POTASSIUM LEVELS, ANTIOXIDANT ACTIVITY, AND ACCEPTABILITY OF YELLOW VELVETLEAF (*LIMNOCHARIS FLAVA* (L.) BUCHENAU.) SNACK BAR

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ABSTRACT

Snack food consumption are high in fat and sodium, contributing to the risk of hypertension. One potential solution to this issue is to transform snacks into a more nutritionally superior form, such as snack bars. Previous studies did not thoroughly explore the potassium content of yellow velvetleaf as a potential product for addressing hypertension. This study aimed to investigate the differences in potassium content antioxidant activity and acceptability in snack bars with the addition of yellow velvetleaf flour. This research adopted a true experimental design. The gravimetric method was employed to determine potassium content, while the DPPH method was used to assess antioxidant activity. Statistical analysis of the average potassium content and antioxidant activity revealed significant differences among snack bars with 0%, 5%, 10%, and 15% added yellow velvetleaf flour. The highest average potassium content, 325.67 mg, was observed in the 15% treatment, while the maximum average antioxidant activity reached 21.7%. Considering the acceptability of the snack bars based on liking tests and statistical analysis, the treatment with 10% added yellow velvetleaf flour emerged as the most preferred in terms of taste and texture. The incorporation of yellow velvetleaf flour into snack bars not only increased potassium levels and antioxidant activity but also influenced overall acceptability. Conclusion of this research is the optimal formulation for the yellow velvetleaf snack bar is X2, because of containing a higher acceptance level and contains potassium which could serve as a viable solution to enhance potassium intake following current dietary habits.

Keywords—*antioxidant, hypertension, potassium, snack bars, yellow velvetleaf*

INTRODUCTION

Hypertension is a leading cause of high mortality and morbidity rates globally (Saputra et al., 2023). According to Basic Health Research (2018), the prevalence of hypertension in Indonesia is approximately 31.4%, with the age group of 25 to 34 years accounting for 20.1% of the total population. Hypertension increased risk of various cardiovascular-related diseases such as stroke, heart attack, coronary artery disease, myocardial infarction, accelerated atherosclerosis, congestive heart failure and also affects the risk of kidney failure. (Kaczmarski et al., 2019). Various factors influence hypertension, including lifestyle elements such as physical activity and diet (Elvira & Anggraini, 2019). Presently, the consumption patterns of the Indonesian population are shifting towards Western foods known for their appealing taste and quick processing, such as fast food with high levels of fat and sodium. This preference for practical and efficient options (Nurdiansyah, 2019) is contributing to the high prevalence of hypertension. Notably, the contents found in fast food are also present in snack foods widely available in the market. The demand for snacks is on the rise, particularly among young adults and adolescents (Crofton & Scannell, 2020).

Currently, there is inadequate awareness about the importance of vegetable consumption, particularly yellow velvetleaf (*Limnocharis flava*) known as genjer, an aquatic plant commonly found in shallow water areas like swamps or rice fields, and often regarded as a rice weed (Perkasa & Petropoulos, 2020). Despite being rich in potassium, antioxidants, fiber, and various other nutrients, the utilization of yellow velvetleaf remains suboptimal, limited mainly to dishes such as stir-fry. Additionally, the nutritional benefits of yellow velvetleaf are not widely known. As per the Indonesian Ministry of Health (2019), per

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100 g yellow velvetleaf plants boast a potassium content of 905.8 mg. What sets yellow velvetleaf apart from other aquatic plants is its lack of anti-nutritional substances (Sianipar et al., 2022). Potassium, a key component found in yellow velvetleaf, acts as a diuretic, contributing to the reduction of blood pressure. Potassium consumed in large quantities can reduce blood pressure by increasing the concentration of intracellular fluid, thereby drawing fluid from the extracellular (Da Usfa et al., 2023). Body fluid balance and blood pressure that are disturbed due to excess sodium minerals in the body can be suppressed by high potassium content as well (Jacoeb and Abdullah, 2020). Furthermore, the antioxidants present in yellow velvetleaf can play a role in lowering cholesterol levels and supporting normal blood pressure (Saribu et al., 2021).

Better dietary pattern is encouraged to combat hypertension. Increasing potassium intake in the diet by 2-5 gram/day can effectively lower blood pressure in individuals with hypertension, as it aids in regulating sodium balance in the body (Nanda et al., 2021). A viable solution to enhance snack consumption patterns, considering current preferences, is to opt for highly nutritious snacks, such as snack bars enriched with yellow velvetleaf.

Various studies on yellow velvetleaf plants have explored their benefits. For example, Husni *et al.* (2020) focused on creating fiber-enhancing supplements by formulating instant granules from dried powder obtained from yellow velvetleaf stalks (*Limnocharis flava* (L.) Buchenau.). This study highlighted the development of functional foods, specifically with an emphasis on fiber. In another study by Jacoeb & Abdullah (2020) compared potassium and sodium levels in seaweed salt production using yellow velvetleaf, revealing a 0.59 reduction in sodium levels, particularly advantageous for individuals with hypertension. However, the exploration of functional food development from yellow velvetleaf, especially in the form of snacks to address hypertension, remains limited.

Previous research integrated yellow velvetleaf (genjer) formulations into meatball products at 5%, 10%, and 15%, while Silva et al. (2016) studied snack bars with 5%, 10%, 15%, and 20% formulations, indicating enhanced quality. Inspired by these outcomes and driven by the need to address societal conditions and hypertension, researchers initiated this snack development study. It aims to analyze potassium content, antioxidant activity, and determine the optimal formulation for hypertensive patients based on nutritional content and acceptability.

METHODS

This research employed a true experimental design with a posttest-only control design. The experimental design followed a complete randomized design (RAL) and was conducted between January 2023 and March 2023. The target population for this study covered all individuals within the jurisdiction of the Sumbersari Health Center in Sumbersari District, Jember Regency. The sample size for this study consisted of 30 individuals selected from the general public of the Sumbersari Health Center working area, chosen through the systematic random sampling method. Inclusion criteria were selected based on the incidence of hypertension from basic health research data and data at the Jember district health office. Panelists were chosen based on inclusion criteria, specifically individuals aged 15–34 years residing in the Sumbersari Health Center area of Jember Regency. Exclusion criteria encompassed panelists with allergies to the ingredients used in the yellow velvetleaf leaf snack bar, those who liked or strongly liked yellow velvetleaf leaves and snack bars, individuals over 34 years old, pregnant individuals, and those in ill health. The research process involved multiple locations: the University of Jember RPHP laboratory for yellow velvetleaf flour production, the Jember State Polytechnic food analysis laboratory for potassium testing and antioxidant activity analysis, and the Sumbersari Health Center for acceptability testing.

The research began with producing yellow velvetleaf flour, followed by formulating snack bars added with this flour. Subsequently, laboratory tests were conducted to measure the potassium content and antioxidant activity of both the yellow velvetleaf flour and the resulting snack bars. This phase included a acceptability test to evaluate the overall liking of the snacks. The acceptability test for the yellow velvetleaf snack bars in this

study used the hedonic scale test, assessing panelist acceptance of taste, aroma, texture, and color components. The test involved 30 untrained panelists. Statistical analyses of the potassium content, antioxidant activity, and the results of the hedonic test, and the calculation of the adequacy of the snack bar content adjusted to RDA.

The primary ingredients for producing yellow velvetleaf flour are yellow velvetleaf leaves and stems. The tools employed in this process include cutting boards, knives, baking sheets, and cabinet dryer ovens. The ingredients for yellow velvetleaf snack bars involve four treatment variations: the control group (0% yellow velvetleaf flour), the experimental groups with 5%, 10%, and 15% yellow velvetleaf flour additions. The components for these bars include wheat biscuits, instant oats, low-fat skim milk powder, rice flakes, honey, and raisins. Tools utilized in the making of yellow velvetleaf snack bars consist of a pot, stove, cutting board, knife, and aluminum foil.

The procedure for making genjer flour is adjusted to previous research in making vegetable flour that has similar characteristics to genjer (Priyanti et al., 2019), with modifications. Yellow velvetleaf flour is made by cutting fresh yellow velvetleaf stems and leaves into small, thin pieces to facilitate the drying process. The drying of yellow velvetleaf leaves is accomplished using a cabinet dryer set at a temperature of 60°C for approximately 7 hours. Subsequently, the dried yellow velvetleaf is sieved using a 40-mesh sieve.

The making of snack bars in this study used a recipe that referred to previous research conducted by (Silva et al., 2016) with modifications. Yellow velvetleaf snack bars involve four treatment levels: the control group (0% yellow velvetleaf flour), the experimental groups with 5%, 10%, and 15% yellow velvetleaf flour additions. The stages of making yellow velvetleaf snack bars include: 1) Weighing the ingredients; 2) Crushing biscuits; 3) Preparing the ratio of biscuits to yellow velvetleaf leaf flour for each formulation: 5% (380 g: 20 g), 10% (360 g: 40 g), 15% (340 g: 60 g); 4) Mixing dry ingredients in a stainless steel container; 5) Heating the binder syrup mixture (honey and raisins) to boiling; 6) Mixing the hot binder syrup into the dry ingredients while stirring until homogeneous; 7) Laminating the dough and letting it rest at room temperature for 4 hours; 8) Cutting into 6 × 2 cm pieces weighing approximately 50 g; 9) Packing with aluminum foil.

The next stage is testing the content of potassium and antioxidant activity snack bars in the laboratory then hedonic testing to panelists. The most preferred or accepted snack bar from the hedonic test will be calculated the adequacy of the snack bar content adjusted to the RDA to determine the feasibility of snack bars as a light snack in terms of potassium content.

A One-Way ANOVA test was conducted to analyze the data on potassium content and antioxidant activity, followed by Duncan further test. Meanwhile, acceptability data were analyzed using Friedman analysis and the Wilcoxon signed-rank test. This research was conducted after obtaining ethical clearance from the Health Research Ethics Commission (KEPK) of the Faculty of Public Health, University of Jember, with the number 323/KEPK/FKM-UNEJ/II/2023.

RESULTS AND DISCUSSIONS

The average potassium content and antioxidant activity in yellow velvetleaf leaf snack bars varies depending on the treatment. The potassium content is known through analysis with the gravimetric method in the laboratory. While the DPPH method was used to assess antioxidant activity

Potassium Content Analysis of Snack Bars

This study examined four levels of snack bar treatment: without yellow velvetleaf flour, with 5% yellow velvetleaf flour, with 10% yellow velvetleaf flour, and with 15% yellow velvetleaf

Table 1. Average potassium content and antioxidant activity of yellow velvet leaf snack bars

Parameter	Average potassium content and antioxidant activity yellow velvetleaf snack bars			
	X0 (0%)	X1 (5%)	X2 (10%)	X3 (15%)
Potassium (mg)	$21.33^{a} \pm 1.15$	$124.67^{b} \pm 2.52$	$221.0^{c} \pm 3.0$	$325.67^{d} \pm 3.05$
Antioxidant Activity (%)	$7.76^{a} \pm 0.05$	$14.6^{b} \pm 0.20$	$17.63^{c} \pm 0.30$	$21.7^{d} \pm 1.00$

X0 = 0% yellow velvetleaf flour addition; X1 = 5%yellow velvetleaf flour addition; X2 = 10%yellow velvetleaf flour addition; X3 = 15% yellow velvetleaf flour addition. Description: Different subscript letters indicate significant differences using Duncan further test.

flour. The results showed that as the percentage of yellow velvetleaf flour in the snack bars increased, so did the potassium content. Statistical analysis using the One-Way ANOVA test indicated a significant difference between the treatments, with a p-value of <0.001, confirming that the potassium content varied depending on the yellow velvetleaf flour addition.

The highest average potassium level, 325.67 mg, was observed in treatment X3, representing a snack bar with a 15% addition of yellow velvetleaf flour. Conversely, the lowest average potassium level, 21.33 mg, was found in treatment X0, the control group with 0% yellow velvetleaf flour. The statistical analysis revealed significant differences among the four treatments.

The increase in potassium content with the addition of yellow velvetleaf flour is attributed to the fact that, in the form of flour, an ingredient tends to have better nutritional content compared to its fresh counterpart. According to data from the Indonesian Ministry of Health (2019), 100 gram of fresh yellow velvetleaf contains 905.8 mg of potassium. In this study, laboratory analysis revealed that yellow velvetleaf flour has a higher potassium content compared to fresh yellow velvetleaf, registering 1988 mg per 100 g of flour. Consequently, the addition of yellow velvetleaf flour led to an increase in the potassium content of yellow velvetleaf snack bars.

In line with this study, previous research by Puspaningrum et al. (2019) explored snack bars with the addition of vegetable-based ingredients, specifically moringa flour and soy flour. Their findings indicated that incorporating moringa flour increased the mineral content in snack bars. This increase is attributed to the processing of moringa leaves into flour, resulting in higher mineral content compared to fresh moringa leaves. Consequently, the addition of moringa leaf flour was shown to enhance the mineral content in snack bars. In a related study by Jacoeb & Abdullah (2020), it was noted that the addition of yellow velvetleaf increased the potassium content in seaweed salt. Seaweed salt without yellow velvetleaf had a potassium content of 56.21 mg, whereas seaweed salt with yellow velvetleaf had a potassium content of 115.87 mg.

Antioxidant Activity

The results of the antioxidant activity analysis indicated variations in the average values across different treatments of yellow velvetleaf snack bars without the addition of yellow velvetleaf (X0), with 5% yellow velvetleaf (X1), with 10% yellow velvetleaf (X2), and with 15% yellow velvetleaf (X3). Based on the average antioxidant activity analysis, it can be concluded that the higher the percentage of yellow velvetleaf flour added, the greater the antioxidant activity in the yellow velvetleaf snack bars.

The ANOVA test results indicated, a significant difference between treatments concerning the antioxidant activity of yellow velvetleaf snack bars. To identify specific group differences, Duncan further test was conducted, revealing that the antioxidant activity of X0 significantly differed from that of X1, X2, and X3.

The results in Table 1 show that the average antioxidant activity increases with the percentage of yellow velvetleaf flour added to the snack bar. The highest average antioxidant activity is observed in treatment X3, with the addition of 15% yellow velvetleaf, registering an average antioxidant activity value of 21.7%. Conversely, the lowest average antioxidant activity is in treatment X0, the control group, with an average value of antioxidant activity at 7.76%. The antioxidant activity in yellow velvetleaf snack bars is influenced by yellow velvetleaf flour. Laboratory analysis indicates that 100 gram of yellow velvetleaf flour used in this study has an antioxidant activity of 64.2%.

Similar research conducted by Hastuti & Afifah (2020) focused on sesame seed snack bars with the addition of antioxidants from pumpkin flour. The study revealed that with the incorporation of 5%, 10%, and 15% pumpkin flour, the antioxidant levels in the snack bars increased by 92.207%, 92.263%, and 93.43%, respectively. Another study by Azizaah *et al*. (2020) indicated that incorporating vegetable-based flour, such as moringa, into snack bars can enhance antioxidant activity. Specifically, the addition of 10 gram and 20 gram of moringa flour increased antioxidant activity by 80.76% and 94.56%, respectively.

Acceptability of Yellow velvetleaf Snack Bar

Taste

The analysis of panelist acceptance, based on the results of the hedonic scale test using the Friedman method for evaluating the taste aspect of yellow velvetleaf snack bars, indicates that the X2 experimental group—representing the yellow velvetleaf snack bar with a 10% addition of yellow velvetleaf—is the most preferred group among panelists. This group received a favorability score of 4.33 (like).

Yellow velvetleaf has a naturally fresh and slightly bitter-sweet flavor (Nion et al., 2018). Based on the results of the hedonic scale test and the Friedman method analysis evaluating the taste aspect of yellow velvetleaf snack bars, the X2 experimental group—representing the yellow velvetleaf snack bar with a 10% addition of yellow velvetleaf—is the most preferred among panelists, receiving a favorability score of 4.33 (like). On the other hand, the X3 experimental group is the least favored, with the lowest average favorability score of 3.43 (somewhat like).

Based on the taste descriptions provided in the comments on the acceptability test form for each treatment, treatment X0 is noted for having a taste that tends to be very sweet, treatment X1 retains a dominantly sweet taste, experimental group X2 offers a sweet and slightly bitter taste from yellow velvetleaf, and experimental group X3 imparts a bitter taste in the oral cavity. From these taste descriptions, it is evident that an increased addition of yellow velvetleaf is believed to contribute to a progressively bitter taste in the snack bar products.

This study aligns with several previous investigations by Nopianti et al. (2019) and Fahlia & Septiani (2020) concerning the addition of vegetable-based flour to snack bars, indicating that an increased addition of vegetable flour tends to intensify the bitterness of the snack bars. Nopianti et al. (2019) research on snack bars with the addition of vegetable-based flour, specifically spinach leaf flour, revealed that panelists did not particularly favor snack bars with a dominant spinach flavor. In contrast, in this study focusing on the addition of yellow velvetleaf flour, panelists demonstrated an acceptance of the taste of snack bars even with a higher percentage of vegetable flour, specifically with the addition of 10% yellow velvetleaf flour (X2).

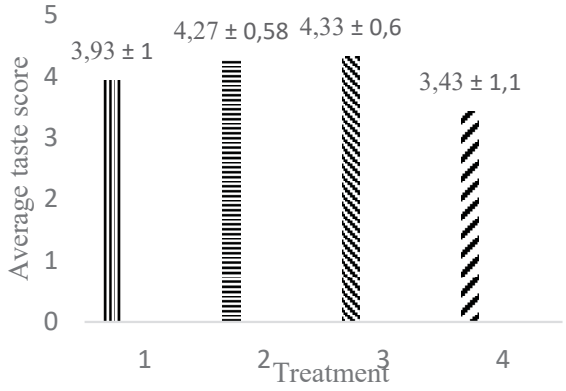

Figure 1 Average taste score

Aroma

The analysis of panelist acceptance of the aroma of yellow velvetleaf snack bars, with proportions of 0%, 5%, 10%, and 15% in four treatment levels, using the Friedman test method revealed that the most preferred sample was X1—treatment with the addition of 5% yellow velvetleaf. The p-value of 0.002, which is <0.05, indicates a significant difference.

Based on the Friedman method analysis of the aroma acceptance test results for the yellow velvetleaf snack bar, the X1 experimental group, with a 5% addition of yellow velvetleaf, emerged as the most preferred treatment in terms of aroma, garnering a mean favorability value of 4.07 (like). In contrast, the X3 experimental group recorded the lowest mean favorability value of 3.50 (somewhat like). In a prior study by Fahlia & Septiani (2020) on the addition of vegetable plant flour, specifically moringa flour, it was observed that the higher the percentage of moringa flour

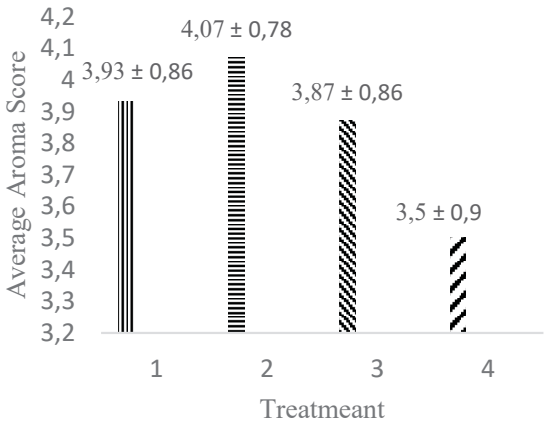

Figure 2 Average aroma score

added, the lower the favorability value of the snack bar product aroma, attributed to the intensified moringa aroma.

Texture

The analysis of panelist acceptance of the texture of yellow velvetleaf snack bars, featuring proportions of 0%, 5%, 10%, and 15% across four treatment levels, using the Friedman test method, revealed that the texture in X2—the formulation with a 10% addition of yellow velvetleaf—was ranked first, signifying the most preferred texture with a mean value of 3.83. The p-value of 0.027, being <0.05, indicates a significant difference.

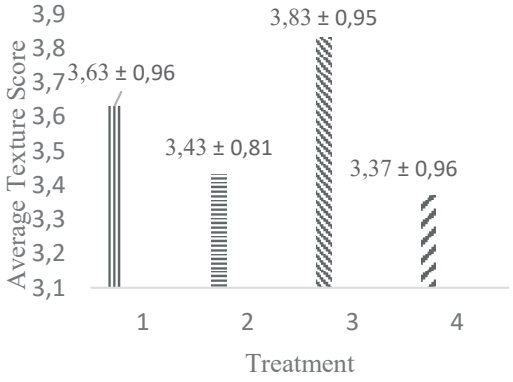

Figure 3 Average Texture Score

Based on the results of Friedman analysis, the texture of the yellow velvetleaf snack bar in the X2 experimental group with the addition of 10% yellow velvetleaf flour is panelist most favored treatment compared to other treatments with the highest mean value of 3.83 (somewhat like). Experimental group X3 had the lowest mean value of 3.37 (somewhat like). The variation in panelist liking for texture can be attributed to the X3 experimental group having the coarsest texture. Meanwhile, the X0 and X1 treatments exhibit a soft texture, and the X2 treatment, as the most preferred experimental group, features the right texture—neither too soft nor too rough.

The texture of the snack bar is influenced by the ingredients used; in X0 and X1, the texture is softer and sticky, while in X2, the texture is denser but not rough like the texture in X3 with the addition of the most yellow velvetleaf flour at 15%. The more yellow velvetleaf flour added, the denser, drier, and rougher the snack bar texture will be. This is suspected to be attributed to the high fiber content in yellow velvetleaf. Fiber in food can impact the texture, affecting factors such as hardness or density (Henrique et al., 2020). In a different study by Na'imah & Putriningtyas (2021) on pumpkin and red bean snack bars, it was observed that fiber content influences the texture of snack bars; the higher the fiber content, the rougher and harder to swallow the texture becomes.

Color

The results of the analysis of panelists acceptance of the taste of yellow velvetleaf snack bars, with proportions of 0%, 5%, 10%, and 15% in four treatment levels using the Friedman test method, showed a p-value of 0.022, indicating a significant difference (<0.05). The X0 snack bar had the highest average liking value at 4.13 (like). Snack bars without the addition of yellow velvetleaf flour exhibited the lightest color compared to the other experimental groups—X1, X2, and X3—which had a darker color. The addition of yellow velvetleaf flour resulted in a darker and greener color for the snack bars. The green color is presumed to originate from the yellow velvetleaf flour used, as it comes from the stems and leaves, which have a slightly dark green hue.

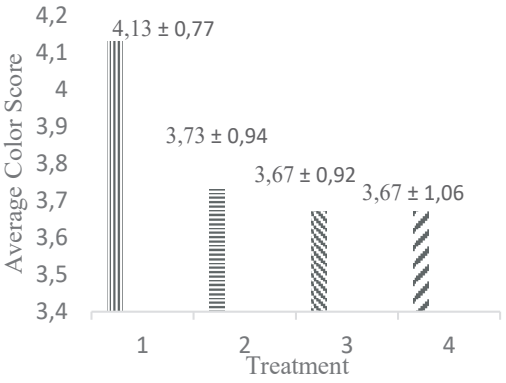

Figure 4 Average Color Score

Previous research on the quality of vegetable leather comparing yellow velvetleaf and pumpkin pulp, conducted by Limbong et al. (2017) with ratios of yellow velvetleaf to pumpkin at 80:20, 60:40, 40:60, and 20:80, indicated that the ratio of yellow velvetleaf to pumpkin significantly affects the color aspect. A higher quantity of yellow velvetleaf pulp results in a product with a higher color index. Another study on snack bars with a

Table 2. Contribution of Potassium Content of Yellow Velvetleaf Snack Bars to the RDA Requirement (% Sufficiency)

Age	Requirement 10% RDA (mg)		Potassium content(mg) per snack bar (50 g)	Recommendation (bar)
	Men	Woman		
16-18 years	530	500	110,5	4-5
19-49 years	470	470	110,5	4

leaf base from plants, specifically moringa leaves, demonstrated that the addition of more moringa leaf flour makes the snack bar green and darker. In that study, panelists preferred snack bars without the addition of moringa leaves (Fahlia & Septiani, 2020). This aligns with the findings of the current study, where the quantity of yellow velvetleaf flour added affects the snack bar color, making it darker, and panelists prefer the color of snack bars without yellow velvetleaf flour.

Potassium Adequacy of Yellow velvetleaf Snack Bars

The selection of yellow velvetleaf snack bars as a snack contributing to meeting Indonesia Recommended Dietary Allowances (RDA) was based on the most preferred treatment in the acceptability test, which was treatment X2, excelling in flavor and texture. According to the Regulation of the Minister of Health of the Republic of Indonesia No. 28 of 2019 concerning RDAs, the recommended potassium intake for Indonesian aged 16-18 years is 5300 mg/day for men and 5000 mg/day for women. For those aged 19-29 years and 30-49 years, the recommended potassium intake is 4700 mg/day for both men and women. The percentage of snacks from the total daily food intake is 10%.

According to The National Heart, Lung, and Blood Institute (NHLBI), the recommended potassium content in snacks (10% of the daily requirement) for adults with hypertension is 470 mg (Ariyanti et al., 2022). The calculation of potassium adequacy, according to the RDA, for the yellow velvetleaf snack bar X2 treatment per bar, as per the table, indicates a % sufficiency of 20.84% - 22.1% for individuals aged 16-18 years and 23.35% for those aged 19-49 years. The potassium content in the yellow velvetleaf snack bars in this research can contribute to meeting the RDA needs as a snack food by 20.84% - 23.35%. The recommended consumption of genjer snack bars in a day is 4-5 bars, the recommended number of snack bars is not for one serving but can be divided into 2 snack times.

Potassium-containing yellow velvetleaf snack bars can be a solution to increase potassium intake in accordance with the current habits of people related to snack consumption habits, especially as a way to balance sodium intake and excess levels in the body. Yellow velvet leaf snack bars are recommended as a solution to the problem of lack of awareness of fruit and vegetable consumption and as a substitute for snacks because of the preferred of consuming snacks that are usually high in sodium. According to a study conducted by Filippini *et al*. (2020) additional potassium intake from foods such as snacks is better than supplementation because supplementation can cause resistance.

CONCLUSION

The addition of yellow velvetleaf flour to snack bars increased potassium levels and antioxidant activity. However, higher levels of yellow velvetleaf flour affected panelists acceptance in terms of taste, aroma, texture, and color, with the highest addition resulting in lower acceptance levels.

The best formulation for the yellow velvetleaf snack bar is X2, containing potassium, which could be a solution to increase potassium intake aligning with current public habits, particularly in balancing sodium intake. Further studies are needed to explore the potential impact of consuming yellow velvetleaf snack bars on lowering respondents blood pressure.

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