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The Effects of Unripe Saba Banana Composite Flour on Acceptance and Physicochemical Characteristics of Biscuits

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ABSTRACT

Biscuits are a popular staple food due to its variety of taste, crispiness and digestibility. Conventional biscuits are rich in carbohydrates, fats and calories but low in dietary fibre (DF), minerals and vitamins. Unripe banana contains high resistant starch (RS) which is beneficial for colon health and helps reduce the risk of cardiovascular diseases and diabetes. This study was conducted to determine the feasibility of substituting wheat flour (WF) with unripe Saba banana flour (USBF) to produce biscuits with sensory acceptance and characterising its physicochemical properties. A total of nine (9) formulations were developed by incorporating WF with USBF (10-90%). These formulations were tested for sensory acceptance with the best formulation then proceeded for physicochemical analysis. Sample F5 (50% USBF and 50% WF) was chosen as the best formulation and compared with the control biscuit (100% WF) for physicochemical characteristics. The comparison results showed that F5 biscuit had significant increment ($p<0.05$) in ash (5.72%), RS (6.17%) and DF (6.26%) as well as significant reduction ($p<0.05$) in moisture (2.78%) and protein (5.41%). In terms of texture, the hardness (883.33 g) of F5 biscuit was significantly reduced ($p<0.05$). F5 Biscuits showed significant increase ($p<0.05$) in RS and exhibited a good source of DF without diminishing its sensory acceptability.

***Keywords**: biscuits, unripe banana flour, Saba banana, resistant starch, dietary fiber*

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INTRODUCTION

With improved living standards, food preferences and diet structures have changed. The number of ‘three high’ foods - high calories, high salt and high fat - in the diet has gradually increased over the years resulting in poor eating habits that pose potential threats to human health [1,2]. To address this issue, our diet patterns need to be restructured and aligned more towards the consumption of healthy foods with appropriate nutritional and health functions [3]. Biscuits in the market are typically high in carbohydrates, fats and calories but low in dietary fibre, vitamins and minerals thus making this food source unhealthy for daily consumption [4,5]. With its long shelf life, the biscuit industry in Malaysia has witnessed both steady growth and increasing demand for bakery products [4,6]. Biscuits are ranked among the top 10 in the list of daily foods consumed [7]. Biscuit fortification was developed in the industry to enhance nutritional and functional quality by means of adding ingredients such as unripe banana flour that act as efficient carriers of nutrient content.

Bananas are among the world's most sought-after tropical fruits. However, much of this fruit is wasted due to post-harvest loss. Processing bananas into a more stable product, such as banana flour, could be an alternative means of reducing this loss [8,9]. Its year-round production, affordable price, light colour and mass output present it as a feasible option for large-scale usage in different products [10]. Past studies have pointed to positive correlations between the consumption of unripe bananas and human health related to its undigestible components such as resistant starch [11]. Unripe banana flour is composed of 73.4% total starch (TS), 17.5% RS and 14.5% DF which are beneficial for health in terms of reducing the risk of diarrhea, colon cancer, cardiovascular diseases and diabetes [12,13]. Recently, researchers examined the effect of unripe banana flour added to pasta [14], noodle [15], bread [12] and cookies [16] and concluded that a positive impact was demonstrated in the nutrition levels such as increase in DF and RS in associated food products.

A meal intake of between 6g -12g RS is found to have a positive effect on postprandial glucose and insulin levels with a RS intake of approximately 20g/day deemed necessary to improve health [17]. The DF recommended daily intake varies by country and organization; in Malaysia, the recommended nutrient intake (RNI) for DF is 20-30g/day although over half of Malaysian adults consume less than this [18]. A recent study found that the daily mean intake of DF in adolescents in the country (14.8±1.5 years of age) was still below the recommended daily intake of DF with an average of 12.4±5.3g /day DF [19].

The rate of starch digestion in starchy baked goods is associated with its degree of gelatinisation. Biscuits are products with low moisture content which is inadequate for complete starch gelatinisation during baking [20]. Some of these starch granules that remain ungelatinised would have a significant role in increasing the potential high nutritional value such as DF and RS in biscuits. This study was conducted to determine the feasibility of substituting wheat flour (WF) with unripe Saba banana flour (USBF) to produce biscuits with sensory acceptance and characterizing its physicochemical properties.

METHODS AND MATERIALS

Raw Materials

The raw materials presented in Table 1 (except for USBF) were acquired from a local supermarket, Bake with Yen, and stored in glass/ plastic containers at room temperature (25°C) or under refrigeration (4°C) depending on the storage requirements of the particular materials. USBF (*Musa acuminata* x *Musa balbisana*, BBB) was purchased commercially from HIMI Agricultural Biotech (Sabah) Sdn. Bhd, a local manufacturing company located at Kota Kinabalu Industrial Park (KKIP) in Sabah. Unripe Saba bananas (USB) with maturity level 2 were collected, washed, peeled and rinsed with water. After rinsing, the USB pulp was sliced into 0.2 cm thickness and dried at 80°C for 1 h. The dried pulp was then ground and sieved at 80 mesh screens (British standard). The USBF was weighed and packed separately in airtight polypropylene (PE) plastic.

Production of Biscuits

In a mixer (KitchenAid, Australia) butter and sugar were creamed together for two minutes after which pre-sieved dry ingredients - baking powder, soda bicarbonate, salt and flour - were then added together with milk and vanilla essence. The ingredients were kneaded together to form a dough and subsequently rolled into a 2mm thickness layer and shaped into 5mm diameter rounds. These were then baked for eight min in an oven (SINMAG SM-944F, Taiwan) at 170ºC. After baking, the biscuits were left to cool to room temperature for 2 h then packed and sealed into airtight PE plastic. Nine formulations were prepared with different percentages of USBF and WF and one as control formulation (Table 1).

Table 1: The Percentage of Ingredient Use in Composited USBF Biscuits Formulation (%)

Ingredient (%)	C	F1	F2	F3	F4	F5	F6	F7	F8	F9
WF	58.5	52.7	46.8	41	29.3	35	23.4	17.6	11.7	5.8
USBF	0	5.8	11.7	17.6	29.3	23.4	35	41	46.8	52.7
Salt	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Baking powder	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Soda bicarbonate	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Butter	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2
Sugar	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2
Milk	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7
Vanilla essence	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Total	100	100	100	100	100	100	100	100	100	100

**USBF – Unripe Saba banana flour, WF – Wheat flour, C – control. F1 – 10 USBF/90 WF, F2 – 20 USBF/80 WF, F3 – 30 USBF/70 WF, F4 – 40 USBF/60 WF, F5 – 50 USBF/50 WF, F6 – 60 USBF/40 WF, F7 – 70 USBF/30 WF, F8 – 80 USBF/20WF, F9 – 90 USBF/10WF

Sensory Evaluation

Balanced incomplete block design (BIB) sensory test was conducted by 40 semi-trained panelists to determine the most acceptable formulations. The sensory test continued with the hedonic test to determine the best formulation. Analysis was conducted 24 h post-baking by 50 semi-trained panelists who evaluated the colour, aroma, texture, taste, aftertaste and overall acceptance with a structured hedonic scale of seven points.

Nutritional Composition of Biscuits

Determination of the chemical composition of all samples was conducted according to the standard methods recommended by AOAC (2000) [21]: moisture method 925.10, crude proteins method 920.87, total fats method 922.06, ash method 923.03, crude fibre method, 962.09 and total carbohydrates were calculated by the difference. DF and RS was analysed using AOAC (2000) method 985.29 megazyme dietary fibre kit and AOAC (2002) [22] method (2002.02) megazyme resistant starch kit, respectively.

Physical Characteristics of Biscuits

Colour intensity on the surface of the biscuits was measured using colorimeter (Chroma-meter CR-400, Japan) expressed in the CIE L*a*b*. Biscuit hardness was determined using a CT3 Texture Analyser (Brookfield, USA) based on the following experimental conditions: supports 5mm probe travel distance, a trigger force of 5g and a test speed of 2.0 mm/s [23].

Statistical Analysis

Sensory tests were analysed using One-way ANOVA, turkey-d. Physical and chemical analysis were conducted using an independent sample t-test in triplicate. All statistics were run using IBM SPSS version 25 to determine whether there were any significant differences ($p<0.05$) between the samples and recorded as mean ±SD.

RESULTS AND DISCUSSION

Sensory Analysis

Table 2: Total Scores of BIB Sensory Test on All Formulations

Formulation	Score
F5	31^{d}
F6	32^{d}
F1	33^{cd}
F3	33^{cd}

F2	40^{ab}
F4	40^{ab}
F8	41^{a}
F7	42^{a}
F9	43^{a}

[a] Values are means ± standard deviation. Means (n=3) with different letters in the same column differ significantly ($p < 0.05$).

Sample F9 (Table 2) had the highest score ($p<0.05$) which indicated it as the most unacceptable formulation. F5 meanwhile showed the lowest score ($p<0.05$) marking it as the most accepted formulation. BIB was conducted with Four coded samples were randomly arranged among the nine formulations. The panellists tasted each sample and selected those based on the level of likes where the scale was 1= Most Liked and 4= Least Liked. Table 2 indicates that there were significant differences ($p<0.05$) between the different biscuit formulations. Four formulations (F1, F3, F5 and F6) were later selected for the hedonic test since they had the lowest number of scores ($p<0.05$) among the nine.

There were significant differences ($p<0.05$) between texture, taste, aftertaste and overall acceptance between the four biscuit samples as ranked by the panellists (Figure 1). In terms of texture, all biscuits were significantly different ($p<0.05$). F1 presented the lowest score of 6.22 and F5 the highest score of 6.72 which indicated that the USBF inclusion was capable of affecting the texture of biscuits. Similar results [24] indicated that substitution with banana flour lowered the hardness of cookies. According to [25], consumer preference for biscuits varies depending on their hardness; generally, biscuits with low hardness are preferred although some groups may prefer products with a more rigid structure. F5 biscuits may be suitable for this kind of bakery product with its low hardness (compared to F1) and rigid structure (compared to F6).

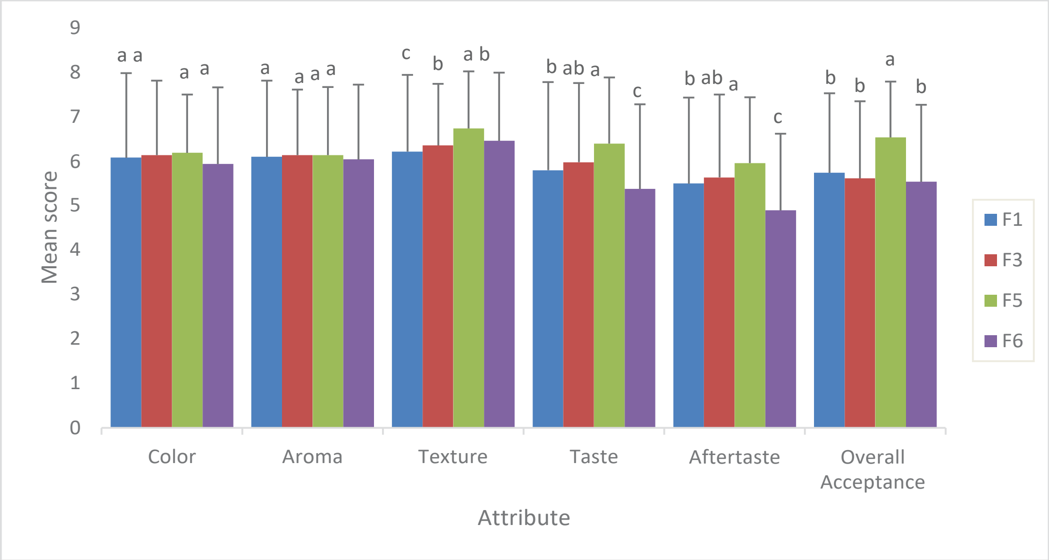

Figure 1: Mean Score of Hedonic Tests on F1, F3, F5 and F6 Biscuits

The scores for sensory attributes (Figure 1) such as taste, aftertaste and overall acceptability were highest for F5 and lowest for F6 biscuits. Statistical analysis for taste, aftertaste and overall acceptance showed a significant difference ($p<0.05$) in the level of acceptance of the biscuits. This could have occurred due to the higher percentage of USBF content in F6 which triggered a strong bitter taste intensity; this heightened bitterness resulted in the lowest aftertaste acceptance. As explained earlier, F6 biscuits had the least favourable taste (5.36) and aftertaste (4.88), this might have affected their overall acceptability (5.52) and scored them the lowest overall acceptability. Previous research [26] reported a resultant bitter taste when banana flour was added to food products. The bitter taste of USBF therefore might have contributed to the reduced scores for sensory attributes such as taste, aftertaste and overall acceptance of F6 biscuits. F5 receiving the highest overall acceptance (6.52) could be attributed to the texture and taste of the biscuits which was preferable or more suited to the panellists' preference.

There was no significant difference ($p>0.05$) in terms of colour and aroma between the four biscuit samples (Figure 1). The colour of the biscuits, possibly a result of a Maillard reaction and caramelisation during baking, made it difficult for the panel to detect differences in the colour of the different formulation biscuits. In terms of aroma, the panellists were unable to detect any difference in the biscuits possibly due to the fact that

USBF in itself did not produce a strong aroma. In addition, the butter used in the production of the biscuits produced its own distinctive aroma which might have been more dominant [27]. Among all USBF-based biscuit formulations, biscuit incorporated 50% USBF had the highest scores for all sensory attributes. Based on the hedonic tests, F5 was selected as the best formulation due to its higher scores for all sensory tests and put forward for further chemical composition and physical characteristics analysis along with the control formulation.

Chemical Composition of Biscuits

Prior study indicated that the USBF contained a low level of moisture (8.30%), protein (3.88%) and fat (0.80%) but a high amount of ash (2.54%) carbohydrates (84.39%), RS (53.83%) and DF (11.48%) content. The moisture content for control and F5 sample (Table 3) was 5.90% and 2.78% showing a significant decrease ($p<0.05$) due to the increase in DF content in the F5 biscuits. The DF content in F5 biscuits increased significantly ($p<0.05$) from control to F5 biscuits with 2.67 and 6.26% respectively. According to [28], high DF products tend to absorb more water resulting in lower moisture content. These findings are in agreement with [25] who reported a significant decrease in the moisture content of cookies when WF was partially substituted with raw plantain flour. The moisture content of biscuits is used as an indicator of their quality; low moisture content ensures that biscuits are mostly free from microbiological spoilage thus delivering a longer shelf life. The significant increment ($p<0.05$) of DF in F5 biscuits was primarily due to the intrinsic property of banana flour that contained a high amount of DF in USBF (11.48%), which falls within the range of previously reported 10.4 and 14.5g/100g of DF in unripe banana flour [12, 29]. According to the Food Act 1983 & Food Regulation 1985 [30], foods proclaiming to be a 'source of fibre' must contain at least 3g/100g DF while any ‘high fibre’ claim should present at least 6g/100g DF. Biscuits incorporated with 50% USBF contain 6.26g/100g DF which renders them ‘high fibre’. A similar finding of improved DF content was ascertained in cinnamon powder formulated biscuits [31] as a result of the inclusion of high DF.

Table 3: Proximate and Nutrient Composition of Control Biscuits and F5 Biscuits

Composition	gl100g	
	Control	F5
Moisture*	5.90±0.02^{a}	2.78±0.13^{b}
Ash	1.54±0.03^{b}	5.72±0.29^{a}
Total fat	11.44±0.47^{a}	12.12±0.44^{a}
Crude protein**	7.96±0.02^{a}	5.41±0.27^{b}
Crude fibre	0.41±0.18^{a}	0.77±0.11^{a}
Total carbohydrate	73.19±0.25^{a}	73.97±0.27^{a}
Dietary fibre	2.67+0.252^{b}	6.26±0.80^{a}
Resistant starch	1.13±0.15^{b}	6.17±1.34^{a}

^{a} Values are means ± standard deviation. Means (*n*=3) with different letters in the same column differ significantly ($p < 0.05$).
* g water/ 100 g
** N X 6.25

The addition of USBF increased the ash content significantly ($p<0.05$) with this pattern linked to the high ash content in the flour (2.54%). This trend agrees with [29] when the ash content in cookies increased when substituted with oyster mushroom powder with its high ash content. The protein content in the biscuits decreased significantly ($p<0.05$) from control to F5 biscuits at 7.65 and 5.41% respectively. The protein content decreased when substituted with 50% USBF due to the dilution effect [32] produced by the flour's lower protein (3.88%). A similar pattern was found in bread prepared by gradually replacing part of the wheat flour with green banana flour [33].

Meanwhile, fat and crude fibre content (Table 3) were found to increase with USBF substituted in the biscuits although the change was not significant (P>0.05). The fat content in both biscuits was estimated according to the corresponding amount of butter used in the formulations. Similar results obtained by [16] showed no difference (P>0.05) in the fat content of control cookies (12.55%) and resistant starch-rich lintnerised banana starch-cookie (12.69%). The amount of crude fibre in the biscuits increased due to the increased fibre content of USBF. A previous study reported an increase of crude dietary fibre in noodles upon the addition of 30% banana flour-substitute noodles [34]. Carbohydrates are the main component of biscuits with content ranging between 72.19g/100g and 73.97g/100g for control and F5 biscuits respectively, reflecting mainly the high starch content present in the flour.

F5 biscuits presented an increase ($p<0.05$) in RS content. An increase triples its value (6.17g/100g) was calculated in F5 biscuits compared with the control biscuits (1.13g/100g). This was primarily due to the high percentage of resistant starch (53.83%) in USBF. A comparable trend was found when cookies (100% WF) had a resistant starch content of 2.3g/100g while those added with 50% unripe banana flour indicated 8.37g/100g [32].

Physical Characteristics of Biscuits

Colour and hardness are essential physical characteristics and crucial factors of the acceptance of biscuits [23,30]. The inclusion of USBF had a potential effect of darkening the biscuits (lower L* values). A previous study of [35] whereby the substitution of banana starch (30%) caused a darkening of sugar-snap cookies. However, no significant differences ($p>0.05$) were found in L* between control and F5 biscuits. In addition, F5 biscuits resulted in less reddish colour (lower a* values) and less yellowish tone (lower b* values) with significant difference ($p<0.05$) between the two samples. The lightness of cookies could also occur due to a Maillard reaction and caramelisation during baking which correspondingly might result in no apparent change in biscuit colour (L) even with the addition of 50% USBF.

Table 4: Colour Analysis and Hardness of Control Biscuits and F5 Biscuits

Sample	Colour analysis			Hardness (g)
	L*	a*	b*	
Control	68.79±2.23^a	7.51±1.23^a	33.41±1.02^a	1141.33±90.56^a
F5	67.78±1.50^a	5.09±1.27^b	29.64±2.06^b	883.33±57.13^b

^{a} Values are means ± standard deviation. Means (n=3) with different letters in the same row differ significantly ($p < 0.05$).

The inclusion of USBF in the formulation of F5 biscuits significantly decreased ($p<0.05$) their hardness compared to the control biscuits (Table

4). This could be attributed to the hampering effects of USBF on the interaction between wheat proteins (gliadins and glutelins) and starch components resulting in weaker arrangements of the food matrix and decreased deformation resistance. Similar findings [25] suggested that the addition of raw plantain flour reduced the hardness in cookies.

CONCLUSION

Biscuits prepared in 50% USBF and 50% WF combination were the most accepted by the panelists. The results showed that the incorporation of USBF into biscuits resulted in significant increase in DF, RS, and ash content and similarly significant decrease in protein, moisture and hardness, although still within the range of a good quality biscuit. There was no significant difference in the lightness (L*) between control biscuits and F5 biscuits. This research confirms the viability of including USBF to enhance the nutritional value of biscuits without diminishing their acceptability. However, it should be noted that the inclusion of USBF might be detrimental to the biscuit appearance and textural parameters as desired by consumers.

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