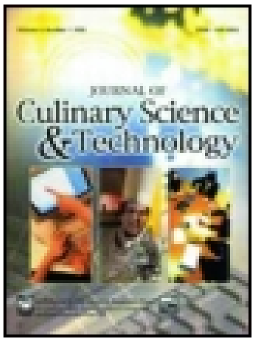

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ABSTRACT

Using byproducts from the food industry to produce healthy and sustainable food was an integral component of the sustainable development goals. This research was aimed to assess the effect of substituting wheat flour with nutrient-rich green soybean okara (GSBO) flour on the quality and nutritional values of butter cake. The result showed that the GSBO-substituted flour had significantly ($p \leq 0.05$) higher water and oil absorption capacities, higher protein, fiber and total phenolic content (TPC), and more favorable sensory characteristics compared to wheat flour. Specifically, 20% GSBO butter cake contained significantly ($p \leq 0.05$) highest amounts of protein, fiber, TPC, and scores of all sensory characteristics. In conclusion, substitution of up to 20% GSBO to wheat flour could improve the nutritional quality of butter cake. Application of GSBO flour in butter cake contributes to the sustainable goal of achieving zero waste and development of a plant protein-based product in sustainable healthy diet.

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Butter cake; green soybean; wheat flour substitution; phenolic content; antioxidant

Introduction

Green soybean (*Glycine max* L.) is an important legume for human nutrition in tropical and subtropical regions. Green soybean is highly nutritious and has been shown to benefit growth, energy metabolism, immunity, heart health and digestive health. Due to its high protein content, green soybean is often used as a supplement in cereal-based diet (Abiola, Akinyode, & Folami, 2019). Supplementation of cereals with protein-rich legumes has been used to prevent protein-calorie malnutrition in the developing world (Karri & Nalluri, 2017; Wolfe, Cifelli, Kostas, & Kim, 2017).

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Green soybean okara (GSBO) is pulpy waste with low economic value that is produced during green soybean milk processing. In Thailand, it was reported that about 80 tons of GSBO were generated on an annual basis as a result of green soybean beverage production (Lanna Agro Industry Co.,Ltd.). The waste of GSBO was just sold to farmer for use as animal feeds in the low price of 3 Thai Baht per kg. Since GSBO contains fiber and bioactive compounds, reuse of GSBO as a functional ingredient is a potential strategy for not only reducing waste treatment cost but also creating new value-added products. There is potential to reduce food loss and waste by creating value-added which is an important goal of the 2030 Agenda for a key goal of the Sustainable Development Goals (SDG target 12.3 on food loss and waste). Noncommunicable diseases (NCDs) have become the primary health concern for most countries around the world, as well as the current COVID-19 pandemic. Many people attempted to eat a healthier diet that is rich in legume, fruit, and vegetables (Borsellino, Kaliji, & Schimmenti, 2020). Health awareness may increase demand for healthier baked products. Several researchers reported using food by-products to increase fiber content in baked foods (Sodchit, Tochampa, Kongbangkerd, & Singanusong, 2013). One common type of bakery is butter cake, which is made from butter, wheat flour, eggs, sugar, leavening agents, etc. Like other bakery products, butter cake is high in fat and carbohydrate and low in fiber, protein and minerals. Nowadays, cakes are consumed more frequently, and the volume sales of cakes have been growing substantially with a market share of 44%. These types of baked product are likely to be consumed as regular snacks, contributing to the increase in fat and sugar intake (Hashem, He, Alderton, & MacGregor, 2018). Previous studies enhanced the nutritional quality of butter cake by utilizing different types of composite flour such as pigeon pea flour (Uchegbu, 2016), mushroom powder (Arora, Kamal, & Sharma, 2017), sweet potato flour and beetroot flour (Nagib & Zidan, 2019). The optimum level of substitution of GSBO flour for wheat flour may create a new developed butter cake product with antioxidant enrichment and help to improve nutritional values by increase in crude fiber and protein content. Therefore, the objective of this research is to determine an optimal level of GSBO flour substitution that enhances the physico-chemical and nutritional quality of butter cake and to evaluate its organoleptic property using a 9-point hedonic scale.

Materials and methods

Materials

By-products of green soybean milk processing was obtained from Lanna Agro Industry Co., Ltd. (Chiang Mai, Thailand). The residue was kept in plastic bags and stored at −10°C until further use. The other ingredients of butter cake were wheat flour (Thai Flour Mill, Thailand), milk powder (Cottage Farm YOK intertrade, Thailand), double acting baking powder (Unilever Food Solutions, Thailand), surface perfectant (UFM, Thailand), evaporated milk (Falcon, Thailand), syrup (Lin, Thailand), salt (Prung Thip, Thailand), sugar (Mitr Phol, Thailand), butter (UDF, Thailand), soybean oil (Angoon, Thailand) and eggs (local stores in Chiang Mai, Thailand).

Preparation of GSBO flour

GSBO samples were thawed in a refrigerator for at least 24 h. Then, 1 kg of the samples were spread on a drying tray (460 × 660 mm) and dried in an electric convection dryer (BSR-40, Kluaynamthai, Thailand) at 70°C for 8 h until its moisture content was less than 7%. The dried residue was ground into powder by using a blender (HR 2071, Philips, Netherlands). The flour was then sieved twice through a 50-mesh screen with particle size 300 μm. The GSBO flour was stored in vacuum plastic bags in a freezer for baking and analysis of proximate composition, total phenolic content (TPC) and water and oil absorption capacities.

Processing of green soybean butter cake

Green soybean butter cake was prepared by substituting wheat flour with GSBO flour at the following proportions: 0% (1), 20% (2), 30% (3), 40% (4) and 50% (5). The wheat – GSBO flour blend was mixed with other ingredients shown in Table 1 using a standard protocol. First, 150 g of flour, 5 g of double-acting baking powder and 10 g of powdered milk were sifted and set aside. Second, 125 g of salted butter and 50 g of sugar were hand-whipped together in a bowl. In another mixing bowl, three eggs, 50 g of evaporated milk, 45 g of syrup, 7.5 g of surface perfectant, 2.8 g of salt, and 22.5 g of water were combined using a stand mixer at the lowest speed for 1 min (DN677, KitchenAid, USA). Third, dry and wet ingredients were combined and

Table 1. Formulation of wheat – green soybean okara batter.

Mixture	(1)	(2)	(3)	(4)	(5)
wheat flour (g)	150	120	105	90	75
gsbo flour (g)	0	30	45	60	75
powdered milk (g)	10	10	10	10	10
double acting baking powder (g)	5	5	5	5	5
salted butter (g)	125	125	125	125	125
eggs	3	3	3	3	3
sugar (g)	50	50	50	50	50
evaporated milk (g)	50	50	50	50	50
syrup(g)	45	45	45	45	45
surface perfectant (g)	7.5	7.5	7.5	7.5	7.5
salt(g)	2.8	2.8	2.8	2.8	2.8
water(g)	22.5	22.5	22.5	22.5	22.5

mixed at the highest speed for 5 min and the lowest speed for another 2 min. The creamed butter and sugar were then gently added and folded in until the mixture became smooth. Finally, the batter was poured into a mold and put in a preheated oven (OUYH-503, Jintan Medical Instrument Factory, China) at 180°C for 40 min. Green soybean butter cake was stored in a refrigerator at 10°C for up to 1 days for sensory evaluation, proximate composition, TPC, color, texture, and nutritional value analysis.

Proximate composition analysis of flour and butter cake

Moisture was determined using the National Forage Testing Association method (no. 2.1.4). The Association of Official Analytical Chemists (AOAC) methods were used to quantify amounts of crude fat (no. 2003.06), protein (no. 990.03), fiber (no. 2002.04) and ash (no. 942.05) (AOAC, 2005). Total carbohydrate was calculated by difference as 100 – (% moisture + % ash + % crude fat + % crude protein). Results were expressed as g/100 g dry matter.

Determination of TPC

Analysis of TPC was performed according to Maisuthisakul, Suttajit, and Pongsawatmanit (2007) as follows: a sample of flour or cake weighing 3 g was mixed with 12 mL of 80% (v/v) ethanol (RCI Labscan, Thailand) and vortexed for 1 min. The mixture was separated by centrifugation (Hermle Z206A, Hermle, Germany) at 3000 × g at 4°C for 20 min, and the supernatant was collected. The TPC of sample was determined by the Folin-Ciocalteu method. Briefly, one mL of crude extract was diluted 10 folds with distilled water. The diluted extract (1 mL) was dissolved in 2.5 mL of 10% (v/v) Folin-Ciocalteu reagent (Sigma-Aldrich, Germany) for 8 min at ambient temperature, followed by the addition of 2 mL of 7.5% (w/v) sodium carbonate (Merck, Germany). The mixture was kept for 2 h in the dark, and the absorbance was measured at 765 nm by using a spectrophotometer (10S UV-Vis, Genesys, USA). The TPC was calculated from a standard curve of gallic acid (Sigma-Aldrich, Germany; 2–12 μg/mL; $y = 0.099\ x - 0.0086$ ($R^2 = 0.995$)) and expressed as μg gallic acid equivalent per gram of dry weight (μg GAE/g DW).

Water and oil absorption capacities of wheat and GSBO flour

Water absorption capacity of wheat flour and GSBO flour was determined by the method of Akubor and Badifu (2004). Specifically, 1 g of flour samples was mixed with 10 mL of either distilled water or soybean oil in two separate centrifuge tubes. The solution was mixed thoroughly for a min and allowed to stand at ambient temperature (30 ± 2°C) for an hour. Then, the mixtures were centrifuged at 2000 × g for 30 min (Hermle Z206A, Hermle, Germany). The volume of the supernatant was noted in a 10 mL graduated cylinder. The water absorption and oil absorption were calculated as the difference between the initial volume of water added to the sample and the volume of the supernatant and examined as percent water-bound per gram of flour and percent oil-bound per gram of flour, respectively.

Sensory evaluation

Color, aroma, texture, taste and overall acceptability of green soybean butter cake were evaluated by 55 untrained panelists who were students and staff of the Faculty of Agro-Industry, Chiang Mai University, Thailand. The panelists evaluated the cake samples labeled with 3-digit random number codes on a 9-point Hedonic scale. Formulation with the highest score was then selected for comparison with the butter cake control (formula 1) in physical and chemical property analysis.

Physical property analysis of butter cake

Color measurement

Butter cake sample of 1.0 cm thickness was removed from surface and the piece of size 6.0 cm × 6.0 cm × 2.0 cm was taken from the center of the cake. The butter cake color was measured in triplicates by using a colorimeter (CR-410, Konica Minolta, Japan), and the average of the three readings was recorded for each of the formulation. The results were expressed on the $L^*a^*b^*$ color scale. L^* indicates lightness, 0–100 with 0 indicating black and 100 indicating white. a^* corresponds to red (positive values) and green (negative values) while b^* corresponds to yellow (positive values) and blue (negative values).

Texture analysis

Texture analysis was determined by using a texture analyzer (TA-XT plus 10,207, Stable Micro Systems, UK). In a double compression test (texture profile analysis), an aluminum cylindrical probe (25-mm diameter) was used with a compression up to 50% depth at 2 mm/s speed and 30 s delay between the first and the second compression. Hardness (N) and springiness were calculated using a texture profile analysis program. The tested cake samples were sliced into 20-mm thick pieces and measured in triplicates.

The nutritional profile of green soybean butter cake and “a source of protein and vitamin A” claim

Nutritional analysis and labeling of green soybean butter cake were performed by ALS Laboratory Group (Thailand) Co., Ltd. Claim consideration of the product as a source of protein and vitamin A was determined per 50-g serving size based on the average the Thai Dietary Reference Intakes (recommended dietary allowances and adequate intakes of energy and selected nutrients) for adults aged 19–50 years. To be considered "a source of protein and vitamin A," a product must contain 52–57 g of protein and 600–700 ug RAE of vitamin A (Ivanovitch, Klaewkla, Chongsuwat, Viwatwongkasem, & Kitvorapat, 2014).

Statistical analysis

All experiments were carried out in triplicates, and significant difference ($p \leq 0.05$) between sample means were determined using T-test (for wheat vs. GSBO flour and for control vs 20% GSBO cake) and one-way analysis of variance with Duncan's Multiple Range Test multiple hypothesis correction (for % GSBO replacement) within the SPSS 20.0 statistical program (SPSS Inc., Chicago, IL, USA). Results were expressed as mean ± standard deviation.

Results and discussion

Proximate composition and TPC comparison between GSBO and wheat flour

The amount of carbohydrate, the major constituent of GSBO flour, was significantly lower than that of wheat flour (Table 2). The GSBO flour also contained a larger proportion of ash compared to wheat flour. The proportion of ash in GSBO flour (4.27%) was relatively high compared to other flour such as chickpea flour (2.79%) and dried green pea flour (2.74%) (Wani & Kumar, 2014). Moreover, the GSBO flour contained 4-time higher ash proportion than wheat flour ash content reported in a study of David, Arthur, Kwadwo, Badu, and Sakyi (2015). The protein content of the GSBO flour was 28.67 ± 0.15% which was twice as much as wheat flour (14.34 ± 0.10%). Approximately 44% of protein in green soybean is essential amino acids (Abiola et al., 2019). Abdelghany et al. (2020) also reported that cooked green soybean contained significantly higher content of serine and tyrosine compared to raw samples. The crude fiber content of the GSBO flour was 7.84 ± 0.14%, which was in line with that of raw and dried green soybean flour (7.29–8.02%) reported by Onimawo and Akpojovwo (2006). The relatively high crude fiber content of

Table 2. Proximate composition and tpc of wheat and gsbo flour.

Flour quality	Wheat flour	GSBO flour
carbohydrate (%)	84.87 ± 0.80^a	50.95 ± 0.20^b
protein (%)	14.34 ± 0.10^b	28.67 ± 0.15^a
fat (%)	0.76 ± 0.002^b	11.37 ± 0.09^a
fiber (%)	1.25 ± 0.03^b	7.84 ± 0.14^a
ash (%)	0.87 ± 0.08^b	4.27 ± 0.17^a
moisture content (%)	11.56 ± 0.16^a	4.74 ± 0.12^b
tpc (µg gae/g dw)	116.63 ± 1.52^b	163.23 ± 0.81^a

Mean values ± standard deviation followed by a different lower-case letter within the same row were significantly different ($p \leq 0.05$).

the GSBO flour was likely due to more cell wall-associated polysaccharides. Crude fiber plays a beneficial role in the prevention of heart diseases, colon cancer and diabetes (Odunlade et al., 2017) by reduction of blood cholesterol and decrease of glucose absorption at the small intestine (Sibian & Piar, 2020). Despite its high fiber and protein contents, it is worth noting that GSBO flour had higher fat content than wheat flour, because green soybean contains 15% to 20% oil on average with palmitic, stearic, oleic, linoleic and α-linolenic being major fatty acids (Abdelghany et al., 2020). The moisture content of GSBO flour was 4.74 ± 0.12% which is within the acceptable limit of not more than 10% for storage stability and longer shelf life (Ahmed, 2015). Taken together, our preliminary investigation indicated that GSBO flour was a rich source of protein and crude fiber compared to wheat flour.

In addition, green soybean was studied as one of the natural sources of polyphenols with antioxidant capacity (Gan et al., 2016). The TPC of GSBO flour used in this study was 163.23 ± 0.81 µg GAE/g DW, which was significantly higher than that of wheat flour control. Our finding suggested that legumes offered greater levels of polyphenols compared to wheat. However, the TPC of the GSBO flour was relatively low compared to 9.44 mg GAE/g DW of whole green soybean seeds (Rani, Poswal, Yadav, & Deen, 2014). This might be due to the characteristics of the GSBO flour as residues of thermal processing, which resulted in lowered phenolic content and poorer antioxidant property of the flour.

Water and oil absorption capacities of wheat flour and GSBO flour

GSBO flour showed significantly ($p \leq 0.05$) higher water and oil absorption capacities (54.89 ± 0.82% and 14.35 ± 0.21% respectively) than wheat flour (17.66 ± 0.63% and 11.81 ± 0.46% respectively). Protein in legumes has both hydrophilic and hydrophobic properties, thus allowing interaction with both water and oil (Oyewole, Abu, & Enujiugha, 2017). The higher water absorption capacity of GSBO flour might be due to more availability of polar amino acids which increase the probability of water binding and contribute to solubility characteristics and surfactant properties of protein. Abdelghany et al. (2020) found that hydrophilic amino acids serine and tyrosine were abundant in green soybean. In addition to being influenced by protein content, water absorption capacity was also influenced by carbohydrate content, which included dietary fiber and starch. Dietary fiber could absorb water (Itthivadhanapong & Sangnark, 2016). GSBO flour had higher crude fiber content compare to wheat flour by approximately 84.06% by dry basis. Therefore, the higher total fiber present of GSBO flour might help to increase the water absorption. High water absorption capacity of flour is desirable in bakery products that require soft texture and consistent dough. A plausible mechanism of oil absorption for the GSBO flour is the physical entrapment of oil through the binding of fats to the nonpolar chain of the protein (Nakai & Li-Chan, 2018). The oil absorption capacity of flour improves mouth feel and retains flavors. Therefore, green soybean flour substitution may improve characteristics of wheat flour-based bakery (Hasan, Vajiha Aafrin, & Antony, 2015).

Effect of substitution levels of wheat flour with GSBO flour on the sensory quality of butter cake

Four GSBO-substituted butter cake samples and one wheat-flour control cake sample were evaluated. The preference scores of different sensory parameters of the samples were presented in Table 3. The appearance of the butter cake samples was shown in Figure 1. There was no significant difference between the control sample (0%) and 20% or 30% substituted green soybean butter cake in color, aroma, taste, texture and overall acceptability. 40% GSBO flour cake sample had lower ratings on taste, texture and overall acceptability than 20% GSBO-substituted sample. 50% GSBO flour replacement level received the lowest rating in all attributes and was rated significantly lower in color and aroma than the others. Additionally, panelists detected the characteristic odor of the GSBO flour and slight rancidity in 40% and 50% GSBO-substituted samples. It was concluded that 20% was the highest substitution level that showed no significant difference in sensory evaluation from 100% wheat flour butter cake and was chosen for further analysis.

Chemical property of butter cake

The proximate composition and TPC of 20% GSBO-substituted vs. control butter cake were shown in Table 4. The GSBO butter cake significantly differed from the control in all compositional measures except fat and moisture content. Specifically, crude protein and crude fiber content of the 20% GSBO-substituted cake was 6.78 ± 0.03% and 2.35 ± 0.05% respectively, which was significantly higher than that of the control cake (5.86 ± 0.10% and 1.29 ± 0.11%, respectively). Additionally, the amount of carbohydrate was lower in the green soybean butter cake. These results indicated a better nutrient profile

Table 3. Sensory evaluation of green soybean butter cake in hedonic scale.

	Replacement levels (% GSBO flour)				
Sensory characteristics	0%	20%	30%	40%	50%
color	7.16 ± 1.3^{a}	6.98 ± 1.3^{a}	6.95 ± 1.3^{a}	6.64 ± 1.4^{a}	5.85 ± 1.4^{b}
aroma	6.60 ± 1.2^{a}	6.62 ± 1.4^{a}	6.60 ± 1.3^{a}	6.55 ± 1.2^{a}	6.00 ± 1.3^{b}
taste	6.75 ± 1.5^{ab}	7.02 ± 1.2^{a}	6.53 ± 1.4^{abc}	6.35 ± 1.2^{bc}	6.07 ± 1.4^{c}
texture	6.75 ± 1.4^{ab}	7.16 ± 1.2^{a}	6.65 ± 1.3^{b}	6.42 ± 1.2^{bc}	6.07 ± 1.3^{c}
overall acceptability	6.96 ± 1.2^{ab}	7.31 ± 1.2^{a}	6.84 ± 1.2^{b}	6.53 ± 1.1^{bc}	6.22 ± 1.3^{c}

Mean values ± standard deviation followed by a different lower-case letter within the same row were significantly different ($p \leq 0.05$) by duncan's multiple range test.

Figure 1. Butter cakes from 0%, 20%, 30%, 40% and 50% of GSBO flour on the left to the right.

of the green soybean butter cake over normal butter cake. Protein not only provides essential amino acids but also plays an important role in the structure and texture of cake (Perera, 2010). Fiber improves digestive health by preventing constipation. Fiber helps bulk up the feces material and aid its movement through the digestive system. Moreover, soluble fiber in foods, such as nuts, seeds, beans, lentils, peas, and some fruits and vegetables, acts to slow transit of food materials through the small intestine and enhances nutrient absorption (Barber, Kabisch, Pfeiffer, & Weickert, 2020). Fiber has also been associated with decreased risks of colon cancer and heart disease (Anderson et al., 2009). The ash content of green soybean butter cake was also higher than the control, suggesting that the GSBO-substituted butter cake contained more minerals than normal butter cake. Notably, there was no statistical difference in moisture and crude fat content between 20% GSBO flour butter cake and the control, even though GSBO flour exhibited higher water and oil absorption capacities than wheat flour. These results were desirable from a manufacturer's standpoint, because higher moisture content poses complications in the preservation, storage, packaging and shipping of food products (Mauer & Bradley, 2017), while oxidation of fat causes rancidity (Velasco, Dobarganes, & Márquez-Ruiz, 2010). In addition, the green soybean butter cake had significantly higher TPC (92.53 ± 1.76 µg GAE/g DW) compared to the control (63.7 ± 0.47 µgGAE/g DW).

Physical property of butter cake

The color of green soybean butter cake was dependent on the ratio of GSBO flour to wheat flour. Using International Commission on Illumination (CIE) L* a* b* color scale, it was found that green soybean butter cake was darker than the control cake (L* = 73.83 ± 0.64 vs. 75.86 ± 1.22). The darker color of green soybean butter cake might be attributed to the interaction of protein and sugar during baking resulting in a higher degree of Maillard reaction. Previous studies reported that a higher protein content in GSBO flour was negatively correlated with lightness of cookies, indicating that the Maillard reaction played a significant role in color formation (Ostermann-Porcel, Quiroga-Panelo, Rinaldoni, & Campderrós, 2017). Saentaweesuk and Santea (2014) also observed that the more soybean okara

Table 4. Instrumental evaluation of green soybean butter cake quality.

	Butter Cakes	
Green Soybean Butter Cake Quality	Control	20% GSBO flour
crude protein (%)	5.86 ± 0.10[b]	6.78 ± 0.03[a]
crude fiber (%)	1.29 ± 0.11[b]	2.35 ± 0.05[a]
crude fat (%)	28.28 ± 0.39[a]	29.65 ± 0.84[a]
ash (%)	2.83 ± 0.05[b]	3.70 ± 0.17[a]
carbohydrate (%)	28.78 ± 0.17[a]	25.06 ± 0.14[b]
moisture content (%)	34.26 ± 0.25[a]	34.81 ± 0.22[a]
tpc (μg gae/g dw)	63.70 ± 0.47[b]	92.53 ± 1.76[a]
l* value	75.86 ± 1.22[a]	73.83 ± 0.64[b]
a* value	0.44 ± 0.12[a]	−1.23 ± 0.11[b]
b* value	32.12 ± 0.22[a]	31.50 ± 1.11[a]
firmness(g)	4189.23 ± 2.86[a]	3396.30 ± 3.29[b]
springiness	0.58 ± 0.01[a]	0.54 ± 0.01[b]

Mean values ± standard deviation values followed by a different lower-case letter within the same row were significantly different (p ≤ 0.05) by duncan's multiple range test.

was used in butter cake, the darker it became. In addition, as a result of chlorophyll pigments in GSBO flour, the a* value of green soybean butter cake was negative (−1.23 ± 0.11) while the control had a positive a* value (0.44 ± 0.12). The b* values was positive and did not differ between samples ($p > .05$), which indicated yellow color of the cake. The yellow color of the GSBO flour was partly derived from green soybean isoflavone (Lian, Luo, Gong, Zhang, & Serventi, 2020), but this appeared to have little effects on the samples.

Textural analysis results showed that the GSBO-substituted butter cake was more fragile than the control cake (Table 4). Higher water and oil absorption capacities of the GSBO flour may cause water vapor to be trapped, resulting in larger pores, higher specific volume and subsequently softer crumb texture (Jahanbakhshi & Ansari, 2020). The use of 20% GSBO flour in cake could enhance its water and oil absorption and resulting in a softer crumb texture. Enriching cake with dietary fiber also causes the lower specific volume and crumb firmness. As for the springiness, the 20% GSBO flour was less springy/elastic than the wheat control cake potentially because the green soybean cake might have had lower gluten content thus reducing the ability to form a continuous network (Xu, Zhang, Guo, & Qian, 2012). This was also supported by the fact that gluten played important role in producing internal texture of cake.

Nutrition discussion

Green soybean butter cake provided both macronutrients and micronutrients and appreciable amounts of protein, vitamin A, and calcium (7.77 g, 12.6 μg RE, and 66.5 mg respectively per 100 g) (Table 5). Vitamin A and carotenoids were major antioxidants in green soybean aside from phenolic compounds. Moreover, GSBO flour had lower total carbohydrate and higher fiber, protein, and fat content than wheat flour. When the GSBO flour was used to make 20%

Table 5. Nutritional values of a serving 50 g of 20% gsbo flour butter cake.

Nutrient	Per 100 g	Per serving 1/20 piece (50 g)
calories (kilocalories)	345	170
calories from fat (kilocalories)	176	90
total fats (g)	19.5	10
protein (g)	7.77	4
total carbohydrates, include dietary fiber (g)	34.7	17
dietary fibers (g)	2.92	1.4
vitamin a (beta-carotene) (μg re)	12.6	6.30
vitamin b1 (mg)	0.02	0.01
vitamin b2 (mg)	0.10	0.05
calcium (mg)	66.5	33.2
iron (mg)	0.92	0.46
ash (g)	1.07	-
moisture (g)	37.0	-

GSBO-substituted butter cake, these favorable results persisted with no difference in fat content from normal butter cake. Although the amounts of nutrients per serving size were not large enough to make substantiated claims, the developed product was overall healthier compared to a typical butter cake. For example, the product contained 2.92 g of dietary fiber per 100 g serving and would help a person reach his/her daily fiber intake goal when consumed together with other fiber-rich food. Dietary fiber plays an important role in the prevention of several chronic diseases by reducing or controlling plasma cholesterol and triacylglycerol levels and promoting overall health (Ostermann-Porcel et al., 2017). Additionally, GSBO protein is consisted of essential amino acids such as glutamic acid, aspartic acid, arginine and leucine (Li et al., 2020). Therefore, GSBO is a source of nutritious plant-based protein that can be used in functional food.

Conclusions

Green soybean okara is a food byproduct that contains many beneficial components. The study findings indicate that butter cake made from 20% GSBO flour has higher levels of protein, fiber and TPC compared to normal butter cake. The GSBO flour also has higher water and oil absorption capacities than wheat flour which might favorably affect the texture, functional and sensory properties of butter cake. Substituting 20% of wheat flour with GSBO flour in butter cake achieves the highest liking scores in sensory evaluation. The nutritional values of the green soybean butter cake suggest that the product is a healthier alternative to typical butter cake. Therefore, GSBO flour could be considered as a potential functional ingredient for the development of value-added food products. Further research is needed to improve the stability of GSBO flour and assess texture quality and shelf-life of GSBO butter cake.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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