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Effect of overripe banana pulp incorporation on nutritional composition, physical properties, and sensory acceptability of chocolate cookies

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Abstract

The intake of dietary fibre (DF) has been proven to lower the risk of chronic diseases, leading to the increasing demand for fibre-enriched bakery product. Banana is one of the most consumed fruits that exhibits rich sources of DF and provides excellent nutritional health benefits. However, overripe banana is discarded due to its low quality and appearance. Thus, the present work was aimed to determine the properties of chocolate cookies formulated with overripe banana pulp powder (OBPP) as partial replacement (0, 6, 8, and 10%) for wheat flour. Nutritional composition, physical properties, and sensory acceptability of the cookies were analysed using AOAC methods, texture profile analyser, and 7-point hedonic scaling method, respectively. Results showed that increased incorporation of OBPP significantly increased the nutritional values of chocolate cookies. Chocolate cookies formulated with 10% of OBPP recorded the highest total dietary fibre (8.21%) and ash (1.23%) contents. In texture profile analysis, the firmness of the chocolate cookies was recorded to increase slightly with increasing level of OBPP, although this was not significant. Sensory scores for the control (0%) and 6% OBPP-incorporated cookies were not significantly different for all the sensory attributes. However, the incorporation of 8% OBPP produced the highest scores in terms of aroma, flavour, and overall acceptance. In summary, the addition of 8% OBPP could be an effective way to produce nutritious and the most palatable chocolate cookies.

Introduction

Recently, the incidence of chronic diseases is increasing at an unprecedented rate and becoming a major public health issue all over the world including Malaysia. Chronic diseases, including cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes mellitus (DM), are the major causes of mortality globally (Ramli and Taher, 2008). The prevalence of chronic diseases is rising rapidly and forecasted to exceed the current prevalence as the common causes of death by 2030 (WHO, 2011). Dietary fibre (DF) is an important component in our daily diet and naturally presents in cereals, vegetables, fruits, and nuts (Dhingra *et al.,* 2012). High consumption of DF has been proven to reduce the risk of certain diseases such as obesity, diabetes, cancer, and cardiovascular diseases (Lattimer and Haub, 2010; Cho *et al.,* 2013). DF is proven able to lower LDL-cholesterol and blood pressure, to regulate blood sugar level, to maintain body weight by prolonging satiety, and also to prevent constipation (Timm and Slavin, 2008).

DF is the edible part of the plant which is resistance to enzymatic digestion and absorption in human small intestine with complete or partial fermentation in large intestine (Dhingra *et al.,* 2012). The recommended DF intake for adults are 20 - 35 g/day (ADA, 2000). Nevertheless, the intake for DF among populations is low, ranging from only 3 - 16 g/day (Timm and Slavin, 2008; Lee and Wan Muda, 2019). The importance of DF has lead researchers to look for new sources of DF for the development of fibre-rich products such as crackers and cereal-based products (Dhingra *et al.,* 2012).

Banana (*Musa* sp.) is a popular fruit grown and consumed worldwide. Banana is well known for its source of nutrients, minerals, and DF content (Sidhu and Zafar, 2018). However, it is a perishable fruit that has a short lifespan from harvest until the onset of deterioration (Karim *et al.,* 2018). Previous studies have claimed that the purchase intention for overripe banana is significantly low due to low quality, brown spots appearance as well as decrease in firmness of the pulp (Rohm *et al.,* 2017; Symmank *et al.,* 2018). As a

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result, banana has been shown as one of the most wasted products as most retailers ask for fruit in yellow colour which is associated with ripe banana (Shahir and Visvanathan, 2014; Mattsson *et al.,* 2018). Despite its nutritional values and health benefits, overripe banana is still underutilised, and very little effort has been put to identify its functionality in terms of application in food products (Padam *et al.,* 2014). Previous study by Chaipai *et al.* (2018) revealed that the DF in banana pulp did not vary with maturity although most of the starch has been converted into sugar in overripe banana. Hence, the utilisation of overripe banana will not only help in increasing value of food product but also indirectly reducing food waste.

Based on the Malaysian Adult Nutrition Survey (MANS), cookies are among the top ten foods consumed by Malaysians (Noraida *et al.,* 2018). Currently, research has been conducted on the use of banana pulp powder as a source of DF in noodle (Ritthiruangdej *et al.,* 2011), ice cream (Yangılar, 2015), and wheat-based product (Adubofuor *et al.,* 2016; Loong and Wong, 2018). However, the application of overripe banana pulp powder (OBPP) in bakery product such as cookie is still lacking. Therefore, the present work investigated the development of chocolate cookies incorporated with different percentages of OBPP as partial replacement for wheat flour. The present work helps to improve the nutritional values of cookies especially DF without affecting its physical and sensory properties.

Materials and methods

Experimental design

The experiment involved a control sample and three experimental samples. The control sample was the chocolate cookie without the incorporation of OBPP (0%) while the experimental samples were the chocolate cookies incorporated with 6, 8, and 10% OBPP to partially replace wheat flour. The proximate composition, the total dietary fibre (TDF), the physical characteristic, the textural properties as well as the sensory acceptability were compared between control and treatments.

Preparation of raw material

Fully ripened *Musa acuminata cv. Berangan* banana (stage 4) was purchased from a local fruit store in Kota Bharu, Kelantan and kept at room temperature (25°C) and relative humidity (80 - 85%) until the fruit reached the desired ripeness (stage 5, overripe) without the aid of any ripening agent.

Determination of banana ripening stages

The stage of ripening was determined according to Karim *et al.* (2018), using a colour chart and physical observation by comparing the colour of the peel and the hardness. Stage 1 - 3: banana peel is rigid and green in colour; stage 4: banana peel is firm and fully yellow in colour; stage 5: banana peel is soft and yellow colour with increasing brown spots.

Preparation of OBPP

The extraction of banana was done following Albuquerque *et al.* (2005) with modifications. The banana pulps were homogenised with water in a ratio of 1:3, and centrifuged at 15,000 *g* for 25 min at 4°C. Filtration was done with filter paper Whatman No. 4 to extract the non-fibrous portions (minerals, organic acids, soluble polysaccharides, and sugars) from the liquefied banana pulps. The extracted banana pulps (w/v) were dried in the conventional oven (Memmert, Germany) at 55°C for 24 h, followed by milling into powder using electrical blender and then sieved into fine powder (125 μm diameter) using a sieve. The resulting pulp powder was kept in screw cap bottle at 4°C until further use.

Development of chocolate cookies

Chocolate cookies were formulated by using commercially available raw ingredients such as butter, margarine, castor sugar, egg, baking powder, cocoa powder, wheat flour, and corn flour. OBPP was used to partially substitute wheat flour at the percentage of 6, 8, and 10% as shown in Table 1 and Figure 1. In a mixing bowl, butter and castor sugar were beaten by using an electric hand mixer followed by the addition of egg into the mixture slowly until a creamy texture was achieved. After the addition of all dry ingredients, the mixture was beaten again for 5 min and kept in the fridge for 2 h. The refrigerated dough was manually shaped into 3 mm thick using a 5 cm diameter mould. After that, they were put on a baking sheet and baked at 170°C for 12 min. The cookies were then cooled at room temperature for 1 h before ground into powder form and kept in screw cap bottle at 4°C until further nutritional analyses.

Nutritional analyses

Proximate analysis for OBPP and OBPP-enriched cookies were conducted following AOAC (1996a) for moisture (air-oven method), total ash (dry-ashing method), protein (Kjeldahl method), and fat (Soxhlet method). Carbohydrate was calculated using Eq. 1:

$$\text{Total CHO} = 100 - (\text{g of moisture} + \text{ash} + \text{protein} + \text{fat}) \quad \text{(Eq. 1)}$$

Table 1. The raw ingredients used in the preparation of chocolate cookies incorporated with OBPP.

Item	Ingredient	Quantity (g)			
		Control (0% OBPP)	6% OBPP	8% OBPP	10% OBPP
1	Butter	35	35	35	35
2	Margarine	5	5	5	5
3	Castor sugar	41	41	41	41
4	Egg	20	20	20	20
5	Baking powder	0.5	0.5	0.5	0.5
6	Cocoa powder	8	8	8	8
7	Corn flour	5	5	5	5
8	Wheat flour	76	71.4	69.9	68.4
Total weight		190.5	190.5	190.5	190.5

The recipe was adopted from Mohan *et al.* (2018) with slight modification.

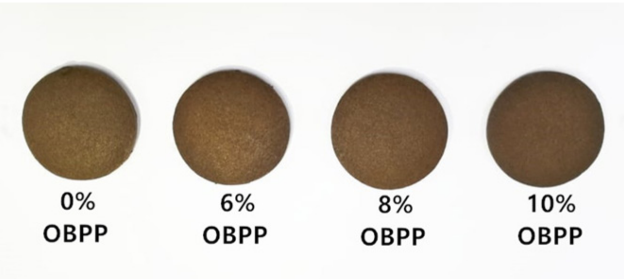

Figure 1. Chocolate cookies incorporated with different levels of OBPP.

The TDF was determined by using enzymatic-gravimetric method based on AOAC (1996b) with TDF-kit from Sigma Chemical Company (St. Louis, MO). The analysis was performed by using Fibertec E system (FOSS Analytical, Sweden) which comprised of Filtration Module (Fibertec E 1023) and Thermostatic Shaking Water Bath (FOSS 1024). The defatted sample (1000 ± 5 mg) was mixed with 50 mL phosphate buffer. The mixture was gelatinised with 50 µL α-amylase and incubated in boiling (95 - 100°C) water bath for 30 min. After pH of the mixture was adjusted to 7.5 ± 0.1 by using 0.725 N NaOH, protease (100 µL) was added, and the mixture was incubated in shaking water bath (60°C) for 30 min with continuous agitation. Next, 200 µL amyloglucosidase was added when the pH of mixture was adjusted to 4.0 - 4.6 by adding 0.325 M HCl and incubated again in shaking water bath for 30 min. Then, 280 mL of 95% ethanol was added to precipitate the dietary fibre. The residues were then filtered and washed with ethanol and acetone followed by drying at 105°C overnight before weighed. Half of the dried residues was analysed for protein and while the remaining was analysed for ash. TDF content was calculated using Eq. 2 and 3:

$$\text{Blank} = \text{residue weight (mg)} - \text{protein (mg)} - \text{ash (mg)} \quad \text{(Eq. 2)}$$

$$\text{TDF} = \frac{[\text{residue weight (mg)} - \text{protein (mg)} - \text{ash (mg)} - \text{blank}]}{\text{sample weight (mg)}} \quad \text{(Eq. 3)}$$

Physical analyses

Physical analyses of the cookies were determined based on the method from Ng *et al.* (2017). One hour after baking, weight (W) of ten pieces of cookies from each formulation was taken by using analytical balance (Mettler-Toledo Dragon 204, Switzerland) and the mean value (g) was obtained. The cookie diameter (D) was recorded by arranging ten pieces of cookies edge-to-edge. The cookie thickness (T) was measured by stacking ten pieces of cookies. The spread ratio (D/T) was calculated as the diameter to thickness ratio. The mean values of mm/10 of three different trials were calculated and measurements were expressed in mm.

Texture profile analysis (TPA) of the cookies incorporated with OBPP was performed by using a TA.XTplus Texture Analyser (Stable Micro Systems, Surrey, UK) with a 3D extensibility method coupled with Texture Exponent Software. Pieces of cookies (approximately 50 mm diameter and 3 mm thickness) were placed on the base of the heavy-duty platform equipped with a 3-point bend rig. The operation conditions were pre-test speed (1.0 mm/s), test speed (3.0 mm/s), post-test speed (10.0 mm/s), distance between probe and cookie (10 mm), compression distance (3 mm), trigger force (50 g), and option (return to start). The peak force (kg) and the mean distance at point break (mm) from the curve indicated the firmness and crispiness of the cookies, respectively.

Sensory evaluation

Sensory evaluation of chocolate cookies was carried out by 60 untrained panels consisting of staff and students of the School of Health Sciences, Universiti Sains Malaysia Health Campus. The samples were coded with 3-digit permuted number and evaluated based on the 7-point hedonic scale method (Sharif *et al.,* 2017). Sensory attributes included aroma, colour, appearance, crispiness, flavour, and overall acceptability (1 = dislike the most, and 7 = like the most).

Ethics

The present work was reviewed and approved for implementation by the Human Research Ethnics Committee USM (HREC) with study protocol code of USM/JEPeM/19030180.

Data analysis

All data were tested for significance by using one-way repeated measure analysis of variance (ANOVA) followed by Tukey's *post-hoc* test to compare the mean differences among the samples. Data analysis was performed using SPSS, Version 24.0. (SPSS Inc, Chicago, Illinois). Three batches of OBPP and chocolate cookies were produced for all measurements. Results were expressed as mean of three replicates (n = 3) ± standard deviation (SD) except for TDF (n = 2) and sensory evaluation (n = 60). Significance level was established at $p < 0.05$.

Results and discussion

Proximate compositions and TDF content

The proximate composition of OBPP is shown in Table 2. From the result obtained, OBPP contained an appreciable amount of TDF (33.61%). According to Xiao *et al.* (2018), most of the starch including insoluble fibre in banana will turn into sugar as it ripens. Surprisingly, the TDF content in the OBPP was still in a great quantity. A previous study by Ramli *et al.* (2009) found that the TDF in ripe banana flour was higher as compared to unripe banana flour because of the increment of water-soluble pectin. Pectin is a fibre that is also responsible for the pulp softening when banana ripens (Duan *et al.,* 2008). Thus, OBPP could be used for enhancing the DF content of the chocolate cookies.

Table 2. Nutritional composition of OBPP.

Nutritional composition*	Concentration (%)
Moisture	4.19 ± 0.03
Fat	0.17 ± 0.01
Protein	5.21 ± 0.09
Ash	2.76 ± 0.06
Carbohydrate	87.74 ± 0.04
TDF	33.61 ± 0.23

Data are means ± standard deviation of three replicates (n = 3), except for TDF (n = 2).

The nutritional values of chocolate cookies incorporated with different levels of OBPP as partial replacement of wheat flour are shown in Table 3. In general, the results showed an increment in ash and TDF in the chocolate cookies when the level of OBPP increased

Table 3. Nutritional composition of chocolate cookies incorporated with OBPP.

Nutritional composition	Concentration (%)			
	Control (0% OBPP)	6% OBPP	8% OBPP	10% OBPP
Moisture	2.58 ± 0.07^{a}	2.51 ± 0.02^{ab}	2.44 ± 0.04^{b}	2.32 ± 0.03^{c}
Fat	21.15 ± 0.03^{a}	21.22 ± 0.03^{a}	21.28 ± 0.08^{a}	21.25 ± 0.01^{a}
Protein	7.41 ± 0.04^{a}	7.30 ± 0.05^{b}	7.20 ± 0.03^{c}	7.16 ± 0.15^{cd}
Ash	0.72 ± 0.03^{d}	1.01 ± 0.04^{c}	1.12 ± 0.02^{b}	1.23 ± 0.05^{a}
Carbohydrate	68.14 ± 0.11^{a}	67.94 ± 0.05^{a}	67.95 ± 0.06^{a}	67.97 ± 0.05^{a}
TDF	3.18 ± 0.53^{b}	7.25 ± 0.07^{a}	7.77 ± 0.13^{a}	8.21 ± 0.16^{a}

Data are means ± standard deviation of three replicates (n = 3), except for TDF (n = 2). Means with different superscript letters within the same row indicate significant difference ($p < 0.05$).

from 0 to 10%. There was no significant difference ($p > 0.05$) in terms of fat and carbohydrate content for 6, 8, and 10% of OBPP-chocolate cookies as compared to the control.

A significant ($p < 0.05$) increase in TDF was observed when level of OBPP increased to 6% as compared to the control (ranging from 3.18 to 7.25%), but there was no significant difference ($p > 0.05$) between 6, 8, and 10% OBPP-chocolate cookies. Similar trends of rising in DF content were described in bakery products formulated with red capsicum pomace powder (Nath *et al.,* 2018) and *Citrus limetta* powder (Younis *et al.,* 2016) at 6, 8, and 10%. There is a solid health claim that the increase in DF intake is associated with better diet quality, decreased incidence of chronic diseases, and improved overall bodily function (Walia *et al.,* 2009). A study was done by Brauchla *et al.* (2013) regarding the effect of high fibre snack (cereal, cracker, and bread) on diet quality in children. The result revealed that the children readily accepted the high fibre snacks. The addition of high fibre snack significantly increased their daily fibre intake and physical well-being. Therefore, high fibre snack could be an alternative source of fibre. Indeed, food product which contains high DF is able to increase the DF intake of individual who does not take fruits and vegetables in their daily diet. Moreover, the addition of OBPP also significantly ($p < 0.05$) increased the ash content in all formulations, rising from 0.72 to 1.23%. The increase was mainly due to high amount of ash content in OBPP.

Despite that, an inverse relationship between moisture and protein content in chocolate cookies was observed as the level of OBPP increased. Significant difference ($p < 0.05$) in protein content was found in 6, 8, and 10% OBBP-chocolate cookies as compared to the control, a decrease from 7.41 to 7.16%. However, no significant difference ($p > 0.05$) was observed between 8 and 10% OBBP-chocolate cookies mainly due to the lower protein content (5.21%) in OBPP as compared to wheat flour. Meanwhile, moisture content was also shown to significantly decrease from 2.58 to 2.32%, at 8 and 10% of OBPP-chocolate cookies. These results are in accordance with Chong and Noor Aziah (2008) who substituted green banana flour as partial replacement for wheat flour in doughnut. This is because cookies are known to have lower moisture content (< 5%) which resulted from high heat processing. Furthermore, high DF content in OBPP might absorb water which resulted in the decline of moisture content. According to Ho and Abdul Latif (2016), the amount of moisture content serves as an indicator of cookie quality. It is important to measure moisture content because of its marked effect on the texture, sensory, and shelf life of the final products. Thus, substitution of OBPP for wheat flour in cookies could produce shelf-stable and microbial-free product due to its lower moisture content.

Physical properties

The effect of OBPP incorporation on the physical properties of chocolate cookies is shown in Table 4. In terms of physical characteristics, the results demonstrated slight decrease in weight (6.40 to 6.32 g), diameter (50.43 to 50.20 mm) and spread ratio (16.81 to 16.73) as the level of OBPP increased, but there were no significant ($p > 0.05$) differences among all formulations. However, all chocolate

Table 4. Physical properties of chocolate cookies incorporated with OBPP.

Properties	**Control (0% OBPP)**	**6% OBPP**	**8% OBPP**	**10% OBPP**
Weight (W, g)	6.40 ± 0.04^a	6.34 ± 0.04^a	6.34 ± 0.03^a	6.32 ± 0.01^a
Diameter (D, mm)	50.43 ± 0.20^a	50.32 ± 0.02^a	50.28 ± 0.02^a	50.20 ± 0.03^a
Thickness (T, mm)	3.00 ± 0.00^a	3.00 ± 0.00^a	3.00 ± 0.00^a	3.00 ± 0.00^a
Spread ratio (D/T)	16.81 ± 0.07^a	16.77 ± 0.01^a	16.76 ± 0.01^a	16.73 ± 0.01^a
Firmness (kg)	1.05 ± 0.03^c	1.17 ± 0.03^b	1.23 ± 0.04^{ab}	1.28 ± 0.03^a
Crispiness (mm)	0.38 ± 0.04^a	0.37 ± 0.07^a	0.35 ± 0.02^a	0.34 ± 0.02^a

Data are means ± standard deviation of three replicates ($n = 3$). Means with different superscript letters within the same row indicate significant difference ($p < 0.05$).

cookies showed no changes in terms of thickness (3 mm). The observation was in line with the biscuits incorporated with increasing level of mango peel powder (Ajila *et al.,* 2008), citrus peel powder (Nassar *et al.,* 2008), and apple powder (Kohajdová *et al.,* 2014).

Firmness and crispiness are textural properties which attract attention in the evaluation of baked goods due to their connection with human perception of freshness (Pereira *et al.,* 2013). The incorporation of OBPP in chocolate cookies did not produce significant ($p > 0.05$) differences in crispiness which ranged from 0.34 to 0.38 mm. Previous study by Kohajdová *et al.* (2018) showed a similar trend when grape skin and seed flours were added into biscuit formulation.

Meanwhile, the firmness of the chocolate cookies was shown to increase with the level of OBPP, from 1.05 to 1.28 kg. This significantly ($p < 0.05$) increased in 6% OBPP-chocolate cookie as compared to the control, but no significant ($p > 0.05$) differences were observed between 6 and 8% as well as 8 and 10% OBPP-chocolate cookies. This result agrees with a study done by Varastegani *et al.* (2015) which claimed that the addition of papaya pulp flour as DF source increased the firmness of the cookie. The increase in firmness of chocolate cookie could be attributed to the decreasing moisture content (2.58 to 2.32%) when the level of OBPP increased. DF has high capacity for water absorption, causing the matrix to be hardened by interacting with the gelatinised starch thus making it less available for dough inflation during baking. Consequently, more compact structure and higher degree of firmness cookies are produced (Leiva-Valenzuela *et al.,* 2018).

Sensory acceptability

The development of fibre-enriched products with acceptable sensory characteristics is one of the challenges faced by the food industry in order to fulfil consumers' expectations. In the present work, cookies incorporated with OBPP were evaluated by 60 panellists for the selected sensory attributes as compared to the control chocolate cookie. The sensory scores for the chocolate cookies formulated with different levels of OBPP are shown in Table 5.

Generally, the scores for all attributes of all formulations ranged from 4.37 to 5.45 which can still be considered as acceptable values. A similar result was shown in a previous study by Ng *et al.* (2017) who replaced wheat flour with *Pleurotus sajor-caju* mushroom in cinnamon biscuits, thus obtaining scores from 4.33 to 5.48. Among all the chocolate cookies, chocolate cookie with 6% OBPP had the highest score for colour (5.18), appearance (4.73), and crispiness (5.45). There was no significant ($p > 0.05$) difference in comparison with the control. However, the scores significantly ($p < 0.05$) decreased in aroma, flavour, and overall acceptability when the level of OBPP increased from 6 to 10%, at 4.37, 4.45, and 4.48, respectively. This might be due to the stronger overripe banana flavour and aroma. The addition of a small amount of OBPP is believed to be able to enhance the aroma and flavour in comparison to the control. However, the incorporation of higher amount of OBPP will lead to undesirable results.

In terms of colour, appearance, and crispiness, the incorporation of OBPP could be increased up to 8% in chocolate cookie as there was no significant ($p > 0.05$) difference as compared to the control and 6% OBPP-chocolate cookie. Moreover, chocolate

Table 5. Sensory acceptability of chocolate cookies incorporated with OBPP.

Properties	Control (0% OBPP)	6% OBPP	8% OBPP	10% OBPP
Colour	5.02 ± 1.02^a	5.18 ± 1.08^a	5.05 ± 0.98^a	5.12 ± 0.90^a
Appearance	4.55 ± 1.21^a	4.73 ± 1.23^a	4.72 ± 1.11^a	4.57 ± 1.14^a
Aroma	4.92 ± 1.03^a	4.92 ± 1.09^a	4.93 ± 1.12^a	4.37 ± 1.07^b
Crispiness	5.38 ± 1.26^a	5.45 ± 1.02^a	5.38 ± 0.90^a	5.27 ± 1.16^a
Flavour	4.95 ± 1.06^a	5.07 ± 1.02^a	5.13 ± 0.89^a	4.45 ± 1.15^b
Overall Acceptance	4.98 ± 1.28^a	5.03 ± 1.02^a	5.10 ± 1.08^a	4.48 ± 0.98^b

Means with different superscript letters within the same row indicate significant difference ($p < 0.05$).

cookie with 8% OBPP scored the highest for aroma (4.93), flavour (5.13), and overall acceptance (5.10). The results obtained in the present work indicated that the incorporation of 8% of OBPP in replacement of wheat flour could be an effective way to produce a fibre-enriched chocolate cookie without affecting the desirable sensory properties.

Previous study revealed that the addition of banana flour to 7 - 10% in cookie was found to have the optimum sensory scores (Dhar *et al.,* 2013). A similar trend was also found by Kuchtová *et al.* (2018) which replaced different levels (0, 5, 10, and 15%) of grape skin and seed flours in cookie development. The incorporation of grape skin and seed flours up to 10% affected the texture, colour, appearance, taste, and overall acceptance of the cookie. These studies proved that higher amount of DF incorporated into bakery products decreased consumers' satisfaction.

Conclusion

The present work demonstrated that the incorporation of OBPP into chocolate cookies resulted in increased TDF content, ash content, and degree of firmness, but also resulted in decreased moisture, protein, and sensory attributes. Chocolate cookie with 10% OBPP recorded the highest nutrient contents, but the lowest scores in sensory attributes. This could be due to the original strong aroma and flavour of banana, as well as higher degree of firmness which caused low moisture content and high TDF content in chocolate cookie. In summary, the incorporation of OBPP up to 8% to partially replace wheat flour could be an effective way to improve the nutrient content, especially TDF content in cookie with acceptable physical and sensory properties.

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