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ANALYSIS OF GLUTEN CONTENT, FOOD FIBER, CALORIE VALUE, AND ACCEPTANCE OF WET NOODLES WITH SUBSTITUTION OF SORGUM FLOUR (*Sorghum bicolor (L)*) AS A HALAL ALTERNATIVE FOOD LOW IN GLUTEN

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ABSTRACT

Moist noodles are often made with wheat flour as the main ingredient. However, those who have gluten intolerance and celiac disease are unable to consume the gluten present in wheat flour. A viable way to address this problem is to employ gluten-free flour, such as sorghum, which does not contain gluten. The objective of this study was to evaluate the gluten content, dietary fiber content, caloric value, and acceptability of wet noodles produced using sorghum flour as a replacement ingredient. This study utilized a Completely Randomized Design (CRD) with 5 treatments: 1 control formulation (100%:0%) and 4 treatment formulations (F1 (90%:10%); F2 (80%:20%); F3 (70%:30%); F4 (60%:40%). A group of thirty inexperienced individuals participated in an organoleptic test to assess the acceptability of the five formulations. Consequently, three formulas that were highly preferred were selected to analyze the gluten content, dietary fiber, and value. Caloric expenditure during three repetitions. Significant differences were seen in the color (p=0.001), taste (p=0.002), aroma (p=0.001), texture (p=0.001), and preferences of the wet noodle compositions. Additionally, the three most preferred wet noodle compositions were identified. The recommended choices are F0, F1, and F2. The statistical analysis of food fiber content shows a significant difference (p=0.001), as well as in gluten content (p=0.048), however there is no significant difference in calorific value (p=0.162). Increasing the use of sorghum flour results in a higher amount of dietary fiber and caloric value, while also decreasing gluten levels.

Keywords:
gluten; calories; dietary fiber; noodles; Sorghum

Introduction

Gluten is a naturally occurring protein found in grains such as wheat, rye, barley, and their derivative products. Gluten imparts elasticity to cake and bread dough, enabling the final items to rise and possess desirable quality. Nevertheless, several individuals suffer from illnesses that prevent them from consuming gluten-containing foods, such as gluten intolerance and celiac disease. In addition to individuals with celiac disease and gluten intolerance, it is also advisable for individuals with Autistic Spectrum Disorder (ASD) to restrict their gluten intake. Individuals afflicted with this ailment are strongly recommended to ingest meals that are devoid of gluten. As per the BPOM guidelines, gluten-free food should have a maximum of 20 mg/kg of gluten, whereas low-gluten food should have a range of 21-100 mg/kg of gluten (BPOM, 2016).

Gluten-free food is prepared using foods that are free from gluten, such as corn, tapioca, sorghum, chia seeds, peanut flour, rice, quinoa, buckwheat, millet, amaranth, and flaxseed (Quan, Ferreiro, & Cantón, 2018). Sorghum is a type of grain crop, similar to wheat and corn. Sorghum plants have a wide distribution in India, America, and Africa. Sorghum seeds are edible and can be utilized as food, either in the form of flour or as a rice alternative. Sorghum seeds have a higher protein concentration compared to wheat and corn, specifically 9.5%. Sorghum has a high starch content, specifically 80.42%. The sorghum grain has insoluble fiber at a concentration ranging from 6.5% to 7.9%, whereas the water-soluble fiber content ranges from 1.1% to 1.23% (Lestari, et al., 2022). In addition, sorghum is abundant in vitamin B complex, minerals such as potassium, magnesium, phosphorus, and zinc, as well as unsaturated fatty acids and antioxidants (Xiong, Zhang, Warner, & Fang, 2019). In 2016, the Food and Drug Supervisory Agency of the Republic of Indonesia stated that food products claiming to be a source of dietary fiber must have 3 g of fiber per 100 grams of solid material. Additionally, food products claiming to be high in fiber must have at least 6 g of dietary fiber per 100 grams of solid material (BPOM, 2016). Sorghum seeds can be milled into flour and utilized as an ingredient in the production of cakes, noodles, bread, and other bakery items.

Calories, often known as calorie, refer to the quantity of energy required to increase the temperature of 1 gram of water by 1ºC. Calories in the field of health are measured in kilocalories (kcal) (McComb, Carnero, & Gutiérrez, 2014; Katz, Friedman, & Lucan, 2015). Calories in the context of food and health refer to the quantity of energy present in food and the quantity of energy required by the body for metabolic processes (Duyff, R. L, 2006). Food contains components that undergo processing in the body to serve as sources of energy, specifically carbs, lipids, and proteins. The energy generated by these three nutrients can be measured using a device known as a bomb calorimeter, and subsequently converted. The proposal to convert calorific values from carbs, proteins, and fats was initially made by Atwater in 1896 (FAO, 2002). Based on the information provided by BPOM, low-energy food has an energy content of 40 kcal per 100 grams, whereas calorie-free food has an energy content of 4 kcal per 100 grams (BPOM, 2016). Sorghum has an energy content of 366 kcal per 100 grams, according to Kemenkes (2018).

Noodles, like rice, bread, and tubers, are a significant source of carbs. As per the laws set by the Ministry of Religious Affairs of the Republic of Indonesia (Food Certification Guidelines, Ministry of Religious Affairs, 2020), halal certification is not mandatory for plant-based ingredients. Noodles are extensively consumed in Indonesia and are favored by individuals from diverse backgrounds as a rice alternative or as a complement to main courses. Replacing wheat flour with sorghum flour in the production of wet noodles can have an impact on the color, flavor, consistency, aroma, and overall look of the final product. The reason for this is that sorghum flour possesses distinct physical attributes compared to wheat flour, one of which is its deeper hue.The objective of this study is to assess variations in gluten content, dietary fiber, caloric value, and acceptability of wet noodles that have been replaced with sorghum flour (*Sorghum bicolor* (L)) at different percentages: 0%, 10%, 20%, 30%, and 40%.

Methods

Materials and tools

The necessary components for preparing wet noodles include medium protein wheat flour, Tambiyaku brand sorghum flour, table salt, chicken eggs, and mineral water. Wet noodles are produced using five different formulations that consist of varying ratios of wheat flour and sorghum flour. These formulations are labeled as F0 (100% wheat flour: 0% sorghum flour), F1 (90% wheat flour: 10% sorghum flour), F2 (80% wheat flour: 20% sorghum flour), F3 (70% wheat flour: 30% sorghum flour), and F4 (60% wheat flour: 40% sorghum flour). Each wet noodle formulation will undergo a single acceptance test, and the three most favorable formulations will be further examined for gluten content, dietary fiber, and calorific value, each test being repeated three times. The acceptability and gluten levels were tested in the Nutrition laboratory of the Faculty of Psychology and Health, with the participation of 30 untrained panelists. The food fiber content analysis was conducted at the SIG Saraswanti Bogor laboratory, whereas the calorific value analysis was performed at the Central Laboratory of Muhammadiyah University Malang.

Preparing Moist Noodles Using Sorghum Flour as a Replacement
Wet noodles are a culinary item produced from wheat flour. They are prepared by combining the flour with various other ingredients, followed by a series of steps including mixing, kneading, moulding the dough, creating noodle strands, and cutting the noodles (Badan Standardisasi Nasional, 2015). The procedure of producing wet noodles involves combining wheat flour with chicken eggs, salt, and water. Thoroughly knead the dough until all the ingredients are uniformly combined and the texture is smooth. Subsequently, encase the dough with plastic wrap and allow it to rest for a brief period. Prior to flattening the dough, perform multiple rounds of kneading. Use a rolling pin to compress the moist noodle dough until it reaches a thickness of approximately 1.5 mm. Next, thinly slice the moist noodles into strands. Subsequently, the noodles are subjected to boiling until their texture undergoes a transformation, rendering them more resilient and thoroughly cooked.

Acceptance testing
The test employs a hedonic testing methodology that utilises a hedonic scale to ascertain the degree of acceptance or preference for the colour, scent, taste, texture, and overall preference of wet noodle products. The hedonic scale comprises five levels of scoring: 1 (strongly detest), 2 (dislike), 3 (moderately like), 4 (like), and 5 (strongly like). The testing comprised of a group of 30 panellists who had not received any prior training (Setyaningsih, Apriyantono, & Sari, 2010). The implementation of the place and time is determined in accordance with the guidelines specified in SNI 01-2346, namely in an organoleptic laboratory equipped with booths and seats.

Analysis of Gluten Content
The analysis of gluten content is conducted using the hand washing method. A 100-gram sample (as per the prescribed formulation) is combined with 20 ml of water until it forms a thick dough. The provided dough was immersed in water for a duration of 1 hour. Subsequently, the sample dough is thoroughly rinsed under a steady flow of water until the water used for washing the dough appears transparent and free from any cloudiness. A layer of gauze or a 150 mesh sieve is positioned at the bottom to serve as a foundation for capturing the disintegrated dough or gluten. Once the dough has been washed, the water within the residual gluten is extracted. Subsequently, the gluten is subjected to a drying process in an oven for a duration of 2 hours at a temperature of 120ºC. Following this, the dried gluten is measured in terms of weight (Imran, Hussain, Ghafoor, Nagra, & Ziai, 2023).

Analysis of Dietary Fiber
The enzymatic methods were employed to analyse the fiber content of the food. This approach pertains to the protocols developed by AOAC International. This technique utilises the assistance of the enzymes α-amylase, amyloglucosidase, and protease enzymes, which are subsequently precipitated by ethanol.The specimen to be examined is measured to a mass of 1 gramme using a digital scale. The specimen was placed into an Erlenmeyer flask, followed by the addition of 50 mL of phosphate buffer solution with a pH of 6 and 50 µL of α-amylase. The water bath is heated until it reaches a temperature of 95-100ºC. The Erlenmeyer flask was wrapped with aluminium foil and submerged in a heated water bath for a duration of 15 minutes, with stirring occurring at 5-minute intervals. Following the process of heating, the sample was subsequently cooled using a desiccator. After the chilling process, a volume of 10 mL of a solution containing 0.275 N NaOH was introduced to the sample solution in order to achieve a pH of 7.5. Subsequently, a volume of 100 µL of protease enzyme was introduced into the sample, which was then subjected to incubation at a temperature of 60ºC for a duration of 30 minutes, followed by cooling. Following the chilling process, a volume of 10 mL of 0.325 N HCl was introduced into the solution to achieve a pH of 4.5. Subsequently, 200 µL of the amyloglucosidase enzyme was added and the mixture was incubated at a temperature of 60ºC for a duration of 30 minutes. The sample was precipitated by adding 280 mL of 95% ethanol at a temperature of 60ºC. The mixture was then allowed to settle for 60 minutes. The obtained sediment sample was filtered through filter paper and

subsequently rinsed with 3x20 mL of 78% ethanol, 2x10 mL of 95% ethanol, and 2x10 mL of acetone. Following the washing process, the remaining substance was subjected to drying at a temperature of 105ºC for a duration of 1 hour using an oven. The resulting weight of the residue was recorded as W1. Subsequently, the obtained residue is split into two halves for analysis of protein content (W2) using the Kjeldahl method and ash content (W3) as a correction factor in the determination of total dietary fiber (Adawiyah, Wefiani, & Patricia, 2021)**.**

Analysis of Caloric Value

Calorimetry, the process of measuring calories in food, is often conducted using a device known as a bomb calorimeter. A bomb calorimeter is a device utilised to quantify the amount of heat generated by the combustion of a sample within a sealed container at elevated oxygen pressure. The outcome of the bomb calorimeter measurement is referred to as the combustion value. The specific instrument employed is an IKA C2000 bomb calorimeter. The specimen to be examined is measured at a weight of 0.5-1 gramme and thereafter positioned within an iron container. A nickel wire measuring 10 cm in length is affixed to the iron support located within the decomposition vessel. The sample is put on the cup support using an iron cup. A strand of cotton thread is affixed to the ignited wire and linked to the solid sample to facilitate its combustion. The sample is subsequently deposited into the decomposition tank and securely sealed. The decomposition vessel is filled with pure oxygen at a maximum pressure of 30 bar. An oxygen-filled decomposition chamber is placed within the calorimeter vessel. The calorimeter vessel was filled with 2 litres of water. Subsequently, the bomb calorimeter is sealed and the process of combustion commences. The heating value results, along with the rise in combustion temperature, will be shown on the screen of the bomb calorimeter display (Nainggolan & Hasan, 2016; IKA, 2014).

Results and Discussions

Acceptability

Colour is a crucial element that can make a strong initial impact on a product, as it is evaluated through the sense of sight. Colour is a factor that can captivate consumers' palates and entice them to try a culinary product (Lamusu, 2018). According to the examination of the organoleptic test values for colour parameters using the Kruskal Wallis test in Table 1, the probability value of 0.001 suggests a significant difference in the colour of wet noodles.

The colour of wet noodles will darken as the proportion of sorghum flour used as a substitute increases. The darkening of sorghum flour occurs due to the reaction between the tannin concentration in sorghum and protein, resulting in oxidation (Patty, Putri, & Rukmi, 2023). The control treatment (F0) exhibited the characteristic colour of regular noodles, specifically a pale yellow hue, primarily derived from the eggs. The F1 treatment, consisting of a mixture of 90% wheat flour and 10% sorghum flour, has a brownish yellow hue. The F2 treatment, consisting of a mixture of 80% wheat flour and 20% sorghum flour, has a light brown colour with sporadic black specks. The F3 treatment, consisting of a mixture of 70% wheat flour and 30% sorghum flour, exhibits a deeper shade of brown with the presence of black specks. The F4 treatment, consisting of a blend of 60% wheat flour and 40% sorghum flour, exhibits a deep brown hue and is characterised by numerous black specks.

The fragrance of food products is determined by the components employed in the preparation of food. The data acquired from the organoleptic tests of fragrance parameters were analysed using the Kruskal-Wallis test. The analysis yielded a probability value of 0.002, which is less than 0.05. This suggests that there is a significant difference in the aroma of wet noodles. Sorghum possesses a unique fragrance that remains unfamiliar to a large number of individuals. Sorghum contains volatile chemicals, including formaldehyde, which are produced through the oxidation of lipids, alcohols, ketones, terpenoids, and esters. The volatile compounds emitted by this substance produce distinct fragrances, including almond, malt, grass, citrus, fatty, and rancid scents

(Shuang, et al., 2021). The wet noodles treated with the F0 control (100:0) had a characteristic scent of flour and egg, but my wet treatments F1 to F4 possessed a powdery perfume with the inclusion of a distinct sorghum scent. As the amount of sorghum flour increases, the intensity of the unique sorghum aroma also increases.

Table 1. Analysis of Organoleptic Test Data

Formulation	**Parameter**				
	Color	**Aroma**	**Feel**	**Texture**	**Favorite**
F0 (100%:0%)	4,53 ± 0,571[a]	4,13 ± 0,73[a]	4,27 ± 0,640[a]	4,37 ± 0,669[a]	4,23 ± 0,626[a]
F1 (90%:10%)	4,20 ± 0,664[b]	3,9 ± 0,712[a]	4,00 ± 0,788[a]	4,03 ± 0,765[ab]	4,10 ± 0,712[a]
F2 (80%:20%)	3,87 ± 0,819[bc]	3,80 ± 0,761[ab]	3,50 ± 0,777[b]	3,73 ± 0,785[ab]	3,60 ± 0,777[b]
F3 (70%:30%)	3,63 ± 0,890[c]	3,40 ± 0,814[b]	2,97 ± 0,765[c]	2,97 ± 0,809[c]	2,93 ± 0,740[c]
F4 (60%:40%)	3,43 ± 0,935[c]	3,33 ± 1,093[b]	2,73 ± 0,828[c]	2,83 ± 0,950[c]	2,90 ± 0,960[c]
P value	**0,001**	**0,002**	**0,001**	**0,001**	**0,001**

Information: *The same letter notation indicates there is no significant difference in the Post Hoc Man Whitney test*

The taste parameter data was analysed using the Kruskal-Wallis test, yielding a probability value of <0.05 (specifically, 0.001). This result suggests that there is a significant difference in the taste of wet noodles. As the amount of sorghum flour used in wet noodles increases, the level of acceptability among panellists decreases. The presence of tannins in sorghum is responsible for its ability to provide an astringent or sour taste when ingested (Prabawa, Zoelnanda, Anam, & Samanhudi, 2023). According to Table 1, the panellists showed a preference for three formulations: F0 (100:0) with an average rating of 4.27, F1 (90:10) with an average rating of 4, and F2 (80:20) with an average rating of 3.5. On the other hand, the least favoured formulation was F4, which had an average rating of 2.73.

Texture is a key factor in an organoleptic test that assesses the sense of touch. The data on organoleptic test values for texture parameters is highly useful, with a significance level of 0.001. This suggests that there is a significant variation in texture when substituting sorghum flour for wet noodles. The panellists favoured the wet noodles formulation labelled F0 (100:0) the most, which had an average rating of 4.37. The next preferred formulation was F1 (90:10) with an average rating of 4.03, followed by F2 (80:20) with an average rating of 3.73. The panellists expressed the least preference for the F4 (60:40) wet noodle formulation, which had an average value of 2.83.According to this data, it is evident that the panellists expressed a lesser preference for the texture of the wet noodles as the substitution of sorghum flour increased. This is a result of the presence of gluten and fibre in sorghum. The presence of fibre in sorghum can contribute to the development of a firm and brittle texture when it is wet. This is due to the filling of the matrix bonds between the components with fibre (P, Karimah, & Alviona, 2017). Sorghum is a gluten-free food component. Gluten functions as a bonding agent that imparts dough with its resilient and chewy characteristics (Scherf, Köhler, & Freising, 2016).

The panellist preferences for features of product colour, scent, taste, and texture constitute the overall parameters. The data from the overall liking test value were analysed using the Kruskall Wallis test. The results showed a probability value of <0.05, specifically 0.001. This indicates that there is a significant difference in the overall like of the wet noodle product when sorghum flour is substituted. As the number of alternatives to sorghum flour in the production of wet noodles increases, the preference for it among panellists declines. The diminished appeal of wet noodles is a result of their colour, while the presence of sorghum flour introduces a noticeable scent, a mildly puckering flavour, and a fragile texture that loses its chewiness with higher amounts of sorghum flour utilised.

Nutritional Content Analysis

Table 2. Laboratory Test Data Analysis

Nutrient content	**Formulation**			**P value**
	F0	**F1**	**F2**	
Gluten	12,56 ± 0,65[a]	11,53 ± 0,48[b]	11,40 ± 0,96[b]	0,048
Food Fiber	4,47 ± 0,06[a]	13,39 ± 0,35[b]	16,67 ± 0,25[c]	0,001
Calorie Value	407,067 ± 1,97[a]	411,233 ± 1,12[a]	410,73 ± 3,67[a]	0,162

The data acquired from tests measuring gluten content, dietary fibre, and caloric value were analysed using the One Way Anova test. The findings indicate a noteworthy disparity ($p<0.05$) in the food fibre content and gluten content between the control formulation and treatment formulation of wet noodles. However, there was no notable difference in the calorific value ($p>0.05$).

Gluten Content

Gluten is a constituent found in grains like wheat that plays a crucial function in creating a flexible structure in dough. Following the completion of the acceptance test on the wet noodles, we will analyse the three formulations, namely F0, F1, and F2, that were most chosen by the panellists. The analysis will focus on the gluten, dietary fibre, and calorie content (gross energy). Table 2 presents the results of gluten content analysis using the One Way Anova test. The probability value for wet noodles with sorghum flour substitution is greater than 0.05, specifically 0.048. This suggests that there is a significant difference between the control formulation (F0) and the treatment formulations (F1 and F2).

Replacing sorghum flour with another ingredient in the production of wet noodles can impact the amount of gluten present. As the amount of sorghum flour used in wet noodles increases, the level of gluten drops. The control formulation (F0) had an average gluten content of 12.56 grammes, while the F1 formulation had an average gluten content of 11.53 grammes and F2 had an average gluten level of 11.40 grammes. Nevertheless, wet noodle products used as a replacement for sorghum flour fail to meet the criteria for being classified as low-gluten food. This is according to the findings of BPOM in 2016, which indicate that the gluten concentration in low-gluten foods varies between 21-100 mg/kg (BPOM, 2016).

Dietary Fiber Content

Dietary fibre refers to the indigestible portion of plant cell walls in the human digestive system. Vegetables, fruit, grains, and nuts are sources of dietary fibre. The test results were analysed using the One Way Anova test, which yielded a probability value of 0.001. This number indicates that there is a significant difference in the food fibre content.My aqueous control formulation (F0) and treatment formulations (F1 and F2).

According to the investigation, it was observed that replacing Sorghum flour can have an impact on the quantities of dietary fibre in wet noodles. The reason for this is that sorghum flour has a higher content of dietary fibre compared to wheat flour. Specifically, sorghum flour has 10.37% dietary fibre, whilst wheat flour contains 8.69% (Wahjuningsih, Sudjatinah, Azkia, & Anggraeni, 2020). The control formulation F0 included 4.47% dietary fibre, while the F1 treatment formulation contained 13.39% dietary fibre, and F2 contained 16.67% dietary fibre. The wet noodle product, which replaces sorghum flour, contains about 6 grammes of dietary fibre per 100 grammes of components. Therefore, it can be classified as a high fibre food according to the 2016 BPOM standards.

Calorie Value Rate
The energy or calorie content of food products is influenced by several components such as protein, fat, carbs, alcohol, polyols, and organic acids. The gross energy content of food can be quantified by employing a bomb calorimeter (FAO, 2002). The calorific value of three formulations of wet noodles was tested and analysed using the One Way Anova test. The results showed a probability value of 0.162, indicating that there is no significant difference in the energy value between the control formulation (F0) and the treatment formulations (F1 and F2) of wet noodles.

Incorporating sorghum flour into the preparation of wet noodles can impact the caloric content. Table 2 reveals that the calorific value of wet noodles containing sorghum flour rises in direct proportion to the increase in the percentage of sorghum flour substitution. The calorie content of sorghum flour is 357.39 kcal/100 gr, which is somewhat greater than that of wheat flour, namely 350.46 kcal/100 gr (Wahjuningsih, Sudjatinah, Azkia, & Anggraeni, 2020). According to the regulations of BPOM, wet noodles made with sorghum flour as a substitute are not classified as low-calorie foods due to their energy value exceeding 40 kcal/100 gr of ingredient.

Conclusion

Substituting sorghum flour in wet noodles leads to distinct variations in colour, scent, flavour, texture, and individual preferences. There is a notable disparity in the fibre and gluten content between wet noodles and sorghum flour, but there is no substantial variation in their calorific value. As the amount of sorghum flour substitution rose, the fibre content and calorific value of wet noodles increased, while the gluten content decreased.

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Conflicts of interest
There is no conflicts of interest in the research process until the drafting of the journal.

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