitter aftertaste becomes, resulting in lower preference among the panelists.

Aftertaste refers to the taste that remains in the mouth even after the food is no longer present. For cookie products, a low aftertaste value is desired as it is not expected to have an aftertaste.

3.2 Physical characteristics

3.2.1 Hardness

Based on the results of the analysis of variance (ANOVA) on bamboo shoot cookies, it was found that both flour substitution (A) and baking temperature (B) impact the hardness of the cookies, while the interaction between the two variables (AB) has no effect. The effects of flour substitution and baking temperature on hardness are presented in Table 6 and Table 7. The Duncan's post hoc test revealed that the substitution of bamboo shoot flour with cake flour at various levels had a significant effect on hardness, with the more bamboo shoot flour used resulting in harder cookies. This correlation is linked to water content, with higher water content resulting in softer products, and lower water content leading to increased hardness [33].

Table 6. The effects of flour substitution on the hardness of bamboo shoot cookies

Flour Ratio (Bamboo Shoots Flour: Cake Flour) (A)	Hardness (gf)
a_1 (1:2)	2730.02^a
a_2 (2:1)	3958.47^b
a_3 (3:1)	5030.19^c

The mean value marked with a different letter shows a significant difference by the Duncan post hoc test of 5%.

Table 7. The effects of baking temperature (B) on the hardness

Baking Temperature (B)	Hardness (gf)
b_1 (140ºC)	3814.00^a
b_2 (145ºC)	3933.36 ^{a}
b_3 (150ºC)	3971.28 ^{a}

The mean value marked with a different letter shows a significant difference by the Duncan post hoc test of 5%.

Research into water content showed that as bamboo shoot flour substitution increases, water content decreases, thereby impacting hardness. The hardness values preferred by the panelists were between 2000 to 3000 gf. Results indicate that the wet formula was statistically significantly different in hardness and work of breaking force compared to the standard and dry formulas, although there was no statistically significant difference in fracturability.

Previous research related to cookies by Chung et al. [34] showed that the hardness of cookies made from whole wheat flour was around 2200 gf, the use of substitute flour such as white rice and brown rice reduces the hardness, where the higher the addition of white rice or brown rice, the lower the hardness of the cookies. This is different from bamboo shoot flour, where the addition of bamboo shoot flour increases the hardness of the cookies. Therefore, it would be interesting if the flour used was a combination of several of these flours so that the cookies are not too hard and not too soft.

Baking temperature increases during the baking process. Ideal baking time and temperature cause heat to quickly react with the top and bottom of the cookies, leading to the loss of water and expanding gas in those areas, resulting in a softer texture. Conversely, excessive baking time and temperature can lead to a harder texture due to heat reaction at the top and bottom of the cookies [35]. Table 7 shows that different baking temperatures had no significant impact on hardness, suggesting that the heat reaction generated during baking does not significantly increase at varying temperatures. Additionally, the interaction between flour substitution and baking temperature had no significant effect on hardness, meaning that the hardness level of the cookies' surface did not change significantly in any of the tables treatments.

3.2.2 Fracturability

The results of the analysis of variance (ANOVA) on bamboo shoot cookies indicate that there is no significant impact of flour substitution (A), baking temperature (B), and their interaction (AB) on the fracturability of the cookies. Therefore, the Duncan post hoc test was not performed. However, the average value of the fracturability is presented in Figure 1.

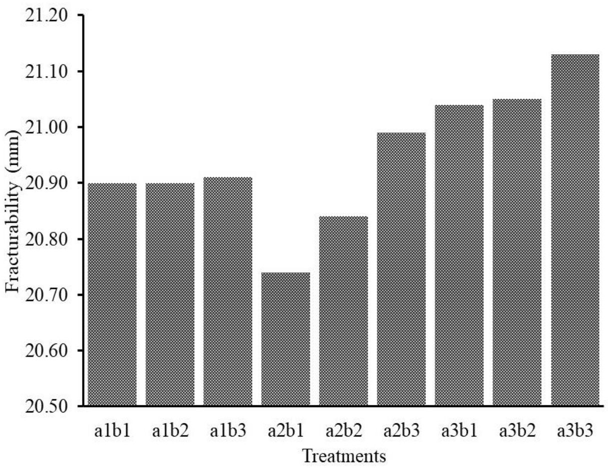

Figure 1. Relationship between treatment and the values of fracturability of the cookies
a1=ratio between bamboo shoot flour and cake flour is 1:2, a2=ratio between bamboo shoot flour and cake flour is 2:1, a3=ratio between bamboo shoot flour and cake flour is 3:1, b1=baking temperature is 140°C, b2=baking temperature is 145°C, and b3=baking temperature 150°C.

Fracturability is the property or resistance of a material or product surface to receiving pressure from a probe, determining the ease of breaking [36]. The homogenization time during the mixing process and the thickness of the material have a significant impact on the fracturability of a product.

Research findings indicate that there is no significant impact of flour substitution, baking temperature, and their interaction on the fracturability of bamboo shoot cookies. This may be due to the uniform dough homogenization during mixing and relatively uniform cookie thickness.

Additionally, the presence of gluten from the use of cake flour contributes to the uniform fracturability in bamboo shoot cookies. Cake flour containing gluten provides an elastic character to the dough [37]. Additionally, the starch gelatinization process, which binds water in the dough during baking, contributes to the crunchiness of the cookies and may affect the fracturability value.

From all the observation. The bamboo shoot flour demonstrated a safe ingredient for making cookies. Flour substitution and baking temperature significantly influenced brown color, odor, sweetness, and bitter aftertaste. The Maillard reaction during baking contributed to the brown color, and a lower level of bamboo shoot flour substitution and baking temperature led to more preferred odor and sweetness. However, higher levels of bamboo shoot flour and baking temperature intensified the bitter aftertaste. The physical characteristics of cookies, specifically hardness and fracturability, were affected by flour substitution, where increased bamboo shoot flour resulted in harder cookies. Interestingly, baking temperature did not significantly impact hardness, and there was no significant effect on fracturability. The uniform dough homogenization and the presence of gluten from cake flour were suggested as factors contributing to consistent fracturability. The study provides valuable insights into optimizing bamboo shoot cookies for consumer acceptance, highlighting the intricate interplay of ingredients and processing conditions in shaping sensory and physical attributes.

4. CONCLUSIONS

The results of this study indicate that bamboo shoot flour is a safe ingredient for making cookies, with a hydrogen cyanide (HCN) content of 4.86 ppm, which is below the Food and Agriculture Organization's (FAO) standard of 10 ppm. The primary concern with HCN exposure is its interference with cellular respiration, as it inhibits the utilization of oxygen by cells. Additionally, bamboo shoot flour exhibits weak antioxidant activity (IC50=2495.73 ppm) because the preparation and processing use high temperatures and a long process, thereby reducing the antioxidant content. In terms of sensory properties, the addition of bamboo shoot flour to cookie dough was found to have a significant effect on the color, odor, crunchiness, sweetness, and bitter aftertaste of the resulting cookies. The baking temperature also had a significant impact on these sensory properties. However, neither the addition of bamboo shoot flour nor the baking temperature had a significant effect on the hardness or fracturability of the cookies. Moreover, the interaction between adding bamboo shoot flour and baking temperature was found to have a significant effect on sensory properties, but it had no effect on the hardness or fracturability of the cookies. The recommended ratio of bamboo shoot flour and wheat flour was 1:2, and the baking temperature was 140-145°C because it produces a product with the highest preference in almost all parameters.

In general, the use of bamboo shoot flour as an ingredient in cookies will reduce dependence on the use of wheat flour, where wheat is not produced in Indonesia (South-East Asian region). Apart from that, this encourages local potential where bamboo is a plant that is easy to grow, does not need intensive treatment and can grow throughout the year. This can increase the economic value of bamboo which is generally not considered. Further research needs to be carried out, especially regarding a more in-depth chemical analysis of the contents of cookies. It is also necessary to conduct studies regarding the availability and dissolution of bamboo in Indonesia as well as an analysis of the feasibility of the bamboo shoot-based cookie industry business. These studies will provide benefits for the implementation of more mature innovations.

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