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Analysis (Analysis of Gluten Content, Food Fiber, Calorie Value, And Acceptance of Wet Noodles with Substitution of Sorgum Flour (Sorghum Bicolor (L)) As an Alternative Food Low in Gluten)

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ABSTRACT

Wheat flour is the basic ingredient commonly used in making wet noodles. However, the gluten content in wheat flour cannot be consumed by suffering gluten intolerance and celiac disease. One alternative to this problem is to use flour that does not contain gluten, such as sorghum. This research was conducted to determine the gluten content, dietary fiber content, calorific value and acceptability of wet noodles substituted for sorghum flour. This research used a Completely Randomized Design (CRD) which consisted of 5 treatments, namely 1 control formulation (100%:0%) and 4 treatment formulations (F1 (90%:10%); F2 (80%:20%); F3 (70%:30%); F4 (60%:40%). The five formulations were tested for acceptability using an organoleptic test involving 30 untrained panelists. Then the 3 most preferred formulations were selected to analyze gluten content, dietary fiber and value. calories with 3 repetitions. There were significant differences in the parameters of color (p=0.001), taste (p=0.002), aroma (p=0.001), texture (p=0.001), and preferences as well as the 3 most popular wet noodle formulations. preferred are F0, F1 and F2. The results of statistical analysis of food fiber content show a significant difference (p=0.001) and gluten content (p=0.048) while there is no significant difference in calorific value (p=0.162). Increase in sorghum flour substitution makes food fiber levels and caloric value increase while gluten levels decrease.

Keywords:
Calories, Dietary Fiber, Gluten; Calories; Dietary Fiber; Noodles; Sorghum.

Introduction

Gluten is a type of protein that naturally occurs in cereals such as wheat, rye, barley and their derivative products. Gluten provides elastic properties to cake and bread dough so that the resulting products rise and have good quality. However, there are individuals who have conditions where they cannot consume foods that contain gluten, such as gluten *intolerance* (gluten intolerance), and celiac disease. Apart from sufferers of celiac disease and gluten intolerance, limiting gluten consumption is also recommended for sufferers *Autistic Spectrum Disorder* (ASD). Sufferers of this disease are strongly advised to consume gluten-free foods. According to BPOM, gluten-free food must contain ≤ 20 mg/kg of gluten, while low-gluten food must contain 21-100 mg/kg of gluten (BPOM, 2016)

Gluten-free food is made from food ingredients that do not contain gluten such as corn, tapioca, sorrows, chia seeds, peanut flour, rice, quinoa, buckwheat (*buckwheat*), millet, amaranthus, and flaxseed (*flaxseed*) (Quan, Ferreiro, & Cantón, 2018). Sorghum is a cereal crop like wheat and corn. Sorghum plants grow widely in India, America and Africa. Sorghum seeds can be used as food, such as flour or as a substitute for rice. The protein content of sorghum seeds

is higher than that of wheat and corn, namely 9.5%. The starch content of sorghum is also quite high, namely 80.42%. The insoluble fiber content in sorghum is 6.5% -7.9% while the water soluble fiber is 1.1% -1.23% (Lestari, et al., 2022). Besides that, sorghum also rich in vitamin B complex, minerals (potassium, magnesium, phosphorus, zinc), unsaturated fatty acids, and antioxidants (Xiong, Zhang, Warner, & Fang, 2019). According to the Food and Drug Supervisory Agency of the Republic of Indonesia in 2016, food product claims that are a source of dietary fiber must contain 3 g of fiber per 100 grams of solid material, while food products that are high in fiber must contain at least 6 g of dietary fiber per 100 grams of solid material (BPOM, 2016). Sorghum seeds can also be processed into flour which can be used as an ingredient in making cakes, noodles, bread and other bakery products.

Calories (*calorie*) means the amount of energy needed to raise the temperature of 1 gram of water by 1ºC. Calories in the world of health are in kilocalories (kcal) (McComb, Carnero, & Gutiérrez, 2014; Katz, Friedman, & Lucan, 2015). The term calories in food and health is the amount of energy contained in food and the amount of energy needed by the body to carry out metabolism (Duyff, R. L, 2006). In the food consumed there are nutrients that are processed by the body to become a source of energy for the body, namely carbohydrates, fats and proteins. The energy produced by these three nutrients can be determined using a tool called a bomb calorimeter which is then converted. The conversion of calorific values from carbohydrates, proteins and fats was first proposed by Atwater in 1896 (FAO, 2002). According to BPOM, low-energy food contains 40 kcal of energy per 100 grams and calorie-free food contains 4 kcal of energy per 100 gr (BPOM, 2016). The energy content of sorghum is 366 kcal per 100 grams (Kemenkes, 2018).

Noodles are a source of carbohydrates besides rice, bread and tubers. In Indonesia, noodles are widely consumed and are popular with people in various circles as a substitute for rice or as an addition to side dishes. Substituting wheat flour with sorghum flour in making wet noodles can affect the color, taste, texture, smell and appearance of the product. This is because sorghum flour has different physical characteristics from wheat flour, one of which is the darker color of the flour.

This study aims to determine differences in gluten levels, dietary fiber, calorific value and acceptability of wet noodles substituted with sorghum flour (*Sorghum bicolor* (L)) with percentages of 0%, 10%, 20%, 30, 40%.

Results and Discussions

The ingredients needed to make wet noodles are medium protein wheat flour, Tambiyaku brand sorghum flour, table salt, chicken eggs and mineral water. Wet noodles are made with 5 formulations with a ratio of wheat flour and sorghum flour including F0 (100%: 0%), F1 (90%: 10%), F2 (80%: 20%), F3 (70%: 30%), F4 (60%: 40 %). Each wet noodle formulation will be tested for acceptability 1 repetition so that the three best formulations are then analyzed for gluten content, dietary fiber and calorific value 3 repetitions. Testing of acceptability and gluten levels was carried out in the Nutrition laboratory of the Faculty of Psychology and Health involving 30 untrained panelists. Analysis of food fiber content was carried out at the SIG Saraswanti Bogor laboratory and calorific value was carried out at the Central Laboratory of Muhammadiyah University Malang.

Making Wet Noodles Substituting Sorghum Flour

Wet noodles is a food product made from wheat flour which can be added with other additional ingredients and then goes through the process of mixing and kneading the ingredients, molding the dough, making noodle strands, and cutting the noodles (Badan Standardisasi Nasional, 2015). The process of making wet noodles is that wheat flour is mixed with chicken eggs, salt and water. Knead the dough until all ingredients are mixed evenly and smooth. After that, cover the dough using plastic wrap then rest for a few minutes. Before rolling out the dough, knead it again several times. Flatten the wet noodle dough using a rolling tool until the dough is ± 1.5 mm thick. Then

cut the wet noodles thinly to form strands. After that, the noodles are boiled until the texture changes to become more chewy and cooked.

Acceptance Testing

The test uses a hedonic test method which uses a hedonic scale to determine the level of acceptance or preference for the color, aroma, taste, texture and preference of wet noodle products. The hedonic scale consists of 5 score levels, namely 1 (dislike very much), 2 (dislike), 3 (quite like), 4 (like), 5 (very like). This testing involved 30 untrained panelists (Setyaningsih, Apriyantono, & Sari, 2010). The place and time for the implementation are carried out in accordance with the guidelines stated in SNI 01-2346, namely in an organoleptic laboratory which has booths and chairs.

Gluten Content Analysis

Gluten content analysis is carried out using the method of hand *washing.* A sample weighing 100 grams (according to the specified formulation) is mixed with 20 ml of water until it becomes a dense dough. The sample dough was soaked in water for 1 hour. After that, the sample dough is washed under continuous running water until the water from washing the dough becomes clear or not cloudy. Gauze or a 150 mesh sieve is placed at the bottom as a base to catch the broken down dough or gluten. After the dough is washed, the water in the remaining gluten is removed then the gluten is dried in the oven for 2 hours at 120ºC then the dried gluten is weighed (Imran, Hussain, Ghafoor, Nagra, & Ziai, 2023).

Dietary Fiber Analysis

Food fiber content was analyzed using enzymatic methods. This method refers to the procedures established by AOAC International. This method uses the help of the enzymes α-amylase, amyloglucosidase and protease enzymes which are then precipitated by ethanol.

The sample to be analyzed is weighed as much as 1 gram using a digital scale. The sample was put into an Erlenmeyer flask and then 50 mL of phosphate buffer solution with pH 6 and 50 µL of α-amylase were added. Water bath heated until the temperature reaches 95-100ºC. The Erlenmeyer flask was covered with aluminum foil then placed in a hot water bath for 15 minutes and stirred every 5 minutes. After heating, the sample was cooled using a desiccator, then after cooling, 10 mL of 0.275 N NaOH was added to the sample solution to make the sample pH 7.5. Then 100 µL of protease enzyme was added and the sample was incubated at 60ºC for 30 minutes then cooled. After cooling, 10 mL of 0.325 N HCl was added to the solution to make the sample pH 4.5, then 200 µL of the amyloglucosidase enzyme was added and incubated at 60ºC for 30 minutes. The sample was precipitated using 95% ethanol at a temperature of 60ºC as much as 280 mL then waited for 60 minutes until the sample settled. The resulting sample sediment was filtered using filter paper and then washed using 3x20 mL of 78% ethanol, 2x10 mL of 95% ethanol and 2x10 mL of acetone. After washing, the residue was dried at 105ºC for 1 hour using an oven and then the weight of the residue (W_1). The resulting residue is then divided into two to be tested for protein content (W_2) using the Kjeldahl method and ash content (W_3) as a correction for calculating total dietary fiber (Adawiyah, Wefiani, & Patricia, 2021).

Caloric Value Analysis

Testing calories in food is carried out using a calorimeter which is often called a bomb calorimeter. A bomb calorimeter is a tool used to measure the heat produced by burning a sample that is burned in a closed vessel under oxygen pressure. The result of the bomb calorimeter measurement is called the combustion value (*combustion value*). The tool used is an IKA C2000 bomb *calorimeter.* The sample to be tested is weighed at 0.5-1 gram and then placed in an iron cup. A 10 cm long nickel wire is attached to the iron support inside the decomposition *vessel*. The iron cup containing the sample is placed on the cup support. Cotton thread is attached to the burning wire and connected to the sample to help burn the solid sample and then inserted inside the decomposition *vessel* then closed. *Decomposition vessel* filled with pure oxygen with a maximum pressure of 30 bar. *Decomposition vessel* which has been filled with oxygen is put into

the calorimeter vessel. 2 liters of water was put into the calorimeter vessel. After that, the bomb calorimeter is closed and combustion begins. The heating value results, the increase in combustion temperature will appear on the screen display bomb calorimeter (Nainggolan & Hasan, 2016; IKA, 2014).

RESULTS AND DISCUSSION

Acceptability

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*

Color is a component that can leave the first impression on a product because color is assessed by the sense of sight. One component that can attract consumers tastes to try a food product is color (Lamusu, 2018). Based on the analysis of the organoleptic test values for color parameters using the Kruskal Wallis test in Table 1, it shows that the probability value is 0.001, which indicates that there is a real difference in the color of wet noodles.

Color of wet noodles substituted by sorghum flour will become darker as the percentage of sorghum flour increases. This is because the tannin content in sorghum reacts with protein and is oxidized, causing the color of sorghum flour to darken (Patty, Putri, & Rukmi, 2023). The control treatment (F0) had the color of normal noodles, namely yellowish white, which mostly came from the eggs. The F1 treatment with a ratio of 90% wheat flour and 10% sorghum flour has a brownish yellow color. The F2 treatment with a ratio of 80% wheat flour and 20% sorghum flour has a brown color that tends to be light with a few black spots. The F3 treatment with a ratio of 70% wheat flour and 30% sorghum flour has a darker brown color with black spots. The F4 treatment with a ratio of 60% wheat flour and 40% sorghum flour has a dark brown color with many black spots.

The aroma of food products is influenced by the ingredients used in making food. Data from organoleptic tests of aroma parameters were analyzed using the Kruskal Wallis test and obtained a probability value of <0.05, namely 0.002, which indicates that there is a real difference in aroma of wet noodles. Sorghum has a distinctive aroma that not many people know about. Sorghum contains compounds volatile formaldehyde which comes from the oxidation of lipids,

alcohols, ketones, terpenoids and esters. Compounds volatile this gives off aromas such as almond, malt, grass, citrus, fatty and rancid (Shuang, et al., 2021). The wet noodles treated with the F0 control (100:0) had a typical flour and egg aroma, whereas my wet treatments F1 to F4 have a powdery aroma with the addition of a typical sorghum aroma. The higher the percentage of sorghum flour, the stronger the distinctive aroma of sorghum.

Taste parameter data was analyzed using the Kruskall Wallis test and obtained a probability value of <0.05, namely 0.001, which indicates that there is a real difference in taste of wet noodles. The higher the substitution of sorghum flour in wet noodles, the lower the level of panelist acceptance of wet noodles. This is due to the tannin content in sorghum which can cause an astringent or sour taste when consumed (Prabawa, Zoelnanda, Anam, & Samanhudi, 2023). Table 1 shows that the 3 formulations preferred by panelists are F0 (100:0) with an average value of 4.27; F1 (90:10) with an average value of 4; and F2 (80:20) with an average value of 3.5, while the least preferred formulation is F4 with an average value of 2.73.

Texture is one of the parameters of an organoleptic test that involves the sense of touch. Data on organoleptic test values for texture parameters is valuable 0.001 which indicates that there is a real difference in texture wet noodle substitution of sorghum flour. The wet noodles formulation that was most liked by the panelists was F0 (100:0) with an average value of 4.37, then F1 (90:10) with an average value of 4.03, and F2 (80:20) with an average value 3.73. Meanwhile, the wet noodle formulation that was least liked by the panelists was F4 (60:40) with an average value of 2.83.Based on this data, it shows that the panelists liked the texture of the wet noodles less with the higher the sorghum flour substitution. This is due to the gluten and fiber content in sorghum. The fiber in sorghum can create texture when wet it becomes hard and brittle because the matrix bonds between the materials are filled with fiber (P, Karimah, & Alviona, 2017). Sorghum is also a food ingredient that does not contain gluten. Gluten acts as an adhesive that provides elastic and chewy properties to dough (Scherf, Köhler, & Freising, 2016).

The overall parameters are the panelist preferences for aspects of product color, aroma, taste and texture. Data from the overall liking test value were analyzed using the Kruskall Wallis test and showed a probability value of <0.05, namely 0.001, which indicated that there was a real difference in the overall liking of the wet noodle product substituted for sorghum flour. There are more and more substitutions for sorghum flour in manufacturing of wet noodles, the more the panelist preference for it decreases. This is caused by the color of wet noodles which becomes less attractive, there is a distinctive aroma from sorghum flour, a slightly astringent taste and a texture that breaks easily and becomes less chewy as the substitution of sorghum flour increases.

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

Data from gluten, dietary fiber and caloric value tests were analyzed using the One Way Anova test obtained The results show that there is a significant difference ($p<0.05$) in food fiber content and gluten content of wet noodles control formulation and treatment formulation, while there was no significant difference in the calorific value ($p>0.05$).

Gluten Content

Gluten is a component contained in cereals such as wheat which has an important role in making dough to provide an elastic dough structure. After carrying out the acceptability test on the wet noodles, the 3 formulations most preferred by panelists, namely F0, F1, and F2, will be analyzed for gluten, dietary fiber and calorie content (*gross energy*). Table 2 shows the results of gluten content analysis using the One Way Anova test where the probability value is at wet noodles with sorghum flour substitution is >0.05, namely 0.048, which indicates that there is a real difference between the control formulation (F0) and the treatment formulation (F1 and F2).

Substitution for sorghum flour in manufacturing wet noodles can affect gluten content. The higher the sorghum flour substitution, the gluten content of wet noodles decreases. The control formulation (F0) had an average gluten content of 12.56 gr while the F1 formulation had an average gluten content of 11.53 gr and F2 of 11.40 gr. However, wet noodle products substituted for sorghum flour do not meet the standards for low-gluten food. This is because according to BPOM in 2016, the gluten content in low-gluten foods ranges from 21-100 mg/kg (BPOM, 2016)

Dietary Fiber Content

Dietary fiber is a part of plant cell walls that cannot be digested by human digestion. Fiber can be found in vegetables, fruit, cereals and nuts. Data from the test results were analyzed using the One Way Anova test and a probability value of 0.001 was obtained, indicating that there was a real difference in food fiber content.my wet control formulation (F0) and treatment formulation (F1 and F2).

Based on the analysis, noted that substituting Sorghum flour can affect dietary fiber levels in wet noodles. This is because sorghum flour contains higher dietary fiber than wheat flour, namely 10.37% while wheat flour is 8.69% (Wahjuningsih, Sudjatinah, Azkia, & Anggraeni, 2020). The control formulation F0 had a dietary fiber content of 4.47% while the F1 treatment formulation had a dietary fiber content of 13.39% and F2 had a dietary fiber content of 16.67%. The wet noodle product substituted for sorghum flour has a dietary fiber content of > 6 grams per 100 grams of ingredients so it can be said to be a high fiber food based on the 2016 BPOM regulations.

Calorie Value Rate

Components in food such as protein, fat, carbohydrates, alcohol, *polyols*, and organic acids affect the energy or calorie content of food products. Rough total energy content (*gross energy*) in food can be measured using a bomb calorimeter (FAO, 2002). Data from testing calorific value of 3 formulations of wet noodles which was analyzed using the One Way Anova test which shows a probability value of 0.162 which indicates that there is no real difference in the energy value of wet noodles control formulation (F0) and treatment formulation (F1 and F2).

Adding sorghum flour in making wet noodles can affect the calorific value. Based on table 2, it is known that the calorific value of wet noodles with sorghum flour increases as the percentage of sorghum flour substitution increases. Sorghum flour has a total energy value of 357.39 kcal/100 gr which is higher than wheat flour, namely 350.46kcal/100 gr (Wahjuningsih, Sudjatinah, Azkia, & Anggraeni, 2020). Based on BPOM provisions, the product wet noodles with substitution sorghum flour is not included in low-calorie foods because it has an energy value above 40 kcal/100 gr of ingredient.

Conclusion

There are real differences in the aspects of color, aroma, taste, texture and preferences of wet noodles with substitution of sorghum flour. The fiber content and gluten content of wet noodles substituted for sorghum flour have a significant difference but the calorific value does not have a significant difference. However, the fiber content and calorific value of wet noodles increased while the gluten content decreased as the percentage of sorghum flour substitution increased.

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Conflicts of interest
None.

References

Adawiyah, D. R., Wefiani, F. P., & Patricia, K. (2021). Karakterisasi Serat Pangan, Kapasitas Pengikatan Air dan Kemampuan Emulsifikasi Biji Selasih dan Chia. *Jurnal Mutu Pangan, 2*, 63-69.

Badan Standardisasi Nasional. (2015). *SNI 2987.*

BPOM. (2016). *Pengawasan Klaim Pada Label dan Iklan Pangan Olahan.*

Duyff, R. L. (2006). *American Dietetic Association Complete Food and Nutrition Guide* (3rd ed.). New Jersey: John Wiley & Sons, Inc.

FAO. (2002). *FAO Food and Nutrition Paper: Food Energy Methods of Analysis and Conversion Factors.* Rome: Food and Agriculture Organozation of The United States.

IKA. (2014). *Calorimeter System C 200.* IKA.

Imran, S., Hussain, Z., Ghafoor, F., Nagra, S. A., & Ziai, N. A. (2023). Comparative Efficiency of Different Methods of Gluten Extraction in Indigenous Varieties of Wheat. *ARCHIVOS LATINOAMERICANOS DE NUTRICIÓN, 63*(2), 180-187.

Katz, D. L., Friedman, R. S., & Lucan, S. C. (2015). *Nutritional in Clinical Practice: a Comprehensive, Evidence-based Manual for The Practitioner* (3rd ed.). Philadelphia, USA: Wolters Kluwer.

Kemenkes. (2018). *Tabel Komposisi Pangan Indonesia.* Jakarta: Kementerian Kesehatan Indonesia.

Lamusu, D. (2018). Uji Organoleptik Jalangkote Ubi Jalar Ungu (Ipomoea batatas L) sebagai Upaya Diversifikasi Pangan. *Jurnal Pengolahan Pangan, 3*(1), 9-15.

Lestari, R., Nugroho, S., Tyas, K. N., Magandhi, M., Sugiharto, A., Sudiana, I. M., . . . Suliasih. (2022). *Petunjuk Teknis Budidaya Sorgum di Lahan Alang-alang atau Lahan Marginal.* Bogor: IPB Press.

McComb, J. J., Carnero, E. Á., & Gutiérrez, E. I. (2014). Estimating Energy Requirements. In e. a. J.J Robert-Mc Comb., *The Active Female: Health Issues Throughout the Lifespan* (pp. 411-449). New York: Springer Science+Business Media.

Nainggolan, R., & Hasan, F. F. (2016). Menguji Akurasi Bom Kalorimeter IKA C200 Ver 1.12 dengan Sampel Batu Bara, Cangkang & Serat Sawit, Minyak Solar dan Bensin. *POLIMEDIA, 19*(3), 34-45.

P, T. K., Karimah, I., & Alviona, Y. Y. (2017). Pengaruh Subtitusi Tepung Sorgum dan Penambahan Tepung Wortel Terhadap Daya Terima Mi Basah. *Bulatin Media Informasi, 2*, 43-47.

Patty, M. D., Putri, E. S., & Rukmi, W. D. (2023). Physicochemical Characteristic of Starch Noodles Based on Sorghum Flour (Sorghum bicolor L. Moenech) and Sago Flour (Metroxylon Sp). *jurnal Pangan dan Agroindustri, 11*(3), 147-157.

Prabawa, S., Zoelnanda, A., Anam, C., & Samanhudi. (2023). Evaluasi Kualitas Sensoris dan Fisikokima Mi Basah Sorgum (Sorghum bicolor L. Moenech) sebagai Pangan Fungsional. *Jurnal Teknologi Hasil Pertanian, 16*(1), 13-28.

Quan, C. V., Ferreiro, S. E., & Cantón, O. S. (2018). Gluten Free Diet: Always as Easy, Useful, and Healthy as People Think? *Journal of Child Science*, 75-81. doi:DOI https://doi.org/10.1055/s-0038-1669381.ISSN 2474-5871.

Scherf, K. A., Köhler, P., & Freising. (2016). Wheat and gluten: Technological and health aspects. *Ernaehrungs Umschau*, 166-175.

Setyaningsih, D., Apriyantono, A., & Sari, M. P. (2010). *Analisis Sensori untuk Industri Pangan dan Agro.* Bogor: IPB Press.

Shuang, C., Li, W., Derang, N., Lin, L., Heyu, W., & Yan, X. (2021). Characterization of Aroma Compounds in Cooked Sorghum Using Comprehensive Two-Dimensional Gas

Chromatography-Time-of-Flight Mass Spectrometry and Gas Chromatography-Olfactometry-Mass Spectrometry. *Molecules, 26*(4796), 1-18.

Wahjuningsih, S. B., Sudjatinah, Azkia, M. N., & Anggraeni, D. (2020). The Study of Sorghum (Sorghum bicolor L.), Mung Bean (Vigna radiata) and Sago (Metroxylon sagu) Noodles: Formulation and Physical Characterization. *Current Research in Nutrition and Food Science*, 217-225.

Xiong, Y., Zhang, P., Warner, R. D., & Fang, Z. (2019). Sorghum Grain: From Genotype, Nutrition, and Phenolic Profile to Its Health Benefits and Food Applications. *Comprehensive Reviews in Food Science and Food Safety, 18*, 2025-2046.

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Conflicts of Interest
None.