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Incorporation of *Pleurotus sajor-caju* powder in cinnamon biscuit: study on nutritional, physical, colour and sensorial properties

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Abstract

Discovery of novel dietary fibre (DF)-rich food ingredient is of great interest to meet the rising consumer demand for healthy food. Intake of DF-enriched food has been positively associated with a decreased risk of chronic diseases. *Pleurotus sajor-caju* (PSC), one of the prominent edible mushrooms widely cultivated in Malaysia, is useful for its culinary and medicinal purpose. This study aimed to determine the nutritional, physical, colour and sensorial properties of cinnamon biscuit formulated with PSC powder as partial replacement (0, 4, 8 and 12%) for wheat flour. Results indicated that elevated incorporation levels of PSC powder significantly ($P<0.05$) increased nutritional values of cinnamon biscuits; with 12% PSC cinnamon biscuit recorded the highest DF (9.84%), protein (7.85%) and ash (1.00%) content. In texture profile analyses, slight increment in firmness and reduction in crispiness of the cinnamon biscuits were detected with increasing levels of PSC powder. PSC-enriched cinnamon biscuits were reported to have lower L^* value (ranged from 65.49 to 69.25) compared to control cinnamon biscuit (70.84), indicating darker surface colour. In comparison to control cinnamon biscuit, incorporation of PSC powder up to 8% produced higher scores in term of aroma, colour and appearance. In summary, incorporation of 8% PSC powder could be an effective way to develop nutritious cinnamon biscuit without jeopardizing its desirable physical and sensorial properties.

Introduction

Presently, the incidences of chronic diseases are undoubtedly increasing at an alarming rate and becoming a major public health issue all over the world including Malaysia. Chronic diseases such as stroke, heart disease, cancer and diabetes are preventable diseases of long duration and generally slow progression (WHO, 2011). Total deaths are assumed to increase by 17% over the next ten years and thus by far one of the leading causes of mortality worldwide (Habib and Saha, 2011).

Dietary fibre (DF) is defined as “the edible constituent of analogous carbohydrates or plants which is resistant to digestion and absorption in the human small intestine, with partial or complete fermentation in the large intestine” (AACC, 2001; Westenbrink et al., 2013). Wide range of scientific researches agrees that DF is positively associated with a decreased risk of chronic diseases. Previous studies have demonstrated that increased intake of DF can bring beneficial effects against cardiovascular diseases, diabetes, certain cancer especially colon cancer and constipation (Bosaeus, 2004; Kaczmarczyk *et al.*, 2012). Therefore, DF is collectively recognised to be one of the important components in a health-promoting diet.

In the recent decades, consumer awareness to consume DF-enriched food products has been increased to improve their health status and quality of life. In order to meet the rising consumer demands for DF-rich foods, improvement of food product quality is continuously encountered in food industry (Ballali and Lanciai, 2012) and thus resulted in emerging of various health promoting products in the market. Traditionally, sources used to improve DF content of foods are come from cereals such as oat, wheat and corns (McKee and Latner, 2000). Nowadays, *Pleurotus sajor-caju* (PSC) or universally known as oyster mushroom is acknowledged to be one of the most important sources of DF (Wan Rosli and Aishah, 2012; Kanagasabapathy *et al.*, 2013).

PSC is one of the prominent edible mushrooms widely available in Malaysia and artificially cultivated on various agricultural residues (Asghar *et al.*, 2007). Its feature can be observed by the white spore print, attachment of gills and usually eccentric stip (Miles and Chang, 1997). Its favourable taste

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Table 1. The raw ingredients used and incorporation level (%) of PSC powder in making PSC-incorporated cinnamon biscuit

Items	Ingredients	Quantities (g)			
		0% PSC (control)	4% PSC	8% PSC	12% PSC
1	Butter	140	140	140	140
2	Icing sugar	86.4	86.4	86.4	86.4
3	Beaten egg white	20	20	20	20
4	Vanilla essence	2	2	2	2
5	Sifted wheat flour	270	259.2	248.4	237.6
6	Corn flour	50	50	50	50
7	Baking powder	2	2	2	2
8	Softener	2	2	2	2
9	CP	3.6	3.6	3.6	3.6
10	PSC powder	0	10.8	21.6	32.4
	Total	576	576	576	576

and pharmacological properties such as anti-cancer properties, blood cholesterol and glucose level lowering effects as well as improvement of antioxidant and immune-modulatory activities (Shah *et al*., 2007; Ng *et al*., 2015) have received a great deal of attention from researchers.

According to outcome from Malaysian Adult Nutrition Survey (MANS), biscuit is one of the most popular daily consumed foods among Malaysians (Norimah *et al*., 2008). Currently, research has been conducted on the use of PSC powder as source of DF in wheat-based and meat products (Wan Rosli and Solihah, 2012; Aishah and Wan Rosli, 2013). However, there is lack of PSC powder application in bakery products such as biscuit. In 2014, Ng and Wan Rosli have identified the incorporation of cinnamon powder at 4% to partially replace sugar in biscuit was the optimum acceptance level to reduce sucrose content. In this context, the development of cinnamon biscuit formulated with different levels of PSC powder as partial replacement for wheat flour with the purpose of further enhancing its nutritional vales especially DF without affecting its physical, colour and sensory properties was studied.

Materials and Methods

Experimental Design

There were control sample and three experimental samples. The control sample was the cinnamon biscuit without incorporation of PSC powder whilst the experimental samples were the cinnamon biscuits formulated with 4, 8 and 12% PSC powder to partially replace wheat flour. This study compared the control cinnamon biscuit and PSC powder-formulated cinnamon biscuits in terms of the nutritional values, physical characteristics, textural properties, colour parameters as well as sensory acceptability. There were four independent variables: 0, 4, 8 and 12% PSC cinnamon biscuit.

Preparation of PSC

Dried PSC was purchased from Anjaad Industries (M) Sdn. Bhd., Malacca Town, Malacca, Malaysia. Fresh PSC was dried (yield: 10% w/w) using a low-heat air dried technique (50–55°C) established by the industry. The dehydrated PSC was milled into powder using an electric blender (Waring Commercial 8010S, USA) and then sifted into fine powder (125 µm in diameter) using a sieve. The obtained PSC powder was placed in polyethylene bags, heat-sealed and stored at 4°C until further use.

Development of biscuit

In order to reduce sucrose content and increase DF content of biscuit, incorporation of 4% cinnamon powder (CP) as icing sugar replacer has been identified as the best formulation in previous study reported by Ng and Wan Rosli (2014). Hence, the biscuit formulated with 4% CP was used throughout this study.

Several commercially available raw ingredients such as butter, icing sugar (sucrose), egg white, wheat flour, corn flour and baking powder were used to develop biscuit. PSC powder was used to partially replace wheat flour at the level of 4, 8 and 12% (Table 1). The recipe has been slightly modified from Brown (2008). In a mixing bowl, butter, egg white and icing sugar were mixed together and beaten by using an electric hand mixer (National Inc., Osaka, Japan) until a creamy texture was achieved. After the other dry ingredients were added to them, the dough was beaten again for 5 min to obtain the desired dough. The dough was sheeted to around 5 mm in thickness on a flat surface and formed into a round shape that was 3 cm in diameter. Next, they were put on lightly greased baking sheet before baked in an oven (Zanussi ZCG841W, England) at 180˚C for 14 min. Next, the biscuits were cooled at room temperature for 1 hr. For nutritional analyses, biscuits were ground into powder form and placed in screw cap bottle at 4°C until further use.

Nutritional analysis

Proximate analysis for PSC powder and PSC-enriched cinnamon biscuit were conducted using AOAC (1996a) for moisture, total ash, crude protein and crude fat content. Carbohydrate (CHO) was calculated by the difference: Total CHO = 100 – (g of moisture + protein + fat + ash) (Charrondiere *et al*., 2004). Total DF (TDF) was determined based on the AOAC (1996b) that was applying enzymatic gravimetric method.

Physical evaluation

Physical characteristics of biscuit were determined following to the method adapted from (Saha *et al*., 2011) with some modifications. After the biscuits were cooled to room temperature, ten pieces of biscuits for each formulation were weighted (W) using analytical balance (Mettler-Toledo Dragon 204, Switzerland) and the mean value (g) was obtained. The biscuit diameter (D) was measured by placing 10 pieces of biscuits side-to-side. Ten pieces of biscuits were also stacked one above the other to measure the biscuit thickness (T). Measurements were shown in mm as the mean value of mm/10. The spread ratio of the biscuits was determined by calculating the ratio of the diameter (D) to thickness (T). All measurement was repeatedly taken by rearranging the biscuits to obtain accuracy.

Other than that, texture profile analyses (TPA) of biscuits formulated with different levels of PSC powder was done by utilising a Texture Analyser TA.XTplus (Stable Micro Systems, Surrey, UK). The texture analyzer with a 3D extensibility method was coupled with Texture Exponent Software. Pieces of biscuits (around 35 mm in diameter and 5 mm in thickness) were placed on base of the heavy duty platform. After that, the instrument was equipped with a 3-point bend rig, and the operating settings were pre-test speed (1.0mm/s), test speed (3.0mm/s), post-test speed (10.0mm/s), distance between probe and biscuit (10mm), compression distance (3mm), trigger force (50g) and option (return to start). The firmness (kg) and crispiness (mm) attributes of biscuits were calculated from the curves.

Colour properties

Colorimetric measurements of biscuit (around 10 g) were determined by utilising a Colorimeter (Minolta Model 3500, Minolta Camera Co., Ltd., Osaka, Japan). The equipment was calibrated by using white calibration plate (CM-A124) and zero calibration box (CM-A124). CIELab coordinates including lightness (L^*), redness to greenness (a^*) and yellowness to blueness (b^*) were studied.

Sensory evaluation

Sensory evaluation of PSC-enriched cinnamon biscuit was carried out by 60 untrained panels consisting of staffs and students of the School of Health Sciences, Universiti Sains Malaysia. Panels received four different formulations of PSC-incorporated cinnamon biscuits for sensory test. The samples were coded with 3 digits permuted number and evaluated according to the 7-hedonic scaling method outlined by Aminah (2000). Sensory parameters including aroma, colour, appearance, crispiness, flavour and overall acceptance were assessed on a 7 point scale (1 = dislike the most; 7 = like the most).

Data analysis

All data were subjected to one-way repeated measure analysis of variance (ANOVA) followed by Bonferroni's multiple comparisons test to compare mean differences among the samples. Data analysis was done using GraphPad Prism version 6.0 for windows (GraphPad Software, San Diego California USA). Results were expressed as mean ± standard deviation (SD). All measurements were conducted in triplicate (n=3) except TDF analysis. The experiments were repeated three times. All test were two-tailed and significance level was established at $P<0.05$.

Results and Discussion

Proximate compositions and total DF content

Proximate analyses indicated that the PSC powder contained low level of fat (2.30%) and moisture (7.04%) but high level in ash (7.79%), protein (22.41%) and CHO (60.47%). Interestingly, appreciable amounts of TDF (56.99%) were also found in PSC powder because DF is rich in cell wall of mushroom fruiting body. The nutritional values of cinnamon biscuits formulated with four different levels of PSC powder as partial replacement for wheat flour are presented in Table 2. In general, increasing the level of PSC powder from 0% to 12% resulted in a significant ($P<0.05$) increase in the level of protein (from 6.50 to 7.85%), ash (from 0.86 to 1.00%) and TDF (from 3.37 to 9.84%) of cinnamon biscuit. There was no significant difference in terms of carbohydrate and fat content.

Collectively, PSC powder could be used for enriching the DF content of biscuits due to its original

Table 2. Nutritional compositions of cinnamon biscuit formulated with PSC powder (mean ± SD)

Nutritional Compositions	Concentration (%)			
	Control (0% PSC)	4% PSC	8% PSC	12% PSC
Protein	6.50 ± 0.06	6.91 ± 0.18[a]	7.43 ± 0.22[ab]	7.85 ± 0.17[abc]
Ash	0.86 ± 0.02	0.88 ± 0.04	0.95 ± 0.08[ab]	1.00 ± 0.10[abc]
Fat	22.68 ± 0.06	22.75 ± 0.34	22.90 ± 0.26	23.08 ± 0.46
Moisture	1.37 ± 0.05	1.34 ± 0.09	1.25 ± 0.13[ab]	1.16 ± 0.15[abc]
Carbohydrate	68.59 ± 0.08	68.20 ± 0.54	67.47 ± 0.24	66.92 ± 0.96[a]
TDF	3.37 ± 0.19	6.19 ± 0.06[a]	8.62 ± 0.14[ab]	9.84 ± 0.12[abc]

[a] $p<0.05$ as compared to control (0% PSC) biscuit
[b] $p<0.05$ as compared to 4% PSC biscuit
[c] $p<0.05$ as compared to 8% PSC biscuit

Table 3. Physical properties of cinnamon biscuit formulated with PSC powder (mean ± SD)

Properties	Control (0% PSC)	4% PSC	8% PSC	12% PSC
Weight (*W*, g)	5.35 ± 0.05	5.34 ± 0.06	5.32 ± 0.08	5.32 ± 0.07
Diameter (*D*, mm)	35.33 ± 0.58	35.18 ± 0.42	35.11 ± 0.55	35.12 ± 0.52
Thickness (*T*, mm)	5.00 ± 0.00	5.00 ± 0.00	5.00 ± 0.00	5.00 ± 0.00
Spread Ratio (*D/T*)	7.00 ± 0.06	7.00 ± 0.15	7.01 ± 0.04	7.00 ± 0.08
Firmness (kg)	2.50 ± 0.15	2.53 ± 0.24	2.59 ± 0.12	2.62 ± 0.10[ab]
Crispiness (mm)	0.36 ± 0.03	0.36 ± 0.02	0.35 ± 0.02	0.34 ± 0.05

[a] $p<0.05$ as compared to control (0% PSC) biscuit
[b] $p<0.05$ as compared to 4% PSC biscuit

high DF property. The similar trends of increased DF content were reported in biscuit formulated with raising levels of mango peel powder (Ajila *et al.*, 2008) and cinnamon powder (Ng and Wan Rosli, 2014). Moreover, PSC powder addition also increase the protein and ash content of biscuit, mostly attributed to its original high amounts of protein and ash in PSC powder.

However, there was an inverse relationship between moisture and the level of PSC powder incorporated in the cinnamon biscuit formulations. Moisture content was shown to reduce from 1.37 to 1.16%, with significantly ($P<0.05$) decreased at 8 and 12% PSC powder incorporation as compared to control biscuit. Biscuits contain very low moisture content as thermal processing reduces the final moisture content (ranged from 1 to 5%) in the product. Moreover, DF contents in PSC might absorb a large amount of water, which resulting in decrement of moisture content. This is in agreement with Ayo *et al.* (2007) who incorporated soybean flour as partial replacement for wheat flour in biscuits. The amount of moisture content in biscuit is an indicator of biscuit quality. It is crucial to measure it due to its potential impact on the sensory, textural and microbial properties of final products (Ahlborn *et al.*, 2005). Low moisture content ascertains that products are basically free from microbiological spoilage and possess a long shelf life.

Physical properties

Table 3 shows the effect of PSC powder addition on the physical properties of cinnamon biscuit. In terms of physical characteristics, results showed that the weight (ranged from 5.32 to 5.35 g) and diameter (35.12 to 35.33 mm) of cinnamon biscuit were decreased accordance to the increasing level of PSC powder added, but no significant differences. However, all formulations of cinnamon biscuits were reported no changes in terms of spread ratio (7) and thickness (5 mm). In line with other study,

Table 4. Colour properties of cinnamon biscuit formulated with PSC powder (mean ± SD)

Properties	Control (0% PSC)	4% PSC	8% PSC	12% PSC
L*	70.84 ± 0.01	69.25 ± 0.01	67.86 ± 0.00[ab]	65.49 ± 0.01[abc]
a*	6.47 ± 0.01	6.59 ± 0.00	6.81 ± 0.01[ab]	7.19 ± 0.00[abc]
b*	28.52 ± 0.00	29.04 ± 0.01	29.87 ± 0.00[ab]	30.24 ± 0.00[abc]

[a] $p<0.05$ as compared to control (0% PSC) biscuit
[b] $p<0.05$ as compared to 4% PSC biscuit
[c] $p<0.05$ as compared to 8% PSC biscuit

incorporation of mango peel as DF source exhibited a decrease in diameter and thickness of biscuits Ajila *et al.* (2008). Nevertheless, incorporation of fructo-oligosaccharide (FOS) which is a type of prebiotic soluble DF was documented to increase the diameters and slightly decrease the thickness of the biscuits (Handa *et al.*, 2012). Hence, the types of DF might have different impact on the physical characteristics of biscuits.

Texture is a general term in food that is determined by touch. The TPA allows bakers to objectively determine and guarantee the quality of bakery products. Machine can reveal crispiness and firmness of biscuit by measuring force, time, distance or energy (McWilliams, 2008). Crispiness is the measurement of biscuit resistance to bending. Addition of different levels of PSC powder did not produce significant effect on crispiness (ranged from 0.34 to 0.36 mm) of biscuit up to 12% addition. Anis Jauharah *et al.* (2014) showed the similar trend of results when using young corn powder (*Zea mays* L.) as DF source in biscuit formulation.

Firmness describes a product which presents moderate resistance to breaking during mastication (Bourne, 1978). The firmness of cinnamon biscuit was shown to increase according to the level of PSC powder added, ranging from 2.50 to 2.62 kg. It was increased significantly in 12% PSC cinnamon biscuit but no significant difference among other biscuit formulations. The result of this study was in line with the study done by Sudha *et al.* (2007). They reported that addition of cereals bran such as rice bran, oat bran and wheat bran as sources of DF had also increased the firmness of biscuit.

Bakery products with low level of moisture content were firmer than those with high level of moisture content (Gill *et al.*, 2002). This firmness increment of biscuit could be attributed to the decreasing moisture content (from 1.37 to 1.16%) after addition of PSC powder (0 to 12%). However, there was water retention occurred in cinnamon biscuit with added up to 8% PSC powder, thus resulting in unchanged firmness property. Low moisture content may be attributed to DF content in PSC powder. The DF component could tightly bind large amount of water, hence making it less available for dough inflation and gas cell stability during baking as well as extend the gluten structure, which leading to a more compact structure and higher degree of firmness (Symons and Brennan, 2004; Sahan *et al.*, 2013). Furthermore, high protein content in PSC-enriched cinnamon biscuit was detected to have negative effects on biscuit quality. High level of protein probably interfere with starch by disturbing the uniformity of the starch structure during baking, thus resulting in firmness of bakery products (Hüttner *et al.*, 2010).

Colour properties

Colour is indicated to be a very important factor for the initial assessment of bakery products by consumers. Furthermore, as development of colour occurs mainly during the later stages of baking, it could be used to judge completion of the baking process. The Hunter parameters L^*, a^* and b^* for the surface of the cinnamon biscuits formulated with different levels of PSC powder are shown in Table 4. In general, with increasing level of PSC powder added into cinnamon biscuit, the L^* value of biscuits decreased. Control cinnamon biscuit without addition of PSC powder had the highest L^* value (70.84) which was shown to have significantly different ($p < 0.05$) compared to the other samples ranged from 65.49 to 69.25. The brownish yellow colour may be attributed to the pigment originated from the PSC powder itself. In addition, the L^* values of PSC-enriched cinnamon biscuits were lower compared to that of biscuit supplemented with CP only (ranged from 68.55 to 73.16), indicating darker surface colour of biscuits as there was combination of PSC powder and CP in biscuit formulation. This finding was in line with previous study done on chicken patty. Addition of PSC powder to chicken patty significantly reduced the L^* values (Wan Rosli *et al.*, 2011).

Table 5. Sensory acceptability of cinnamon biscuit formulated with PSC powder (n=60)

Properties	Control (0% PSC)	4% PSC	8% PSC	12% PSC
Aroma	4.67 ± 1.07	5.38 ± 1.17[a]	5.29 ± 1.19[a]	4.97 ± 1.27[abc]
Colour	4.72 ± 0.94	5.03 ± 1.25[a]	4.94 ± 1.21[a]	4.72 ± 1.48[b]
Appearance	4.68 ± 1.02	4.72 ± 1.20	4.75 ± 1.23	4.33 ± 1.34[abc]
Crispiness	5.48 ± 1.07	5.29 ± 1.19	5.34 ± 1.24	5.26 ± 1.36
Flavour	5.22 ± 1.07	5.28 ± 1.18	5.23 ± 1.34	4.65 ± 1.47[abc]
Overall Acceptance	5.32 ± 0.99	5.37 ± 1.28	5.27 ± 1.29	4.68 ± 1.31[abc]

[a] p<0.05 as compared to control (0% PSC) biscuit
[b] p<0.05 as compared to 4% PSC biscuit
[c] p<0.05 as compared to 8% PSC biscuit

Darker colour development of baked products containing flour substitute is induced by higher CHO content, sugar caramelization and Maillard reactions (Alobo, 2001). Maillard reaction of reconstituted biscuit occur likely due to starch and protein degradation, which lead to higher amounts of free amino acids and reducing sugar in the biscuit (Fustier *et al*., 2007). In addition, Gallagher *et al.* (2005) and O'Brien *et al.* (2003) revealed that protein content has a negative correlation with L^* value. In this context, protein content of PSC-enriched cinnamon powder were increased ranging from 6.50 to 7.85%, hence evidenced that increasing protein content in biscuit could reduce L^* value.

The a^* value is a measure of the redness while the b^* value gives an indication of the yellowness of the surface colour. The higher a^* and b^* values were observed for biscuits that were darker in colour (low L^* value), with 12% PSC cinnamon biscuit recorded the highest (7.19 and 30.24, respectively) and control cinnamon biscuit documented the lowest (6.47 and 28.52, respectively). Biscuit incorporated with plant origins may contain high polyphenols which are the substrates for polyphenoloxidase and peroxidase activities, thus resulted in brown colour. The brown pigment formed due to several enzymatic reactions might induce higher redness intensity of biscuit (Ajila *et al*., 2008; Mildner-Szkudlarz *et al*., 2013).The trends of these results (L^*, a^* and b^*) were in agreement with previous researches reported by Eissa *et al.* (2007) and Raymundo et al. (2014) who implemented legume flour and psyllium fibre in biscuit formulation, respectively. In terms of all colour parameters, 4% PSC cinnamon biscuit showed no significant values (P > 0.05) compared to control cinnamon biscuit, indicating 4% PSC powder incorporation did not cause colour changes in biscuit.

Sensory acceptability

Psychological factors such as personality, mood and experience as well as attitude factors such as sensory properties, health or nutrition and price or value are the main determinants of food choice. The development of high-DF and low-sucrose bakery products with acceptable sensory properties is of major industrial concern to fulfill consumers' expectations. In this present study, the PSC-formulated cinnamon biscuit was presented to 60 panellists to evaluate for the selected sensory attributes in comparison to control cinnamon biscuit. Sensory scores of all attributes for cinnamon biscuit formulated with different levels of PSC powder are shown in Table 5.

Among all PSC-based cinnamon biscuit, cinnamon biscuit containing 4% PSC powder recorded the highest score for aroma (5.38), colour (5.03), flavour (5.28) and overall acceptance (5.37); and there were no significant differences with control cinnamon biscuit. It was evidenced that 4% PSC cinnamon biscuit had milder PSC flavour, lighter colour and softer texture, similar to that of control cinnamon biscuit. However, for 12% PSC powder addition, consumers assigned the lowest score (P < 0.05) possibly due to the higher degree of firmness, stronger PSC aroma and flavour as well as darker surface colour of biscuit. It could be believed that addition of small amount of PSC powder can aid in bringing more desirable aroma, colour and flavour in comparison to control cinnamon biscuit. However, incorporation of higher amount of PSC powder contributed to undesirable results. It is attributed to the original brownish-yellow colour and distinguished flavour of PSC powder. This is in agreement with study conducted using oat, wheat and barley bran in biscuit formulation (Sudha *et al*., 2007). Results showed that the crumb colour darkened with increment in the level of bran.

In term of appearance, crispiness, flavour and overall acceptance, PSC powder could be incorporated into cinnamon biscuit up to 8% as there was no significant difference compared to control and 4% PSC cinnamon biscuit. Despite the variation of all of the sensory scores, the scores of the four formulations of cinnamon biscuit were still at acceptable value which is more than 4. In addition, consumers were unable to differentiate crispiness (ranged from 5.26 to 5.48) of cinnamon biscuit added with different levels of PSC powder as there was no marked difference among all biscuit formulations.

Literature stated that the general acceptability of yeast bread containing 2% cornsilk powder significantly higher than yeast bread containing higher level (4 and 6%) of cornsilk powder (Ng and Wan Rosli, 2013). Similar effect was also observed by Kohajdová *et al*. (2013) for different level (0, 10, 20 and 30%) of pea flour supplemented cracker biscuits. Incorporation of pea flour in higher amounts adversely affected the odour, colour, taste, firmness and overall acceptance of cracker biscuits. The previous studies demonstrated the similar results in which fewer consumers expressed satisfaction toward the higher level of DF added into bakery products.

Conclusion

The present study elucidated that incorporation of PSC powder into cinnamon biscuits showed increment in total DF content, protein content, ash content and firmness degree but reduction in moisture content, L^* value and scores of all sensory attributes. Cinnamon biscuit containing highest level (12%) of PSC powder was reported to have highest nutrient contents but scored lowest in sensory attributes among the other formulations of cinnamon biscuits. It could be due to original brownish yellow colour of PSC powder and higher degree of biscuit firmness which might be attributed to the low moisture content, high total DF content and high protein content of biscuit. To sum up, this study demonstrated that the incorporation of PSC powder up to 8% to partially replace wheat flour could develop a more nutritious biscuit accompanying with acceptable physical and sensory characteristics. Further study can be done in the future to investigate its storage stability and functional properties.

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