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SUGAR CONTENT, CRUDE FIBER CONTENT, ANTIOXIDANT ACTIVITY, AND SENSORY CHARACTERISTICS OF SORGHUM (SORGHUM BICOLOR (L.)MOENCH) SNACK BAR WITH ADDITION OF KLUTUK BANANA (MUSA BALBISIANA COLLA) FLOUR

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ABSTRACT

Sorghum and klutuk banana can be utilized as functional foods that are high in fiber and antioxidant and suitable for diabetic people. This study examined the effects of klutuk banana flour on the sugar content, crude fiber content, antioxidant activity, and sensory characteristics of sorghum snack bars. This study is true experimental, employing a completely randomized design (CRD) with 4 formulations: the ratio of sorghum and banana flour klutuk PO (100:0), P1 (90:10%), P2 (80:20%), and P3 (70:30%), and 6 repetitions. Sugar content, crude fiber, and antioxidant activity were observed and analyzed using the one-way ANOVA (Analysis of Varian) test, followed by Duncan test. The sensory properties were evaluated using Friedman test. 1.94–2.86% sugar, crude fiber content is 46.04–70.89%, and antioxidant activity is 9.06–15.0%. The results revealed a significant relationship ($p<0.05$) between the addition of klutuk banana flour to the sorghum snack bar sugar level, crude fiber content, and antioxidant activity. Texture, color, flavor, and scent were not significantly affected by the addition of klutuk banana flour to sorghum snack bars. The optimal formulation of a sorghum snack bar with the inclusion of klutuk banana flour was discovered to be P3 based on the test sugar content, crude fiber content, antioxidant activity, and sensory characteristics. The nutritional value of the P3 formulation have met USDA (2018) standards for the Nutri-Grain Fruit and Nut Bar, but the sugar content have not meet the SNI 01-3702-1995 (Indonesian National Standards) quality requirements for diabetes diet biscuit.

Keywords: antioxidant activity, diabetes mellitus, sugar, sensory characteristics, crude fiber, snack bar, klutuk banana flour

INTRODUCTION

Diabetes mellitus (DM) is a metabolic disorder characterized by blood sugar levels above normal, and results in damage to insulin secretion, insulin action, or both (Akram, 2015). According to Basic Health Research (Riskesdas) data, the prevalence of diabetes mellitus in Indonesia in 2018 was 1.5% (Ministry of Health, 2018). The prevalence is estimated to increase to 578 million in 2030 and 700 million in 2045 (Ministry of Health, 2020).

Individuals with diabetes mellitus (DM) necessitate the incorporation of antioxidant sources into their dietary regimen to impede oxidative damage within the body (Tritisari et al., 2017). Additionally, meticulous regulation and monitoring of carbohydrate intake, both in terms of quantity and type, play a pivotal role in managing blood glucose level effectively (Surayya et al., 2020). Guidance for individual with diabetes includes the adoption of a health-conscious diet, with a specific emphasis on augmenting fiber consumption as a means of blood glucose control (Azrimaidaliza, 2011). It is recommended that individual with diabetes aim for a daily fiber intake within the range of 20-35 gram (Indonesia Endocrinology Association, 2019).

Sorghum exhibits notable nutritional characteristics, boasting a fiber content of 6.7 gram per 100 gram (USDA, 2018). The seeds of sorghum contribute 7.34 gram of glucose per 100 gram (Diyah et al., 2018). Adhering to the regulatory framework outlined in Head of BPOM Regulation Number 13 of 2016 concerning Supervision of Claims on Processed Food Labels and Advertisements, a product can be designated as high in fiber if it attains a fiber content of 6 g/100 g or 6%. Moreover, sorghum emerges as

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a commendable source of antioxidants, with an appreciable content of 40.46% (Wu et al., 2013). In the context of dietary consideration for individual with diabetes mellitus (DM), it is imperative not only to incorporate antioxidant-rich foods but also to introduce supplementary ingredients rich in fiber. Klutuk banana (Musa balbisiana colla) flour emerges as a viable option for enhancing fiber intake among individuals with DM. Traditionally utilized primarily for its leaves as wrappers due to their tear-resistant nature (Hastuti, 2021), Klutuk bananas exhibit superior nutritional attributes compared to other banana varieties. With a substantial crude fiber content of 6.9% (Endra, 2006), and a sugar content of 11.79% (Kehek, 2017), Klutuk banana provides a robust foundation for augmenting the dietary fiber required by individual with DM. Additionally, the antioxidant activity across various banana varieties ranges from 44.4 to 51.6 µg/mL (Siji & Nandini, 2017). This underscores the multifaceted nutritional benefit of incorporating Klutuk banana flour into the dietary regimen of individual managing diabetes mellitus.

Sorghum and Klutuk banana present promising prospect as constituent of functional food, particularly in the formulation of snack bars, offering an alternative dietary option replete with abundant fiber and antioxidant. Snack bars, characterized by their high fiber and low glucose composition, emerge as an especially suitable consumable for individuals, notably those managing diabetes mellitus (DM) (Zaddana et al., 2021). This study aims to advance the development of a functional snack in the form of a sorghum-based snack bar, enriched with the inclusion of Klutuk banana flour. The investigation further seeks to evaluate key parameters such as sugar content, fiber composition, antioxidant activity, and sensory characteristics of the developed snack bars, thereby contributing to a comprehensive understanding of their nutritional profile and palatability.

METHODS

This research adheres to the principles of true experimental design, employing the Completely Randomized Design (CRD) methodology encompassing four distinct formulations denoted as P0 (100:0%), P1 (90:10%), P2 (80:20%), and P3 (70:30%). The study incorporates six replications for each formulation, determined through application of Federer's formula. The control formulation, designated as P0, serves as the reference standard against which experimental formulations are compared. The experimental procedures transpired in June 2022 within the confines of the Food Processing Laboratory at Muhammadiyah University Semarang, where the synthesis of klutuk banana flour and sorghum snack bars, featuring the incorporation of klutuk banana flour, took place. Concurrently, assessment of sugar content, fiber composition, and antioxidant activity were conducted at the Nutrient Analysis Laboratory of Muhammadiyah University Semarang. To further elucidate the sensory attributes of the sorghum snack bars augmented with klutuk banana flour, comprehensive evaluation were carried out at the Organoleptic Laboratory, Muhammadiyah University, Semarang. A discerning panel of 20 semi-trained individuals, specifically selected from students enrolled in the Undergraduate Nutrition and Food Technology program at Muhammadiyah University, participated in the sensory analysis, contributing valuable insights into the palatability and organoleptic dimension of the developed snack bars.

Materials and Tools

The raw materials utilized in this study were meticulously selected, comprising brown sorghum sourced from Batang Regency and klutuk bananas procured from Sembojo Village, Tulis District, Batang Regency, Central Java. The formulation included precise quantities of 5 gram of corn sugar, 15 gram of margarine, 20 gram of chicken egg yolk, 20 gram of skim milk flour, and 15 ml of water, as outlined by Zaddana et al. (2021). For chemical analyses, a comprehensive array of materials was employed, encompassing distilled water, luff-schrool solution, H_2SO_4 6N solution, KI 30%, $Na_2S_2O_3$ 0,1 N, 1% starch, H_2SO_4 0,325 N solution, NaOH 1,25 N solution, K_2SO_4 10% solution, 95% ethanol, 2,2-diphenyl-1-picrylhydrazyl (DPPH) solution and methanol solution. These substances were instrumental in conducting various chemical tests, allowing for a thorough examination of the nutritional and antioxidant properties of the developed snack bars.

The preparation and processing of ingredients used cabinet dryer, knive, cutting board, basin, baking sheet, disk mill, scale, stove, spoon, spatula, oven, and conventional popper. These tools ensured the efficient and standardized execution of the snack bar formulation and processing protocols. The chemical analyses were conducted using scale, porcelain cup, measuring flask, closed Erlemeyer, volume pipette, burette, measuring cup, filler, stamper mortar, Erlenmeyer, return cooler, stative, hot plate, beaker, dropper pipette, funnel, filter paper, desiccator, oven, vortex, test tube, tube rack, aluminum foil, vial, and spectrophotometer. Furthermore, the sensory evaluation component of the study employed tools such as writing instruments and hedonic test forms. The comprehensive array of tools employed in this study underscores the scientific rigor and methodological thoroughness applied to both the chemical and sensory evaluations.

Phase of Making Klutuk Banana Flour

The initial phase of Klutuk banana flour production entails the meticulous peeling of Klutuk banana skin, followed by the precision slicing of banana into thin section measuring 30 x 30 mm. Subsequently, the sliced banana undergo a water immersion process for a duration of 30 minutes. The rehydrated Klutuk bananas are then systematically arranged within a baking dish and subjected to a controlled drying process at 50°C in an oven, spanning a duration of 24 hours. Following the dehydration phase, the banana are finely ground to achieve the desired particle size using a disk mill equipped with an 80 mesh sieve, in accordance with the methodology outlined by Musita (2014). This systematic procedure ensures the production of Klutuk banana flour with optimal physical and compositional attributes for subsequent incorporation into the development of nutritionally fortified snack bars.

$$\text{Rendered Results} = \frac{\text{final weight}}{\text{initial weight}} \text{ x } 100\%$$

$$\text{Rendered Results} = \frac{945 \text{ gram}}{4.875 \text{ gram}} \text{ x } 100\%$$

$$= 19{,}38\%$$

The yield of Klutuk banana flour was 19.38%.

Determining the Formula for Sorghum Snack Bars with the Addition of Klutuk Banana Flour

Table 1. Sorghum snack bar formulation with the addition of klutuk banana flour

Formulation	Brown Sorghum (%)	Klutuk Banana Flour (%)
P0	100*	0*
P1	90	10
P2	80	20
P3	70	30

Source : (Zaddana et al., 2021)

* (Rufaizah, 2011)

Phase of Making Sorghum Snack Bars with the Addition of Klutuk Banana Flour

The preliminary phase involves the preparation of sorghum pop, initiated by washing and subsequently utilizing a conventional popper as delineated by Linda and Panunggal (2015). Following this, the snack bar formulation commences with the amalgamation of wet ingredients, namely margarine, water, and chicken egg yolk. The amalgamated wet ingredients are then judiciously introduced to the dry components, encompassing sorghum pop, klutuk banana flour, skim milk flour, and corn sugar. The ensuing mixture undergoes a meticulous kneading process until achieving a homogenously smooth consistency, adhering to the methodology articulated by Zaddana et al. (2021). Subsequently, the resulting snack bar dough is expertly shaped into a rectangular form within a designated baking pan, in accordance with the procedural guidelines elucidated by Rufaizah (2011). The final transformative step involves the controlled baking of the molded dough in an oven set at 130°C, an operation spanning 30 minutes, aligning with the methodology stipulated by Fajri et al. (2020). This systematic and methodically detailed approach ensures the production of nutritionally fortified sorghum and klutuk banana snack bars with precise physical and compositional attributes.

Chemical Properties Analysis

1. Sugar Level Test (Faizati et al., 2018)

A representative aliquot of 5 gram sample was quantitatively transferred into a volumetric flask, and distilled water was meticulously added to achieve the calibrated volume. Subsequently, a precisely measured 5 mL aliquot of the resultant sample solution was withdrawn and combined with 10 mL of Luff-Schrool solution. The amalgamated solution underwent a controlled reflux process for a duration of 10 minutes. Upon completion of refluxing, the solution was allowed to cool, and a subsequent addition of 10 mL of 6N H_2SO_4 solution and 10 mL of 30% KI was carried out. The ensuing solution was subjected to a meticulous titration protocol utilizing 0.1 N $Na_2S_2O_3$ until the manifestation of a distinct straw-yellow color. Once the solution attained the predetermined straw-yellow hue, 1 mL of 1% starch solution was judiciously introduced into the system. Following this addition, titration resumed until the color transitioned to a milky-white appearance. This methodological approach ensures the precise determination of chemical constituents, employing titration techniques to establish quantitative endpoints indicative of the desired chemical reactions.

$$a = \frac{(\text{V blanko} - \text{V sample}) \text{x real N Na2S2O3}}{\text{N Na2S2O3 0,1 N}}$$

$$\% \text{ sugar} = \frac{\text{b x FP}}{\text{W (g)x 1000}} \text{ x } 100\%$$

Note:
Value a = value b obtained using the help of the Luff Schrool table.

2. Fiber Level Test (AOAC, 2005)

A precisely measured quantity of 1 gram of the sample was meticulously introduced into an Erlenmeyer flask, followed by the addition of 50 mL of 0.325 N H_2SO_4. Subsequently, the mixture underwent a controlled reflux process for a duration of 30 minutes. To this resultant mixture, 50 mL of 1.25 N NaOH solution was incrementally added, and the reflux process was continued for an additional 30 minutes. The ensuring reaction mixture was subjected to filtration using Whatman filter paper, ensuring the separation of the solid residue from the liquid phase. The residual material on the Whatman filter paper was subjected to a sequential washing regimen. Initially, the residue was washed with 25 mL of distilled water, followed by an additional wash with 25 mL of 10% K_2SO_4 solution. Subsequent rinses included a wash with 25 mL of distilled water, and a final wash with 20 mL of 95% ethanol. The residue, now purified, was then subjected to drying in an oven maintained at 105°C for a stipulated period of 2 hours. Following the drying process, the sample was placed within a desiccator for 15 minutes to equilibrate moisture level, after which it was meticulously weighed. This systematic series of procedures ensures the preparation, purification, and quantitative analysis of the sample in a controlled chemical environment.

$$\text{Fiber Content (\%)} = \frac{\text{final weight} - \text{initial weight (gram)}}{\text{sample weight (gram)}} \text{ x } 100\%$$

3. Antioxidant Activity Assessment (Chandra, 2010)

In the pursuit of assessing antioxidant activity, the 0.1 mM DDPH method was employed. A precisely measured 0.5 gram aliquot of the specimen underwent dissolution in a meticulously dispensed 10 ml volume of methanol within a test tube, diligently shielded with aluminum foil. Subsequently, the sample was subjected to vigorous vortexing for a duration of 1 minute, followed by an extraction period of 3 hours. For the subsequent analytical step, a precisely measured 0.2 mL aliquot of the resulting sample solution was introduced into a test tube, enveloped in aluminum foil. To this, 3.9 mL of a meticulously prepared 0.1 mM DPPH solution was added, and the amalgam was subjected to thorough vortexing. This amalgamation was then allowed to stand for a duration of 30 minutes. Following this incubation period, the absorbance of the sample was quantified at a wavelength of 517 nm, employing the precision of a UV-Vis spectrophotometer. Concurrently, a blank sample was meticulously prepared using 0.2 mL of methanol and 3.9 mL of the 0.1 mM DPPH solution, following a parallel

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methodology. This methodological rigor ensured a comprehensive evaluation of antioxidant activity, underscoring the meticulousness inherent in the experimental design and execution.

$$(\% \text{ inhibition}) = \frac{\text{blank absorption} - \text{sample absorption})}{\text{blank absorption}} \text{ x } 100\%$$

Data Analysis

In the domain of nutritional assessment, an examination of data pertaining to sugar content, crude fiber, and antioxidant activity commenced with the utilization of the Shapiro-Wilk statistical test to evaluate normality. This meticulous analysis revealed that the data pertaining to sugar content, crude fiber, and antioxidant activity exhibited normal distributions. Subsequently, a one-way Analysis of Variance (ANOVA) test was employed, followed by a post hoc Duncan test for further discernment of potential variances among the means. This approach was taken to explore and elucidate the nuanced variation within the normal dataset. Conversely, the sensory characteristics data yielded non-normally distributed outcomes. In response to this departure from normality, the Friedman test, a non-parametric alternative suitable for assessing repeated measures, was judiciously employed. This test was selected to discern and expound upon any discernible differences in the sensory characteristics that may not conform to a normal distribution. Through this multifaceted statistical approach, a thorough and nuanced understanding of the nutritional and sensory aspects under investigation was achieved, embodying the methodological precision inherent in medical academic research.

RESULTS AND DISCUSSION

Snack bars emerge as a nutritionally sugar content in brown sorghum establishes it as a prudent dietary choice for individuals contending with degenerative conditions like diabetes.

A comparative analysis with Klutuk banana reveals a decline in sugar content even in its flour form. Klutuk banana fruit registers a sugar content of 11.78%, whereas Klutuk banana flour records a substantially reduced to 2.78% (Kehek, 2017). The decreased sugar content in the banana flour is attributed to the utilization of raw klutuk bananas and the subsequent drying process at a temperature of 50°C. The elevated temperature induces the expansion of starch granules, leading to the dissolution of the low amylose fraction and uniform breakage of starch granules, potentially causing carbohydrate modification, as explicated by Kurniawan et al. (2015).

As per USDA data from 2018, sorghum demonstrates a fiber content of 6.7 gram per 100 gram, while the current study records a slightly elevated value of 8.39%. In the case of Klutuk banana flour, the crude fiber content exceeds that of its fruit counterpart by 44.70%. Endra (2006) reports a crude fiber content of 6.90% in Klutuk bananas. This divergence arises from the drying process employed in Klutuk banana flour production, as elucidated by Simanjuntak et al. (2013), wherein elevated drying temperatures lead to reduced water content, subsequently causing an augmentation in crude fiber content concomitant with an increase in carbohydrate content. It is imperative to note that fiber, a complex carbohydrate inherent in food, plays a crucial nutritional role (Simanjuntak et al., 2016).

The antioxidant activity of sorghum, as reported by Wu et al. (2013), stands at 40.46%, diverging significantly from the findings of Linda and Panunggal (2015) where brown sorghum exhibits an antioxidant activity level of 95.38%. Discrepancies in antioxidant activity level can be attributed to geographical and climatic variation in the locales of ingredient sourcing, influencing the composition of bioactive compounds,

Table 1. Test Results for Sugar Content, Crude Fiber Content, and Antioxidant Activity in Brown Sorghum and Klutuk Banana Flour

Nutriment	Sugar (%) Mean ± standard deviation	Crude Fiber (%) Mean ± standard deviation	Antioxidant Activity (%) Mean ± standard deviation
Brown Sorghum	1.33 ± 0.22	8.39 ± 0.27	46.5 ± 0.74
Klutuk banana flour	2.78 ± 0.28	44.70 ± 1.54	27.21 ± 1.69

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Table 2. Sugar Content, Fiber, and Antioxidant Activity of Sorghum Snack Bars with the Addition of Klutuk Banana Flour

Formulation	Sugar Content (%) Mean ± standard deviation	Crude Fiber Content (%) Mean ± standard deviation	Antioxidant Activity (%) Mean ± standard deviation
P0	1.57±0.48[a]	28.46±1.11[a]	5.00±2.03[a]
P1	1.94±0.51[ab]	46.04±3.93[b]	9.06±2.74[b]
P2	2.19±0.12[b]	52.49±1.47[c]	12.07±2.51[bc]
P3	2.86±0.58[c]	70.89±4.91[d]	15.05±2.86[c]

Note: Formula P0 = (100%:0%), P1 = (90%:10%), P2 = (80%:20%), P3 = (70%:30%)

Values with different lowercase superscripts in the same column indicate significant differences (p<0.05)

particularly flavonoid, phenolic compound, and tannin (Supriatna et al., 2019). The antioxidant activity of Klutuk banana flour, when compared to its fruit counterpart, experiences a reduction. The antioxidant activity level in various banana varieties range from 44.4 to 51.6 µg/mL, whereas in Table 1, the antioxidant activity level in Klutuk banana flour is recorded at 27.21% (Siji & Nandini, 2017). This decline is attributed to the 24-hour drying process at a temperature of 50°C during the production of Klutuk banana flour. Notably, temperature serves as a determinant factor that accelerates antioxidant oxidation, resulting in diminished antioxidant activity (Muktisari & Hartati, 2018).

Sugar Content of Sorghum Snack Bars with the Addition of Klutuk Banana Flour

The examination of sugar content reveals that the P3 snack bar formulation attains the highest concentration at 2.86%, while the P1 formulation exhibits the lowest sugar content at 1.94%. Statistical analysis of the sugar content test results indicates a significant impact on the sorghum snack bar formulation with the incorporation of klutuk banana flour (p=0.001), as delineated in Table 2.

As Table 2 delineates, the sugar content in sorghum snack bars incorporating klutuk banana flour ranges from 1.94% to 2.86%. Elevated proportion of klutuk banana flour, coupled with diminished sorghum content in the snack bar formulation, correspondingly yield higher sugar content test results. This phenomenon stems from the inherently higher sugar content in Klutuk banana flour, specifically at 2.78%, surpassing that in sorghum. The recorded sugar content of 2.86 gram per 100 gram in sorghum snack bars aligns with the general benchmark for snack bars containing less than 9 gram of sugar, as stipulated by Musita (2014). However, it exceeds the criteria outlined in SNI 01-3702-1995 for diabetes diet biscuits, which mandates a maximum sugar content of 1%. The elevation in sugar content is attributed to the heating process, resulting in reduced water content and a subsequent rise in the percentage of sugar content (Sutrisno & Susanto, 2014).

Crude Fiber Content of Sorghum Snack Bars with the Addition of Klutuk Banana Flour

The assessment of crude fiber content reveals that the P3 snack bar formulation exhibits the highest concentration at 70.89%, whereas the P1 formulation displays the lowest crude fiber content at 46.04%. Statistically, a highly significant influence on the sorghum snack bar formulation with the incorporation of klutuk banana flour on crude fiber content is evident (p<0.001), a trend outlined comprehensively in Table 2.

It is noteworthy that the elevated crude fiber content in Klutuk banana flour relative to sorghum underpins the observed statistical significance. Diabetes mellitus patients are recommended to intake 20-35 gram of fiber daily (Indonesia Endocrinology Association, 2019). The fiber content per unit of sorghum snack bar, with the addition of klutuk banana flour, ranges from 11.51 to 17.72 gram. Consequently, each serving of sorghum snack bar incorporating klutuk banana flour satisfactorily meets the daily crude fiber requirements, spanning from 46.04% to 70.88%. These findings position sorghum snack bars with klutuk banana flour as a viable dietary option, contributing more than 10% of the daily fiber intake and aligning with the classification of high-fiber snacks (Indrastati & Anjani, 2016). Crucially, the documented fiber content in sorghum snack bars incorporating klutuk banana flour aligns with the guidelines established by the USDA (2018) for Nutri-Grain Fruit and Nut Bars, specifying a minimum requirement of 7.5 gram of crude fiber content.

Individual with diabetes mellitus can regulate their blood glucose level through the consumption of foods rich in fiber. This dietary approach proves effective by retarding gastric emptying and abbreviating intestinal transit time, consequently mitigating glucose absorption and contributing to reduced blood glucose levels (Avianty & Ayustaningwarno, 2013).

Antioxidant Activity of Sorghum Snack Bars with the Addition of Klutuk Banana Flour

Results of the antioxidant activity assessment revealed that the P3 formulation exhibited the highest levels at 15.05%, whereas the P1 formulation displayed the lowest antioxidant activity at 9.06%. This discrepancy is attributed to the inherent antioxidant content in raw sorghum seeds, which registers at 46.5%, whereas Klutuk banana flour demonstrates an antioxidant activity of 27.21%. The primary sources of antioxidants in sorghum seeds encompass anthocyanins, tannins, and phytic acid (Suarni & Firmansyah, 2016). Additionally, Linda & Panunggal (2015) identify flavonoids, total phenols, and antioxidant activity as key antioxidant sources in sorghum. Statistically, the analysis underscores a significant impact of the sorghum snack bar formulation with the inclusion of klutuk banana flour on antioxidant activity levels ($p<0.001$). Detailed results of the antioxidant activity level test are presented in Table 2.

The diminished antioxidant activity observed in snack bars compared to the raw materials before their production is attributed to the processing steps involved in snack bar manufacturing, which includes both the heating process during pop sorghum production and baking in ovens. The conventional popping method employed in producing sorghum pop leads to a reduction in antioxidant activity levels in the resulting snack bars (Linda & Panunggal, 2015), with temperatures ranging from 170°C to 200°C during the popping process (Salsabiela et al., 2021). Notably, antioxidant activity experiences a decrease of approximately 20% when subjected to a temperature of 90°C (Hidayati, 2017).

In accordance with Linda & Panunggal (2015), employing the extrusion method, showcased an antioxidant activity level of 64.431%. Nevertheless, the subsequent baking phase in an oven at 130°C, integral to the production of snack bars, could potentially accelerate antioxidant oxidation, resulting in a subsequent reduction in antioxidant activity (Hastuti & Rustanti, 2014). Additionally, the washing step in the creation of pops holds the capacity to dissolve water-soluble antioxidant compounds, including flavonoids like anthocyanins (Reis et al., 2018). It is noteworthy that bananas, a component in the snack bar formulation, contribute to antioxidant activity due to their content of vitamin C and vitamin E, both recognized antioxidants (Khoozani et al., 2019). Vitamin E, or tocopherol, particularly exhibit notable resistance to heat (Pambudi et al., 2009).

The classification of antioxidant activity level is determined based on percentage value, where a percentage greater than 50% signifies high antioxidant activity, a range of 20-50% indicates moderate antioxidant activity and a percentage less than 20% indicates low antioxidant activity whereas an antioxidant activity level of 0% for DPPH radicals signifies a lack of reduction in these radicals (Wulansari & Chairul, 2011). In the specific context of sorghum snack bar formulations with the addition of Klutuk banana flour, each formulation exhibit a low antioxidant activity, as evidenced by an aggregated antioxidant activity level falling below the 20% threshold. This classification concurs with established criteria. It is crucial to underscore that for individuals with diabetes mellitus, the supply of dietary sources abundant in antioxidants holds paramount significance. This dietary strategy is essential for impeding the production of free radicals, thereby mitigating oxidative stress and preventing vascular complications commonly associated with diabetes (Prawitasari, 2019).

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Sensory Characteristics of Sorghum Snack Bars with the Addition of Klutuk Banana Flour

The sensory characteristics in sorghum snack bars with the incorporation of Klutuk banana flour was assessed through organoleptic analysis employing hedonic tests. This sensory assessment involved a cohort of 20 semi-trained panelists, specifically selected from students enrolled in the Undergraduate Nutrition Study Program and Food Technology Bachelor Study Program at Muhammadiyah University of Semarang. The chosen panelists possessed relevant expertise, having undergone the Food Technology Science course as part of their academic curriculum.

a. Sorghum Snack Bar Texture with the Addition of Klutuk Banana Flour

The mean panelists' preference score for the texture attribute of sorghum snack bars enriched with Klutuk banana flour ranged from 2.55 to 3.10. Notably, the highest average value was recorded in the P3 formulation, indicating a favorable liking level on the "like moderately" scale. In contrast, the lowest average was observed in the P1 formulation, registering on the "like slightly" scale. The discernible escalation in average texture values across formulations suggests a positive correlation with the increasing proportion of Klutuk banana flour. This implies that the greater the addition of Klutuk banana flour, the more favorably the panelists evaluated the texture. Detailed results of the texture tests for sorghum snack bars with Klutuk banana flour incorporation are tabulated in Table 3.

Statistically, the analysis reveals a non-significant effect on the texture of sorghum snack bars with the incorporation of Klutuk banana flour (p=0.241). This finding can be attributed to the inherent firm texture of sorghum resulting from the puffing process (pops). As elucidated in the study by Salsabiela et al. (2021), sorghum inherently possesses a hard texture, necessitating additional processing and the inclusion of supplementary ingredients to enhance the characteristics of the snack bar. However, notably, in the present investigation, the introduction of Klutuk banana flour did not yield a statistically significant impact on the texture of sorghum snack bars.

b. Sorghum Snack Bar Color with the Addition of Klutuk Banana Flour

The mean panelists' preference scores for the color attribute of sorghum snack bars enriched with Klutuk banana flour varied between 2.60 and 3.10. Notably, the highest average value was observed in the P3 formulation, indicative of a liking level characterized as "like moderately" on the sensory scale. Conversely, the lowest average was recorded in the P1 formulation, aligning with a "like slightly" level. The discernible elevation in average color values across formulations suggests a positive correlation with the increasing incorporation of Klutuk banana flour. This implies that the augmented addition of Klutuk banana flour corresponds to an enhanced preference among panelists. Detailed results of the color tests for sorghum snack bars with Klutuk banana flour incorporation are presented in Table 3.

Statistically, the analysis indicates a non-significant effect on the color of sorghum snack bars with the addition of Klutuk banana flour (p=0.250). Across all formulations, the color of the

Table 3. Sensory Characteristics of Sorghum Snack Bars with the Addition of Klutuk Banana Flour

Formulation	Texture	Color	Flavor	Aroma	Mean
	Mean ± Standard Deviation				
P0	2.45±0.82	2.60±1.04	2.80±0.95	2.75±0.91	2.65
P1	2.55±0.60	2.75±0.91	2.70±0.97	2.85±0.87	2.70
P2	2.70±0.80	2.95±0.68	2.50±0.82	2.95±0.94	2.77
P3	3.10±1.02	3.10±0.85	2.40±1.04	3.00±1.07	2.90

Note: Formulation of Sorghum:Klutuk banana flour

P0 = (100%:0%), P1 = (90%:10%), P2 = (80%:20%), P3 = (70%:30%)

Hedonic scale = 5 : Like extremely, 4 : Like moderately, 3 : Like slightly, 2 : Neither like, 1 : Dislike

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snack bar exhibits a consistent hue, characterized as brown to yellowish-brown. This uniformity in color results from the oven baking process, inducing a brownish-yellow to shiny brown appearance, primarily attributed to the Maillard reaction (Salsabiela et al., 2021). The Maillard reaction, prompted by the addition of sugar and accompanied by a heating process, contributes to the rapid development of a brownish color (Salsabiela et al., 2021). Notably, the progressive addition of Klutuk banana flour correlates with an intensified brownish-yellow coloration in the sorghum snack bar.

c. Sorghum Snack Bar Flavor with the Addition of Klutuk Banana Flour

The mean panelists' taste preferences for sorghum snack bars enriched with Klutuk banana flour spanned from 2.40 to 2.70, with all formulations falling within the "like slightly" range on the sensory scale. The observed decline in the average taste scores across formulations is postulated to stem from an increased disfavor among panelists corresponding to the augmented addition of Klutuk banana flour. Detailed results of the taste tests for sorghum snack bars with Klutuk banana flour incorporation are delineated in Table 3.

Statistically, the analysis reveals a non-significant effect on the taste of sorghum snack bars with the inclusion of Klutuk banana flour (p=0.338). This observation is attributed to the incorporation of supplementary ingredients in the sorghum snack bars with Klutuk banana flour, specifically sugar and skim milk flour in equivalent amounts, contributing to an overall sweet taste profile. Notably, the incremental addition of Klutuk banana flour corresponds to a reduction in flavor intensity, as Klutuk banana flour inherently imparts a bland taste (Musita, 2014).

d. Sorghum Snack Bar Aroma with the Addition of Klutuk Banana Flour

The mean panelists' taste preferences for sorghum snack bars with the incorporation of Klutuk banana flour ranged from 2.75 to 3.00. Significantly, the P3 formulation achieved the highest average value, denoting a liking level on the "like" scale, while the lowest average was registered in the P1 formulation, indicating a liking level on the "somewhat like" scale. This observed increase in average taste scores across formulations is postulated to be associated with the progressive addition of Klutuk banana flour, suggesting a positive correlation between increased Klutuk banana flour content and enhanced liking among panelists. Detailed results of the taste test for sorghum snack bars with Klutuk banana flour incorporation are outlined in Table 3.

Statistically, the analysis indicates a non-significant effect on the aroma of sorghum snack bars with the inclusion of Klutuk banana flour (p=0.472). This outcome can be attributed to the inherent lack of a distinctive aroma in sorghum itself (Lestari & Kristiastuti, 2016). The aromatic profile of sorghum snack bars enriched with Klutuk banana flour is primarily shaped by the influence of high temperatures during the heating process and the inclusion of sugar, which harbors furaneol compounds known for producing a sweet and volatile aroma (Salsabiela et al., 2021). Furaneol compounds are generated through the Maillard reaction, originating from 2-hydroxy proponal (Waskito et al., 2014). The Maillard reaction plays a pivotal role in aroma and taste development in food products, providing a foundation for the aroma noted in sorghum snack bars with the addition of Klutuk banana flour, falling within the range of slightly liked to liked by the panelists.

The Best Formulation of Sorghum Snack Bar with the Addition of Klutuk Banana Flour

As depicted in Table 3, the panelists' average scores for sensory characteristics, encompassing texture, color, taste, and aroma, reveal that the sorghum snack bar with the inclusion of Klutuk banana flour garnered the highest acceptance amongst panelists in the P3 formulation.

CONCLUSION

Sorghum snack bars enriched with Klutuk banana flour represent a targeted development aimed at catering to the dietary preferences of individuals afflicted with diabetes mellitus. Within the formulations, P3 stands out with elevated levels of sugar, crude fiber, and antioxidant activity, albeit the latter remaining relatively modest. The research findings underscore the discernible impact of incorporating Klutuk banana flour on sugar content, crude fiber, and antioxidant activity in sorghum snack bars. In evaluating sensory characteristics, encompassing texture, color, taste, and aroma, it is notable that the addition of Klutuk banana flour exhibits no statistically significant effects. However, among the formulations, P3 emerges as the most favored by panelists. This preference aligns with the overall acceptability of the sorghum snack bars with Klutuk banana flour.

As a prudent recommendation, the daily consumption of sorghum snack bars with Klutuk banana flour is advised at two portions. This suggestion is derived from a comprehensive assessment of nutritional components and sensory attributes, emphasizing P3 as the optimal formulation in the context of both sensory preference and nutritional content for individuals managing diabetes mellitus.

REFERENCES

Akram T, K. dan H. M. D. (2015). Diabetes mellitus: The epidemic of the century. *World Journal of Diabetes*, 6(6), 850–867. https://doi.org/10.4239/wjd.v6.i6.850

Avianty, S., & Ayustaningwarno, F. (2013). Kandungan Zat Gizi Dan Tingkat Kesukaan Snack Bar Ubi Jalar Kedelai Hitam Sebagai Alternatif Makanan Selingan Penderita Diabetes Melitus Tipe 2. *Journal of Nutrition College*, 2(4), 622–629. https://doi.org/10.14710/jnc.v2i4.3823

Azrimaidaliza. (2011). Asupan Zat Gizi dan Penyakit Diabetes Mellitus. *Jurnal Kesehatan Masyarakat*, 6(1), 36–41. http://jurnal.fkm.unand.ac.id/index.php/jkma/article/view/86#:~:text=Dianjurkan bagi masyarakat untuk mengonsumsi,yang berperan sebagai antioksidan dan

Chandra, F. (2010). *Formulasi Snack Bar Tinggi Serat Berbasis Tepung Sorgum (Sorghum bicolor L), Tepung Maizena, dan Tepung Ampas Tahu.*

Diyah, N. W., Ambarwati, A., Warsito, G. M., Niken, G., Heriwiyanti, E. T., Windysari, R., Prismawan, D., Hartasari, R. F., & Purwanto. (2018). Evaluasi Kandungan Glukosa Dan Indeks Glikemik Beberapa Sumber Karbohidrat Dalam Upaya Penggalian Pangan Ber-Indeks Glikemik Rendah. *Jurnal Farmasi Dan Ilmu Kefarmasian Indonesia,* 3(2), 67–73. https://doi.org/10.20473/jfiki.v3i22016.67-73

Endra, Y. (2006). *Analisis Proksimat dan Komposisi Asam Amino Buah Pisang Batu (Musa balbisiana Colla).* In Institut Pertanian Bogor.

Faizati, U. N., Nurrahman, & Suyanto, A. (2018). *Puding Air Tajin Dengan Penambahan Sari Kacang Hijau.*

Fajri, A. N., Rumitasari, A., Andriani, J., Azizah, S. N., & Luthfiah, N. (2020). Snack Bars : Camilan Sehat Rendah Indeks Glikemik Sebagai Alternatif Pencegahan Penderita Diabetes. *Jurnal ABDI,* 2(1), 59–67.

Hastuti. (2021). Pisang Batu Musa Balbisana Colla : Kajian Botani dan Pemanfaatannya. *Jurnal Pendidikan, Matematika Dan Sains*, 5(2), 249–262.

Hastuti, A. M., & Rustanti, N. (2014). Pengaruh Penambahan Kayu Manis Terhadap Aktivitas Antioksidan Dan Kadar Gula Total Minuman Fungsional Secang Dan Daun Stevia Sebagai Alternatif Minuman Bagi Penderita Diabetes Melitus Tipe 2. *Journal of Nutrition College*, 3(3), 362–369. https://doi.org/10.14710/jnc.v3i3.6595

Hidayati, P. R. (2017). *Perbedaan Aktivitas Antioksidan pada Perendaman 1 Jam dan 2 Jam Ekstrak Air Jamur Tiram (Pleorarus ostrestus).*

Indrastati, N., & Anjani, G. (2016). Snack Bar Kacang Merah dan Tepung Umbi Garut Sebagai Alternatif Makanan Selingan dengan Indeks Glikemik Rendah. *Journal of Nutrition College,* 5(4), 546–554.

Indonesia Endocrinology Association. (2019). *Pengelolaan dan Pencegahan Diabetes Melitus Tipe 2 Dewasa di Indonesia.* In Perkumpulan Endokrinologi Indonesia.

Kehek, F. S. (2017). *Pengaruh Variasi Konsentrasi Gula terhadap Kualitas Miinuman Fermentasi Pisang Batu.* In Universitas Sanata Dharma.

Khoozani, A. A., Birch, J., & Bekhit, A. E. D. A. (2019). Production, application and health effects of banana pulp and peel flour in the food industry. *Journal of Food Science and Technology,* 56(2), 548–559. https://doi.org/10.1007/s13197-018-03562-z

Kurniawan, F., Hartini, S., & Hastuti, D. K. A. . (2015). Pengaruh Pemanasan terhadap Kadar Pati dan Gula Reduksi pada Tepung Biji Nangka

(*Artocarpus heterophyllus lamk*) (The Effect of Heating to The Content of Starches and Sugar Reduction of Jackfruits Seeds Flour). *Prosiding Seminar Nasional Sains Dan Pendidikan Sains X*, 1–7. http://fsm.uksw.edu/ojs

Lestari, Y. P., & Kristiastuti, D. (2016). Pengaruh Subtitusi Tepung Sorgum (*Sorghum biocol L. Moech)* dan Proporsi Daging dengan Tepung Tulang Ikan Tuna (*Thunnus sp.*) terhadap Sifat Organoleptik Kerupuk. *E-Journal Boga*, 5(1), 37–45.

Linda, I., & Panunggal, B. (2015). Kandungan Flavonoid, Total Fenol, dan Antioksidan Snack Bar Sorgum sebagai Alternatif Makanan Selingan Penderita Diabetes Mellitus Tipe 2. *Journal of Nutrition College,* 4(2), 342–349.

Ministry of Health of the Republic of Indonesia. (2018). *Hasil Riset Kesehatan Dasar Tahun 2018*. Kementrian Kesehatan RI, 53(9), 1689–1699.

Ministry of Health of the Republic of Indonesia. (2020). *Tetap Produktif, Cegah Dan Atasi Diabetes Mellitus.* In pusat data dan informasi kementrian kesehatan RI.

Muktisari, R. D., & Hartati, F. K. (2018). Analisis Aktivitas Antioksidan pada Beras Hitam dan Tepung Beras Hitam (*Oryza sativa L.indica*). *Food Science and Technology Journal,* 1(1), 20–27. https://doi.org/10.25139/fst.v1i1.1002

Musita, N. (2014). Pemanfaatan Tepung Pisang Batu (*Musa Balbisiana Colla*) Pada Pembuatan Kue Brownies. *Indonesian Journal of Industrial Research,* 8(3), 171–178.

Pambudi, E. P. A., Utami, P. I., & Hartanti, D. (2009). Pengaruh Pemanasan Terhadap Kadar Vitamin E Pada Kacang Hijau (*Vigna Radiata L.*) Dengan Metode Spektrofometri Sinar Tampak. *Pharmacy*, 06(03), 1–8.

Prawitasari, D. S. (2019). Diabetes Melitus dan Antioksidan. *Jurnal Kesehatan Dan Kedokteran,* 1(1), 48–52. https://doi.org/10.24123/kesdok.v1i1.2496

Rufaizah, U. (2011). *Pemanfaatan Tepung Sorghum (Sorghum Bicolor L . Moench) Pada Pembuatan Snack Bar Tinggi Serat Pangan Dan Sumber Zat Besi Untuk Remaja Puteri.* In Institut Pertanian Bogor (Vol. 35). http://repository.ipb.ac.id/handle/123456789/52386

Salsabiela, A. R., Afgani, C. A., & Dzulfikri, M. A. (2021). Karakteristik Kimia, Fisik dan Organoleptik Snack Bar Berbasis Sorgum (*Sorghum bicolor (L.) moench*) dan Kacang Mete. *Food and Agroindustry Journal,* 2(2), 41–52.

Siji, S., & Nandini, P. . (2017). Antioxidants and antioxidant activity common eight banana varieties in Kerala. *International Journal of Advanced Engineering Research and Science,* 4(7), 118–123. https://doi.org/10.22161/ijaers.4.7.18

Simanjuntak, L., Harun, N., & Efendi, R. (2016). Penerimaan Panelis Terhadap Teh Herbal dari Kulit Buah Manggis (*Garcinia mangostana L.*) dengan Perlakuan Suhu Pengeringan. *Sagu,* 13(2), 7–18.

Suarni, & Firmansyah. (2016). *Struktur, Komposisi Nutrisi dan Teknologi Pengolahan Sorgum.* Balai Penelitian Tanaman Serealia, 11(4), 1–21.

Supriatna, D., Mulyani, Y., Rostini, I., & Agung, M. U. K. (2019). Aktivitas Atioksidan , Kadar Total Flavanoid dan Fenol Ekstrak Metanol Kulit Batang Mangrove Berdasarkan Stadi Pertumbuhannya. *Jurnal Perikanan Dan Kelautan,* 10(2), 35–42.

Surayya, N. A., Hilaili, M., Rahmawati, E., Primadiani, E., Syauqi, J. A., Rushydi, A. N., & Wulan, S. N. (2020). Sifat Organoleptik Dan Indeks Glikemik Produk Sorgum Bar Yang Diformulasi Menggunakan Berbagai Jenis Penyalut Nira. *Jurnal Pangan Dan Agroindustri,* 8(2), 56–67. https://doi.org/10.21776/ub.jpa.2020.008.02.1

Sutrisno, C. D. N., & Susanto, W. H. (2014). Pengaruh Penambahan Jenis dan Konsentrasi Pasta (Santan dan Kacang) terhadap Kualitas Produk Gula Merah. *Jurnal Pangan Dan Agroindustri,* 2(1), 97–105.

Tritisari, K. P., Handayani, D., Ariestiningsih, A. D., & Kusumastuty, I. (2017). Asupan Makanan Sumber Antioksidan dan Kadar Glukosa Darah Puasa pada Penderita DM Tipe 2 di Jawa Timur. *Majalah Kesehatan FKUB,* 4(2), 96–104. https://majalahfk.ub.ac.id/index.php/mkfkub/article/view/130/115

USDA (United States Departement of Agriculture). (2018). *Nutri-Grain Fruit and Nut Bar.* National Agricultural Library. USA

Waskito, Y. A. P., Al-baarri, A. N., & Abduh, S. B. M. (2014). Intensitas Warna Kecoklatan , Sifat Antioksidan , dan Goaty Aroma pada Proses Glikasi Whey Susu Kambing dengan L-psikosa , L-tagatosa , dan L- fruktosa. *Jurnal Aplikasi Teknologi Pangan*, 3(4), 160–163.

Wulansari, D., & Chairul. (2011). Penapisan Aktivitas Antioksidan Dan Beberapa

https://doi.org/10.204736/mgi.v19i1.95–106

Tumbuhan Obat Indonesia Menggunakan Radikal 2,2-Diphenyl-1 Picrylhydrazyl (Dpph) Antioxidant Screening Activity of Several Indonesian Medicinal Plants Using 2,2-Difenil 1-1 Picrylhidrazyl(Dpph). *Majalah Obat Tradisional,* 16(1), 22–25.

Zaddana, C., Almasyhuri, Nurmala, S., & Oktaviyanti, T. (2021). *Snack Bar Berbahan Dasar Ubi Ungu dan Kacang Merah sebagai Alternatif Selingan Penderita Diabetes Mellitus.* Universitas Airlangga, 5(3), 260–275. https://doi.org/10.20473/amnt.v5i3.2021.260-275