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Effect of *Kappaphycus alvarezii* and Overripe Banana Sweetener Addition on the Nutritional Composition and Palatability of Cookies

Linlin Nie[1], Wan Rosli Wan Ishak[1*], Khadijah Mohd Kamil[1], Majid Khan Majahar Ali[2]
[1]School of Health Sciences, Universiti Sains Malaysia Health Campus, 16150 Kota Bharu, Kelantan, Malaysia
[2]School of Mathematical Sciences, Universiti Sains Malaysia Main Campus, 11800 Gelugor, Pulau Pinang, Malaysia

ABSTRACT

This study aimed to assess the qualities of butter biscuits made with seaweed flour (*Kappaphycus alvarezii,* (KA) (0, 4, and 8%) and Overripe Banana Sweetener (ORBS) (0, 50, and 100%) as a partial replacement for wheat flour and table sugar. A.O.A.C. and hedonic methodologies have been used to analyze the nutritional composition, color, and sensory evaluation of butter cookies. The increase in ORBS in cookie formulation resulted in a significant rise in the nutritional qualities of butter cookies, according to the result. Butter cookies with 4% seaweed flour and 100% ORBS had higher total dietary fiber (19.6%) and ash (3.07%) values. Sensory scores for the control (0%) and 4% seaweed flour-incorporated cookies did not differ substantially across all sensory qualities. However, the addition of 4% seaweed flour and 50% ORBS resulted in the highest scores for aroma, flavor, and overall acceptance. In conclusion, substituting 4% seaweed flour for wheat flour and 50% ORBS for table sugar could be an effective combination to make nutritious and tasty butter cookies.

Keywords: banana sweetener, cookies, *kappaphycus alvarezii*

INTRODUCTION

Knowledge and prevention of chronic diseases are the most significant issues that need attention in the twenty-first century. As the name implies, a chronic condition lasts a long time and is challenging to treat. Chronic illness development can be influenced by lifestyle factors like stress, imbalanced diet intake, and physical inactivity, according to research conducted in the last ten years (Barber *et al.* 2020). For most people, food is the most essential thing. Healthy eating has entered the mainstream in the current context, where life quality has increased (Timper & Brüning 2017). Foods low in fat, carbohydrates, and dietary fiber have sparked widespread concern and interest (Harcombe 2016; Hinde 2019) among the public. Many studies are now being conducted to develop nutritious and healthful foods.

Among nutrients, dietary fiber has a significant impact on health benefits (Weickert & Pfeiffer 2018). The European Food Safety Authority (EFSA) defines dietary fiber as nondigestible carbohydrates plus lignin (Hijová *et al.* 2019). The EFSA classifies dietary fiber as ingredients such as cellulose, fructooligosaccharides, hydrocolloids, pectins, and resistant starch (Hijová *et al.* 2019). Dietary fiber comes in two types: soluble and insoluble. Grains and whole grain products include insoluble fiber, whereas fruits and vegetables have soluble fiber. According to research, soluble fiber is more likely than insoluble fiber to ferment (Prasad & Bondy 2019). As a result, incorporating grains into diets can provide health benefits such as protection against long-term illnesses such as diabetes, obesity, and colon cancer (Xiong *et al.* 2019).

As a functional food, seaweed can be consumed since it is high in dietary fiber, which is very beneficial to human health (Huang *et al.* 2022). Seaweed is categorized into three categories: red, green, and brown. Red seaweed is the most commonly used seaweed in carrageenan, followed by green and brown seaweed (Torres *et al.* 2019). The red seaweed like *Kappaphycus alvarezii* (KA), Chondrus crispus, and Sarcothalia crispate are often employed as the primary sources in the carrageenan production. It

*Corresponding Author: email: wrosli@usm.my
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is extensively utilized throughout many different industries, particularly the food sector (Naseri *et al.* 2019). The KA is straightforward to cultivate and proliferate (Gereniu *et al.* 2017). According to related studies, soluble dietary fiber found in the seaweed KA. may be a useful food that helps prevent or reduce colon cancer (Raman & Doble 2015). Reduced reliance on wheat flour imports can be achieved by using seaweed flour of KA, which is recognized as an alternative local ingredient with good nutritional value (Munandar *et al.* 2019).

Banana (*Musa sp.*) highly available in the tropical countries of Malaysia. It is one of the most popular fruits in the market due to its rich nutritional value and wide planting area (Clement *et al.* 2019). Because of the unappealing/darkening color of its skin, it is often abandoned due to its high yield and ease of degeneration during maturation. As a result, when processing functional foods, it makes sense to use overripe bananas to produce Overripe Banana Sweeteners (ORBS); on the other hand, it is more natural and healthier because it is prepared from overripe bananas rather than refined sugar (Kumar 2022). The ORBS has a low glycemic index Ng *et al.* (2020b) and can be used as a natural sweetener to replace refined crystal sugar in the production of low GI foods.

The flavor, texture, and color of butter cookies make them a particularly popular bakery item in Malaysia. Flour, sugar, butter, egg, and other ingredients are the main ingredients of butter cookies (Hu *et al.* 2022). Regular consumption of butter cookies may increase the risk of developing chronic diseases due to their high sugar, fat, and dietary fiber content. Consequently, a statement that shows KA flour rather than regular flour and ORBS made from overripe bananas rather than regular sugar are a good combination to improve the nutrient quality of butter cookies. The purpose of this research was to elucidate the nutritional value, color, and sensory evaluation of cookies made from KA powder and ORBS.

METHODS

Design, location, and time

In this study, two experimental samples and one control sample were used. The experimental samples were butter cookies mixed with 0, 4, and 8% seaweed flour and 0, 50, and 100% ORBS to partially replace wheat flour and sugar, respectively. The control was a butter cookie made without the inclusion of seaweed flour (0%) and ORBS (0%). The sensory evaluation, Total Dietary Fiber (TDF), color analysis, and proximate analyses of the control and experiments were compared.

The study was carried out at the Food Preparation Laboratory and Analytical Laboratory, Health Campus of Universiti Sains Malaysia (USM). The study was conducted from September 2023 to March 2024. Before this studied was carried out the ethical approval for this study was acquired from the Human Research Ethnics Committee (HREC) USM with study protocol code of USM/JEPeM/KK/23050423.

Materials and tools

The fully ripened of the Musa acuminata cv. Berangan banana were purchased at a local supermarket in Kubang Kerian, Kelantan, Malaysia. Mainly color changes in banana during ripening are based on the peel color rather than the pulp color.

A color chart and physical inspection were used to compare the peel's color and hardness to assess the stage of ripening. Stages 1 through 3 of a banana peel's development are when it is hard and green in color; stages 4 and 5 are when the peel is flexible and entirely yellow with a growing number of brown patches (Karim *et al.* 2018).

Banana extraction was carried out with a few minor modifications by (Ng *et al.* 2020a). The banana pulps were blended in a 1:3 water to banana pulp ratio and then centrifuged at 4°C for 25 min at 15,000 g. To extract the clear top banana juice, filter paper Whatman No. 4 was used. To eliminate the moisture, 50 g of banana juice was dehydrated at 60°C for 16 hours in a thermal dehydrator (Anywin FD770, China). After that, the concentrated syrup was maintained at 4°C in a screw-top bottle for later analysis and usage. A hand refractometer (Atago 3851 PAL-BX/RI, Japan) and a microprocessor pH meter (HANNA. pH 211, USA) were used to test the syrup's Total Soluble Solids (TSS) °Brix and pH, respectively.

Butter cookies were made with wheat flour, corn flour butter, margarine, castor sugar, baking powder, and eggs as the primary ingredients. The recipe was adopted with slight modifications (Ng *et al.* 2020b). Imtanomic Sdn Bhd is the supplier of seaweed flour (KA). Butter and castor sugar were mixed in a bowl with an electric hand mixer. The egg was then gradually added, beating the mixture until it had a creamy consistency. The mixture was stirred for five min after adding all of the dry ingredients before being refrigerated for two hours. With a 5 cm diameter mold, the cold dough was gently molded into a 3 mm thick disc. After that, they were put on a baking pan and baked for ten minutes at 170°C. After a half-hour of cooling at room temperature, the cookies were crushed into flour and kept at 4°C until additional nutritional analysis was conducted.

Previously, an optimization experiment was carried out to select the two most optimized formulas based on texture profiles analysis data analyzed from 16 treatments utilizing Response Surface Methodology (RSM). Three variables were set with varied combinations of KA. powder: wheat flour, ORBS: table sugar, and butter: margarine. In this optimization study, wheat flour was partially substituted with seaweed flour at percentages of 0, 4, and 8%, while ORBS and butter were used to partially substitute sugar and margarine at percentages of 0, 50, and 100%. Both treatment-12 and treatment-14 are the most optimal formulae obtained from our preliminary study (Ali *et al* 2014). For treatment-12, 41 g of ORBS, 3 g of KA and 40 g butter were added into the butter cookies. As for treatment-14, 20.5 g of ORBS, 3 g of KA, 20.5 g sugar and 20 g margarine were added.

Procedures

The analysis of moisture, total ash, fat content, and protein was conducted by AOAC (2020). The proximate composition of butter cookies was determined using an air-oven method for moisture, a dry-ashing method for total ash, a Kjeldahl method for protein, and a Soxhlet method for fat. Furthermore, Eq. 1 was used to compute the carbohydrate content:

Total carbohydrate = 100-(moisture+ash+ protein+fat+dietary fiber) (Eq.1)

The Total Dietary Fiber (TDF) was measured using the TDF kit from Sigma Chemical Company and an enzymatic method based on AOAC (2020) (St-Louis, MO).

Sensory evaluation of butter cookies was performed by 30 untrained panels involving staff and students at the School of Health Sciences, Universiti Sains Malaysia Health Campus. The samples were coded with a three-digit permuted number and evaluated using the seven-point hedonic scale method. Aroma, color, appearance, crispiness, flavor, and general acceptance were the sensory characteristics studied (1 being the most disliked and seven being the most liked) according to Sharif *et al.* (2017).

According to (Gat & Ananthanarayan 2015), Hunter color characteristics (L*, a*, b*) were measured for cookies formulated with added seaweed flour and ORBS. Color measurement was carried out using a Hunter Lab colorimeter (LabScan XE, Hunter Associates Laboratory, Reston, VA, USA) and the Easy Match QC programmer. The color points in this color space are identified by three color coordinates. L* is the brightness coordinate, a* is the redness coordinate to greenness coordinate, b* is the yellowness coordinate to blueness coordinate. From no reflection for black (L*=0) to perfect diffuse reflection for white (L*=100). The 'redness' coordinate, a*, ranges from a negative value for green to a positive value for red. 'Yellowness' coordinate (b*) ranges from positive values for yellow to negative values for blue. The reported values for each sample were the three replicates' average values (Gat & Ananthanarayan 2016).

Data analysis

All data were analyzed using one-way repeated measure Analysis of Variance (ANOVA), Tukey's posthoc test, and Design-Expert software (v.7.0.0, State-Ease, Inc., Minneapolis, USA). For data analysis, SPSS, version 24.0, was employed. Founded in Chicago, Illinois, SPSS. Inc. Three batches of cookies prepared with seaweed flour and OBS butter were created for all measurements. Except for sensory evaluation (n=30), results were reported as the mean of three replicates and the $p<0.05$ significance level was chosen.

RESULTS AND DISCUSSION

Proximate compositions

Table 1 shows the nutritional information for butter cookies made with varied amounts of seaweed flour as a partial substitution for wheat flour. The results showed that when the amounts of ORBS increased, the ash and moisture levels of butter biscuits increased from experiment-14 to experiment-12. Treatment-12 cookies had

Table 1. Nutritional composition of butter cookies formulated with KA flour and ORBS

Nutritional analysis	Control (%)	Experiment 12 (%)	Experiment 14 (%)
Moisture	4.57±0.04^{a}	15.09±0.11^{b}	8.02±0.10^{c}
Ash	0.82±0.06^{a}	3.07±0.05^{b}	2.53±0.05^{c}
Fat	20.01±0.26^{b}	20.38±0.16^{b}	20.92±0.08^{a}
Protein	6.89±0.28^{a}	6.79±0.06^{a}	6.88±0.11^{a}
Carbohydrate	67.73±0.57^{a}	54.67±0.20^{c}	62.00±0.57^{b}
Total Dietary Fiber (TDF)	14.70±0.03^{c}	19.62±0.06^{a}	16.61±0.05^{b}

The analysis was replicated three times (n=3) and was expressed in Mean±SD

$^{a\text{-}b}$: Mean±SD with different superscript letters within the same row indicate significant difference ($p<0.05$)

KA: *Kappaphycus alvarezii*; ORBS: Overripe Banana Sweetener

the highest moisture content (15.09%) when compared to treatment-14 and the control group (8.02 and 4.57%, respectively). The increased moisture content could be attributed to the fact that treatment-12 was produced with 100% ORBS and zero% table sugar. In actuality, ORBS contains soluble fibers and pectin, which trap more moisture than in experiment-14, in which cookies are baked with 50% ORBS and 50% table sugar.

The different rates at which sugar dissolves when mixed impact how much the moisture content rises. Dryer cookies are baked when crystalline sucrose evaporates more easily because it interacts with water less frequently. Conversely, high glucose and fructose moisture absorption in ORBS leads to increased hydrogen bonding interactions with water and decreased evaporation during baking, resulted in the chocolate cookies being studied containing a higher moisture content (Ng *et al.* 2020a). The moisture content of control cookies made with 100% table sugar was the lowest. Because table sugar lacks dietary fiber, it is incapable of retaining moisture during cookie preparation and baking.

The high Dietary Fiber (DF) content of ORBS and KA may absorb a substantial amount of water, causing a rise in the moisture content of cookies after baking. Ng *et al.* (2020b) found a similar finding, noting that cookies created with ORBS had a higher moisture content than cookies made with lower quantities of ORBS. Furthermore, KA seaweed has a good water-holding capacity during preparation and baking (Mohammad *et al.* 2019). As a result, it enhances the water content of cookies (experiment-12 and experiment-14).

Experiment-14 also revealed a statistically significant ($p<0.05$) increase in moisture and ash content when compared to the control. When ORBS was added to all formulations, there was a significant difference ($p<0.05$) in the ash concentration which increased from 2.53% to 3.07% as ORBS increased from 50% in Experiment 14 to 100% in Experiment 12. The high ash concentration of ORBS and KA powder was primarily responsible for this increment. The increased level of ash in experiment-12 (3.07%) was attributable to the high concentration of ORBS (100% ORBS and zero% table sugar) utilized in the formulation. Both cookies (experiments 12 and 14) had considerably greater ($p<0.05$) ash concentrations (2.53 and 3.07%) than the control (0.82%). The increased concentration of ash in experiments 12 and 14 is attributable to the fact that the dehydrated KA used in the cookies had a higher ash content (48%) (Neoh *et al.* 2016), whereas the control cookie was not formulated with dehydrated KA They discovered that the ORBS has a higher ash content and a significant proportion of TDF.

The inclusion of KA. results in the highest value of TDF in cookies for both experiment-12 (19.6%) and experiment-14 (16.6%) but not in control cookies (14.7%). The higher TDF content in cookies from experiment-12 compared to cookies from experiment-14 is due to the addition of 100% ORBS replacing table sugar in experiment-12, but only 50% ORBS was used to replace table sugar in cookies from experiment-14. Ng *et al.* (2020b) also reported that the addition of ORBS to cholate cookies increase the TDF value compared to the control. This information accurately reflects the nutritional value of ORBS.

In terms of fat content, there was a significant difference (p>0.05) between experiment-12 and experiment-14 (20.38% and 20.92%). However, the fat content of experiment-12 and the control were not significantly different (p>0.05), with fat contents of 20.38% and 20.01%, respectively, owing to the reduced fat content in ORBS and seaweed flour, which were employed as key ingredients in this study. The KA seaweed powder used in this study, supplied by Imtanomic Sdn Bhd, has a lower fat content (1.10%) and can replace wheat flour to reduce fat intake, creating a healthy effect (Munandar *et al.* 2019). Ng *et al.* (2020a) discovered a similar result when they added overripe banana sweetener (ORBS) and Overripe Banana Residue (OBR) to chocolate biscuits. Meanwhile, protein content was not significantly different (p>0.05) for experiment-12, experiment-14, and control cookies, ranging from 6.79% to 6.89%. This is because the protein level of wheat flour and KA powder is similar, ranging from 8.00 to 10.00% (Neoh *et al.* 2016). Despite this, an inverse link between carbohydrate content and moisture content was identified in butter cookies.

Sensory acceptability

Making fiber-enriched goods with acceptable sensory qualities is one of the issues that the food sector has in meeting consumer expectations. In the current study, 30 panelists evaluated the sensory attributes of seaweed flour cookies vs. butter cookies as the control. The sensory evaluations for butter cookies baked with varying amounts of seaweed flour and ORBS are shown in Table 2.

The control butter cookie had higher scores for appearance (5.20) and color (5.27) qualities than the other treatments, but the difference was not significant (p>0.05). However, when the crispness and overall acceptance of the control group were compared with the sensory scores of experiment-14, although the significant difference was not obvious, due to the addition of ORBS and seaweed flour to the butter cookies in experiment-14, the taste of experiment-14 compared with the butter cookies in the control group, they were more popular with sensory consumers. Thus experiment-14 had higher crispness scores (4.60) and overall acceptance scores (5.43) than the control scores (3.90 and 5.20, respectively). This could be due to the intense flavor and aroma of overripe bananas, which the panelist prefers. A similar study on overripe bananas found that bananas can be utilized practically and that many consumers enjoy the flavor and aroma of bananas (Soto-Maldonado *et al.* 2020). In comparison to the control, it is believed that a small amount of ORBS can improve the aroma, flavor, and crispiness. Higher ORBS in butter cookie inclusion, on the other hand, will result in an unpleasant taste.

In terms of appearance and color qualities, the experiment-14 butter cookie did not differ significantly (p>0.05) from the control and experiment-12 butter cookies. The sensory results also demonstrate that using 50% ORBS and 4% seaweed flour in place of table sugar and wheat flour can produce a butter cookie high in dietary fiber without sacrificing the desirable sensory attributes.

Previous research has shown that the sensory properties of gluten-free cookies made

Table 2. Sensory acceptability of optimized butter cookies incorporated with KA flour and ORBS

Properties	Control	Experiment-12	Experiment-14
Appearance	5.20±1.47^{a}	4.60±1.50^{a}	4.97±1.65^{a}
Color	5.27±1.41^{a}	4.40±1.77^{a}	5.20±1.47^{a}
Aroma	5.40±1.22^{a}	4.30±1.90^{b}	5.00±1.53^{a}
Flavor	5.33±1.24^{a}	3.70±1.80^{b}	5.20±1.45^{a}
Crispiness	3.90±1.67^{a}	2.67±1.73^{b}	4.60±1.61^{a}
Overall Acceptance	5.20±1.06^{a}	3.93±1.53^{b}	5.43±1.25^{a}

$^{a\text{-}b}$: Mean±SD with different superscript letters within the same row indicate significant difference (p<0.05)

KA: *Kappaphycus alvarezii*; ORBS: Overripe Banana Sweetener with banana flour and starch are equivalent to those of regular biscuits (Olawoye *et al.* 2020). Shahzad *et al.* (2021) identified a similar tendency when substituting 7.5% Lotus Seed Flour (LSF) for wheat flour in the production of cookies. The sensory evaluation score of overall approval is the highest due to the impact of L.S.F. integration on texture, color, appearance, and taste. This study found that when there was more flour in baked goods, consumers were less satisfied, and replacing foods high in dietary fiber with flour in baked goods can further endow consumer items with functional and health-promoting features.

Color analysis

The L*, a*, and b* values of control butter cookies were compared to cookies with seaweed flour and ORBS (Table 3). The effect of adding seaweed flour and ORBS can be easily noticed by comparing the values of control butter cookies, seaweed flour, and ORBS-added butter cookies. Table 3 shows that as the percentage of seaweed flour increased from 0% to 4% (experiments 12 and 14) while the lightness (L* value) of butter biscuits decreased significantly ($p<0.05$). Meanwhile, the redness (a* value) of seaweed flour added to cookies was dramatically increased ($p<0.05$). Control-butter cookies with no seaweed flour or ORBS had the highest lightness (L* value) and the lowest redness (a* value). This result indicated that when seaweed flour was added to butter cookies, the color turned darker and redder compared to the control butter cookies. The more the level of seaweed flour added, the darker and redder they became. Besides, control butter cookies, without any additives, recorded the lightest and the least reddish in color.

Table 3. Color analysis of butter cookies incorporated with KA flour and ORBS

Properties	Control[*]	Experiment 12[**]	Experiment 14[***]
L*	79.92±0.13[a]	67.25±0.86[b]	65.80±0.19[c]
a*	5.58±0.17[c]	7.34±0.17[b]	8.04±0.17[a]
b*	22.09±1.81[a]	21.14±0.17[a]	21.17±0.3[4a]

[a-b]: Mean+SD with different superscript letters within the same row indicate significant difference. ($p<0.05$)
[*]Control-butter cookies samples containing 0% seaweed flour, 0% ORBS, 50% butter
[**]Experiment 12-butter cookies samples containing 4% seaweed flour, 100% ORBS, 100% butter
[***]Experiment 14-butter cookies samples containing 4% seaweed flour, 50% ORBS, 50% butter
KA: *Kappaphycus alvarezii*; ORBS: Overripe Banana Sweetener

As previously noted, the overall acceptability of the sensory scores obtained was 5.20 (control), 3.93 (experiment-12), and 5.43 (experiment-14), which may be related to the L*, a*, and b* values (Table 3). According to these findings, the control and experiment-14 scores are greater than experiment-12. The reason for this could be that adding butter to the control cookies (without adding KA powder) makes the butter cookies taste more flavorful, which customers prefer. When KA and ORBS were added at 4% and 50%, respectively (in experiment-14), the butter cookies had a greater nutritional value and a crisper flavor but were substantially darker in color. Experiment-14 has a higher sensory assessment score than experiment-12, which may be attributed to experiment-12 containing too much ORBS, which impairs the taste of butter cookies. As a result, the cookies sample made with 4% seaweed flour and 50% ORBS were the most acceptable in terms of color and overall acceptance. Adding ORBS in concentrations greater than 50% resulted in darkening (lower intensity of L* values at 65.80 and 67.25, respectively) of butter cookies, which affected or lowered their overall appeal. The outcome is the same as the previously reported color difference when combining capsicum extract and rice flour under varied circumstances and concentrations. The higher the concentration of chili oil used, the lower the intensity of lightness (L* value), while the intensity of redness (a* value) grew dramatically, namely more of chili oil made things darker and redder (Gat & Ananthanarayan 2016).

CONCLUSION

The current study showed that adding the right amount of seaweed flour and ORBS to butter cookies enhanced crispiness, lowering their moisture and ash content but not affecting fat and protein content. The butter cookie from experiment-14 had the highest sensory ratings, although it performed worse than experiment-12 regarding moisture and ash. This might be because experiment-12 had added half as much ORBS as experiment-14, which resulted in lower moisture content and more ash in the butter cookies. Experiment-14 also had a higher degree of crispiness than experiment-12. In conclusion, experiment-14, which contains 4% seaweed flour and 50% ORBS, is the best choice to replace some of the wheat flour and maybe a successful method to increase the nutritious content while maintaining acceptable physical and sensory qualities. The potential of dehydrated seaweed (KA powder) as a partial replacement for wheat flour and in-depth research is needed which emphasizes the role of cookies developed with DF in impacting glycemic responses in healthy individuals. It is also recommended that the low glycemic index cookies developed from KA powder (rich in dietary fiber) can be used for a natural regiment interventional diet for a reduction of diabetic complications among diabetes individuals.

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DECLARATION OF CONFLICT OF INTERESTS

The researchers have declared that they have no competing interests.

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