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Physicochemical and sensory analyses of high fibre bread incorporated with corncob powder

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Abstract

The primary objectives of the present work were to produce corncob powder (CCP) from corncobs and incorporate the CCP into bread formulation in order to develop high fibre bread, and to investigate the physicochemical and sensory properties of the produced high fibre bread (HFB). The corncobs were collected and washed before they underwent the grinding and drying processes. The obtained CCP was incorporated into the bread formulation in three different proportions (5, 10 and 20%) to partially substitute bread flour in the formulation. All three bread samples and the control (0% CCP in the formulation) were analysed to obtain their physicochemical and sensory properties. The incorporation of CCP significantly affected the texture, colour and volume attributes of the produced breads. Increasing the content of CCP in the formulation was found to be responsible for firmer, smaller and darker bread loaves as compared to the composite bread samples. The bread formulation incorporated with 10% CCP had the highest mean scores (7.00) of overall acceptability among all the other formulations, and it was comparable to the commercial breads in the current market.

Introduction

Corn is one of the most versatile emerging cereal crops which have wide adaptability under different climatic conditions. It is the third most vital cereal crop after wheat and rice (Ramessar *et al.*, 2008). In Malaysia, corn is one of the favourite cereals and is planted extensively. Besides, it has also established a secure market in the country (Wong, 1993). According to FAO (2016), the total amount of corn production in Malaysia alone increased to 86,643 tonnes in 2014 from 47,602 tonnes in 2010. On the downside, one of the main wastes from the corn industry is corncob (CC). Huge amounts of CC were produced considering the proportion between corn kernels and CC may reach 100:18 (Cao *et al.*, 2006). This is because only 60% of corns are edible during its maturity while the remaining 40% had turned into waste. Although there is no report on the yield of CC in Malaysia, by referring to the ratio of corn kernels to CC, it is estimated that 9,531 tonnes of CC were produced in the country in the year of 2014.

For the past ten years, a lot of studies had been carried out on CC. Hromádková *et al.* (1999) reported that they successfully extracted xylan which is suitable as an additive in papermaking, textile printing and the pharmaceutical field from CC. Moreover, CC was also claimed to be successfully processed into bacterial substrate for the yield of forage protein (Perotti and Molina, 1988). Other than that, the action of pyrolysis of CC as an energy source in fixed-bed reactors was studied by Cao *et al.* (2004). Many studies focused on the utilisation of CC in producing CC pipe and biomass fuel source (Lathrop, 2007). However, not a lot of research had been performed on the application of CC in food production. If the essential fibre which is freely available in CC is ignored, this will cause a significant loss in the food industry, especially when food security is one of the major issues in the world nowadays.

Food products which are packed with health benefits are getting increasingly popular nowadays. For example, products rich in dietary fibre (DF) such as cereals, tubers, algae, fruits and vegetables,

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are all recognised due to their high content of DF, low digestibility and low caloric content (Alfredo *et al.*, 2009). According to the latest 2014 nationwide food consumption survey, Malaysian Adult Nutrition Survey (MANS), one of the top ten daily consumed foods among Malaysians is bread (Mahmud *et al.*, 2015). A vast majority of the populations prefer to consume bread daily rather than vegetables and fruits because the former is always available, economical, convenient and easy to be consumed (Ng and Wan Rosli, 2013). Thus, one of the best ways to boost the intake of fibre is to develop bread with high DF content (Wang *et al.*, 2002). Several studies highlighted the ingredients that can be applied to enhance the DF content of bread such as wheat bran (Ranhotra *et al.*, 1990; Sidhu *et al.*, 1999), B-glucans (Yokoyama *et al.*, 1997), modified celluloses and guar gum (Pomeranz *et al.*, 1977). Consumers demand that high fibre bread (HFB) should possess at least the same good attributes of the standard white bread. The main criteria for consumer acceptability of HFB are good texture and delicious flavour. In order to enhance the nutrients and maintain the recognisable taste in white bread, individual or combined utilisation of legumes, non-wheat cereal flours, seeds, and DF play a vital role in the bread formulation. Currently, HFB such as multi-grain bread and wholemeal bread are widely available in the market and they have become a healthy diet trend (Katina, 2003).

The primary objectives of the present work were to produce corncob powder (CCP) from CC, and incorporate the CCP into the bread formulation in order to develop HFB. Furthermore, the physicochemical and sensory properties of the HFB incorporated with CCP was also investigated and discussed.

Materials and methods

Materials

Fresh CCs were sourced from corn plantations owned by Nelson's Franchise Sdn. Bhd. in Ipoh, Perak, Malaysia. Other ingredients which were needed for the preparation and production of HFB were purchased from a local bakery shop and a local supermarket in Sri Serdang, Selangor, Malaysia. In addition, Gardenia Wholemeal Bread (GWB) which is a product by Gardenia Bakery KL Sdn. Bhd. was also purchased from the local supermarket. Similarly, materials required for sensory evaluation test of the HFB were obtained from a local supermarket in Sri Serdang, Selangor, Malaysia.

Preparation of corncob powder (CCP)

The collected CCs were cleaned with distilled water and ground into coarse powdery form using a coconut grinder. After that, the CCs were dried in an oven (Memmert, Germany) for 36 h at 60°C. The dried CCs were then ground into finer powdery particles using a heavy-duty blender (Waring Commercial, USA) for 5 min. Subsequently, they were fractionated into fine and coarse powder fractions with a 80 µm sieve. The fine CCP obtained was sealed in Ziplock plastic bags and stored at 4°C prior to any analysis or utilisation.

Proximate composition analysis

Proximate compositions analysis was conducted on the commercial bread flour (CBF) and CCP based on the official AOAC methods (2002). The parameters that were determined were moisture, ash, fat, crude fibre, protein, carbohydrate (by difference) and calorie content. Gross calorie content was calculated as the Equation 1 below (AOAC, 2002). The results were shown as g/100 g of dry matter.

$$\text{Gross calorie content (kcal)} = [\text{protein (g/100 g)} \times 4\ \text{kcal}] + [\text{carbohydrate (g/100 g)} \times 4\ \text{kcal}] + [\text{fat (g/100 g)} \times 9\ \text{kcal}] \qquad \text{(Equation 1)}$$

Preparation of high fibre bread (HFB)

Four treatments of HFB formulations with substitution of different CCP contents ranging from 0 to 20% were prepared with the amounts of ingredients shown in Table 1. The formulations were modified based on a previous study by Amir *et al.* (2013). The yeast was dissolved in lukewarm water first. Consecutively, bread flour, corncob flour, plain flour, milk powder, caster sugar, and eggs were weighed and mixed slowly in a mixer. After that, the water with yeast dissolved in it was slowly poured into the mixer bowl. Finally, butter was added in and the mixing was continued until dough was formed. The dough was kneaded for around 30 min and it was proofed for about 1 h. After 1 h, the proofed dough was kneaded for the second time until the texture of the dough was membrane-like when stretched. The dough was then put in a baking tray (width: 10 cm × length: 30.5 cm × height: 11 cm and proofed again for the third time until the volume of the dough was doubled. Afterwards, the dough was baked in a preheated oven with a temperature of 180°C for 30 min. The internal or core temperature of the bread was measured using a bakery thermometer until it reached 90°C to ensure that the bread was baked completely. The bread was sliced with a bread knife in a sawing motion for further observation and analysis after it was cooled down to room temperature to avoid any texture disruption in the crumb.

Table 1. Composition of high fibre bread formulas.

Ingredients	Different formulas of high fibre bread			
	HFB0	HFB5	HFB10	HFB20
Bread Flour (g)	350	326	302	254
CCF (g)	0	24	48	96
All-Purpose Flour (g)	150	150	150	150
Milk Powder (g)	20	20	20	20
Sugar (g)	50	50	50	50
Salt (g)	5	5	5	5
Yeast (g)	13	13	13	13
Eggs (g)	100	100	100	100
Butter (g)	75	75	75	75
Lukewarm water at 45°C (mL)	100	100	100	100

HFB0: Control; HFB5: high fibre bread substituted with 5% corncob powder; HFB10: high fibre bread substituted with 10% corncob powder; HFB20: high fibre bread substituted with 20% corncob powder.

Texture profile analysis

A texture analyser TA-XT2i (Stable Microsystem, UK) was utilised to measure the texture profiles of HFB0, HFB5, HFB10, and HFB20. The parameters that were analysed were hardness, springiness, cohesiveness, gumminess and chewiness. In order to ensure the freshness of the bread, all samples were baked on the day of test. Before the test was conducted, the probe was calibrated based on the instructions in the manual of the machine. A 2 cm × 2 cm × 2 cm square samples with thickness of 25 mm was sliced carefully in a sawing motion using a bread knife from the middle part of the bread to avoid any distortion of the sample texture. Then, the sample was put on the base of the analyser. An AACC 36 mm radius cylinder probe (model: P/36R) which was located above the base was attached to the analyser. The samples were analysed once the operating conditions (pre-test speed: 2.0 mm/s; test speed: 2.0 mm/s; post-test speed: 2.0 mm/s; trigger force: 20 g; distance between probe and samples: 10 mm) were set into the computer. The resulting display values were the mean values of three readings for particular samples.

Colour measurement

The colour of the crust and crumb of HFB0, HFB5, HFB10, and HFB20 was analysed using a HunterLab LabScan XE Spectrophotometer with D65 light source (Hunter Associates Laboratory, Inc., Reston, VA) for L^*, a^* and b^* values. Prior to the sample analysis, the system was standardised to RSIN mode (mode for solid or semi-solid samples) with a standardised kit. The crust of each sample was stuffed into the optical glass cell separately. Then the optical glass cell was placed into the spectrophotometer to analyse the colour. The same process was repeated for the crumb of each sample.

Volume, specific volume and density measurement

A bread volume meter that applied the rapeseed displacement principle was used to determine the volume of HFB0, HFB5, HFB10 and HFB20. First, the sample loaf was placed at the basement of the equipment. Then, the separator was removed, and the rapeseeds that were placed at the top end of the meter were dropped to the basement where the loaf was located. The volume of the loaf was shown on the scales of the meter after the rapeseeds had filled the basement completely. Consecutively, the weight of each sample loaf was obtained in order to calculate its specific volume and density. The specific volume and density of the sample loaves were calculated using Equations 2 and 3, below, respectively.

$$\text{Loaf Specific Volume (cm}^3\text{/g)} = \frac{\text{Loaf volume of Bread (cm3)}}{Weight\ of\ Bread\ (g)} \qquad \text{(Equation 2)}$$

$$\text{Loaf Density (g/cm}^3\text{)} = \frac{Weight\ of\ Bread\ (g)}{\text{Loaf volume of Bread (cm3)}} \qquad \text{(Equation 3)}$$

Sensory evaluation

A sensory evaluation was conducted for HFB incorporated with coercion CCP in different ratios (HFB0, HFB5, HFB10, and HFB20) and their commercial counterpart: GWB in terms of colour, aroma, taste, firmness, elasticity and overall acceptability. Thirty healthy untrained panellists comprising of undergraduate and postgraduate students from Universiti Putra Malaysia (UPM) with the age range between 18 and 26 years old participated in this evaluation. They were self-reported to be non-smokers and possessed good dentition. The bread samples were prepared a day ahead of the sensory evaluation test and they were kept at room temperature. The Food Sensory Laboratory at the Faculty of Food Science and Technology in UPM was chosen as the venue to carry out the sensory evaluation due to its ambient temperature and sufficient fluorescent light source. All the panellists were provided with samples and a tray with tissue, plain water, spit cup and spit plate on it. Each panellist was served with five randomly arranged bread samples (approximately 13 cm × 10 cm × 1 cm each) in 3-digit random numbers labelled on the plate. Mineral water was provided for rinsing their mouth before and after each sample evaluation. The panellists were required to evaluate the five attributes and overall acceptability via a 9-point hedonic scale (1 = dislike extremely; 9 = like extremely). In order for a sample to be considered as acceptable, 5 was the minimum mean score for the overall acceptability.

Statistical analysis

The data were analysed using SPSS 18.0 (SPSS Inc., Chicago, USA) with independent *t*-test or one-way ANOVA. The results were expressed as mean ± standard deviation. Analyses were conducted in triplicate (n = 3) and the significant level was adjusted at $p < 0.05$.

Table 2. Proximate composition of CBF and CCP in dry weight basis (g/100 g of dry matter).

Composition (g/100 g of dry matter)	CBF	CCP
Ash	0.73 ± 0.02^{b}	1.89 ± 0.01^{a}
Moisture	12.87 ± 0.02^{a}	11.51 ± 0.02^{b}
Crude Fat	0.77 ± 0.03^{b}	1.40 ± 0.02^{a}
Crude Protein	12.80 ± 0.04^{a}	3.24 ± 0.03^{b}
Crude Fibre	0.52 ± 0.01^{b}	38.39 ± 0.03^{a}
Carbohydrate	72.31 ± 0.08^{a}	43.59 ± 0.04^{b}
Calorie (Kcal/100 g of dry matter)	347.38 ± 0.18^{a}	199.83 ± 0.18^{b}

CBF: Commercial bread flour; CCP: corncob powder. Data are means of triplicate ($n = 3$) ± standard deviation. Means in the same row with different superscripts are statistically significant ($p < 0.05$).

Result and discussion

Proximate composition

The proximate analysis of commercial bread flour (CBF) and corncob powder (CCP) were analysed and their gross calorie contents were calculated according to AOAC (2002). The result of the proximate analysis and gross calorie contents of CBF and CCP are tabulated in Table 2. The CBF was chosen to be the counterpart of CCP because the formulation and production of HFB involved significant amount of CBF and part of the CBF in the HFB formulation was substituted with CCP. All the proximate parameters showed significant differences between CBF and CCP from the obtained results over 100 g of dry matter, at $p < 0.05$. The ash, crude fat and crude fibre contents in CCP (1.89 g, 1.40 g and 38.39 g, respectively) were significantly higher than CBF (ash content: 0.73 g, crude fat content: 0.77 g and crude fibre content: 0.52 g). Conversely, the moisture, crude protein, carbohydrate and calorie contents of CCP (11.51 g, 3.24 g, 43.59 g and 199.83 Kcal, respectively) were significantly lower than CBF (moisture content: 12.87 g, crude protein content: 12.80 g, carbohydrate content: 72.31 g and gross calorie content: 347.39 Kcal). From the results obtained, distinct nutritional contents could be observed between the CBF and CCP. This could be justified by the different parts of the plant used to produce CBF and CCP. The CBF was processed from endosperm and germ of wheat that consisted of high content of protein and starch, whereas the CCP was processed from CC which contained primarily of insoluble fibre (Kuan *et al.*, 2011). Thus, CCP had the advantage over CBF to be used in bakery products including bread to increase their fibre content due to the high fibre content in CCP. Furthermore, CBF had low fibre content because the bran fractions had been removed during the wheat milling process (Klava, 2004; Bodroža-Solarov *et al.*, 2008). Apart from that, the low calorie value and high crude fibre value of CCP also suggested a possibility to produce low calorie food products that can give a great sense of satiety to the consumers due to its high insoluble fibre content. Foods that consist of ingredients with high content of cellulose or insoluble fibre were proven to be effective in the treatment of various diseases related to the alimentary tract such as digestive tract diverticulosis, duodenal and gastric ulcers, haemorrhoids, constipation and colon cancer (Hasik, 1997; Suter, 2005). Moreover, insoluble fibre could bind with cholesterol and colic acids in the alimentary tract and to be excreted out from the body through faeces, resulting in lower level of blood cholesterol (Ebihara and Nakamoto, 2001).

Texture profile analysis (TPA)

The results of TPA on the HFBs are tabulated in Table 3. All the TPA attributes studied were affected by CCP incorporation significantly at $p < 0.05$. HFB20 recorded the highest value of chewiness (0.54 kg), firmness (1.75 kg) and gumminess (0.79 kg). However, it significantly recorded the lowest value of cohesiveness (0.45) and springiness (0.68). The firmness of HFB which had been partially incorporated with CCP ranging from 0% to 20% was proportional to the CCP content. Similarly, the chewiness and gumminess of HFB which were influenced by its cohesiveness, springiness and firmness also revealed the same trend. On the contrary, the cohesiveness and springiness of HFB were lowered with the increasing content of CCP in the formulation. HFB20 recorded the highest value of firmness (1.75 kg), chewiness (0.54 kg) and gumminess (0.79 kg). Notably, it had the lowest value of springiness (0.68) and cohesiveness (0.45). The reduced cohesiveness of HBR20 suggested that it had low ability to resist before the deformation of bread structure in the mouth.

Table 3. Textural properties of high fibre bread added with corncob powder.

TPA parameters	HFB0	HFB5	HFB10	HFB20
Firmness (kg)	0.39 ± 0.00^{d}	0.80 ± 0.00^{c}	0.98 ± 0.00^{b}	1.75 ± 0.00^{a}
Springiness	0.97 ± 0.01^{a}	0.93 ± 0.01^{b}	0.77 ± 0.01^{c}	0.68 ± 0.00^{d}
Cohesiveness	0.75 ± 0.01^{a}	0.71 ± 0.00^{b}	0.51 ± 0.00^{c}	0.45 ± 0.00^{d}
Chewiness (kg)	0.27 ± 0.00^{d}	0.31 ± 0.00^{c}	0.38 ± 0.00^{b}	0.54 ± 0.00^{a}
Gumminess (kg)	0.28 ± 0.00^{d}	0.49 ± 0.00^{c}	0.60 ± 0.00^{b}	0.79 ± 0.00^{a}

HFB0: Control; HFB5: high fibre bread substituted with 5% corncob powder; HFB10: high fibre bread substituted with 10% corncob powder; HFB20: high fibre bread substituted with 20% corncob powder. Data are means of triplicate (n = 3) ± standard deviation. Means in the same row with different superscripts are statistically significant ($p < 0.05$).

The high firmness of HFB20 may be resulted by the low water content in the bread. Gill *et al.* (2002) suggested that bread with high water content were softer or less firm as compared to bread with low water content. The fibre content in CCP had high water holding capacity and bind closely to large amounts of water in the dough. However, the water that was trapped in CCP was lost much more easily during the baking process as compared to the water that was trapped in bread flour. Therefore, the bread was firmer and less elastic after the partial incorporation of CCP which was high in fibre. Additionally, the gluten network in HFB20 was underdeveloped and this subsequently reduced the gas cell stability and inflation of the dough during the dough proofing stage. As a result, the expansions of gas cells in the dough were restricted (Collar *et al.*, 2007). All these conditions eventually produced a firmer loaf which was compact and had reduced volume (Symons and Brennan, 2004). Moreover, the data obtained on the firmness of HFB in the present research are aligned with few other studies. Baiano *et al.* (2009) reported that the firmness, gumminess and chewiness of the bread increased when the amount of durum wheat kernels used as replacement in the formulation was increased. Plus, a significant firmer texture was obtained in all breads that were enhanced with DF as compared to the composite bread (Hu *et al.*, 2009). Furthermore, wheat bread that was supplemented with inulin had firmer and harder structure of crumb as compared to the composite bread (Wang *et al.*, 2002). Despite that, as long as the fibre content in the bread or other bakery products was added in a certain proportion, it may enhance the quality of them (Brockmole and Zabik, 1976; Chaplin, 2003; Lebesi and Tzia, 2011). The springiness of the bread samples was significantly reduced with the incorporation of CCP in the formulation. The lower springiness in HBR5, HBR10, and HBR20 as compared to the control bread could be due to the dilution of the gluten structure as part of the gluten was lost when CBF was substituted with CCP. The gas cell structure had been distorted by CCP and thus, formed a short and rigid network of gluten. Gluten had a vital role in trapping the carbon dioxide which was produced by the yeast in the dough during the proofing process (Gisslen, 2007). Therefore, the bread elasticity was reduced due to the lesser amount of gluten which reduced the capability of the dough to retain the carbon dioxide which was produced by the yeast.

Table 4. Colour properties of high fibre bread added with corncob powder.

Parameters	HFB0	HFB5	HFB10	HFB20
Crust				
L^*	55.58 ± 0.01^{d}	66.67 ± 0.02^{c}	68.51 ± 0.10^{b}	70.26 ± 0.02^{a}
a^*	15.57 ± 0.02^{a}	13.58 ± 0.11^{b}	8.88 ± 0.01^{c}	5.02 ± 0.01^{d}
b^*	35.57 ± 0.02^{a}	35.27 ± 0.03^{b}	34.59 ± 0.02^{c}	29.07 ± 0.02^{d}
Crumb				
L^*	83.69 ± 0.02^{a}	75.56 ± 0.01^{b}	74.91 ± 0.02^{c}	73.71 ± 0.01^{d}
a^*	0.65 ± 0.02^{c}	2.53 ± 0.02^{b}	4.76 ± 0.02^{a}	4.79 ± 0.02^{a}
b^*	17.42 ± 0.02^{d}	26.61 ± 0.02^{c}	28.69 ± 0.02^{b}	31.41 ± 0.02^{a}

HFB0: Control; HFB5: high fibre bread substituted with 5% corncob powder; HFB10: high fibre bread substituted with 10% corncob powder; HFB20: high fibre bread substituted with 20% corncob powder. Data are means of triplicate (n = 3) ± standard deviation. Means in the same row with different superscripts are statistically significant ($p < 0.05$).

Colour measurement

Values of L^*, a^* and b^* of the crust and crumb of the HFBs are shown in Table 4. The crust of HFB20 had the highest value of L^* (70.26) but the lowest values of a^* (5.02) and b^* (29.07) as compared to the other treatments. The Table also shows that the L^* of the bread crust increased proportionally with increasing CCP level in the bread formulation. The colour of crust turned to lighter brown for HFB20 from the darker brown of the control bread. The possible reason to explain this trend was the lesser wheat protein content in the bread to react with the added sugar for the Maillard reaction (Fayle and Gerard, 2002). According to Gómez *et al.* (2003), increasing the amount of protein can enhance the Maillard reaction which could make the crust browner.

The crumb of HFB5, HFB10 and HFB20 had significantly lower values of L^* as compared to the control bread at $p < 0.05$. The darkness of the crumb significantly increased ($p < 0.05$) among all treatments with increasing content of CCP. The value of b^* (yellowness) of the crumbs also significantly increased at ($p < 0.05$) with increasing content of CCP. This may be due to the natural yellow pigmentation of CC. The darkness and yellowish colour of HFB could also be visually observed since their crumbs were more brownish as compared to the plain whitish colour of the control bread.

Table 5. Volume, specific volume and density of high fibre bread added with corncob powder.

Parameter	HFB0	HFB5	HFB10	HFB20
Volume (cm^3)	999.68 ± 0.28^a	900.14 ± 0.31^b	675.18 ± 0.32^c	524.99 ± 0.04^d
Specific Volume (cm^{3}g^{-1})	2.23 ± 0.00^a	1.97 ± 0.00^b	1.48 ± 0.00^c	1.00 ± 0.00^d
Density (gcm^3)	0.45 ± 0.00^d	0.51 ± 0.00^c	0.68 ± 0.00^b	1.00 ± 0.00^a

HFB0: Control; HFB5: high fibre bread substituted with 5% corncob powder; HFB10: high fibre bread substituted with 10% corncob powder; HFB20: high fibre bread substituted with 20% corncob powder. Data are means of triplicate ($n = 3$) ± standard deviation. Means in the same row with different superscripts are statistically significant ($p < 0.05$).

Volume, specific volume and density measurement

The volume and specific volume of the HFB significantly reduced with increasing amount of CCP (from 0 to 20%). By referring to the data in Table 5, it was shown that HFB20 had the smallest volume (524.99 cm^3) as compared to the other treatments at $p < 0.05$.

In contrast, HFB0 (control) had the biggest volume and specific volume as compared to the other treatments of HFB. This result was highly ascribed to the better water absorption capacity of CCP which had high fibre content. A study reported that the loaf volume of bread was mainly affected by the moisture content in it (See *et al.*, 2007). Besides, the reduced volume of HFB5, HFB10, and HFB20 could be attributed to the gluten dilution after the addition of CCP. Moreover, the optimal formation of gluten structuring was affected during the mixing, proofing and baking processes. Ragaee *et al.* (2011) reported that the volume of bread was reduced when some of the grains such as oat and barley were added into the dough to partially substitute wheat flour. The volume reduction of the bread after the introduction of fibre sources into the formulation was also reported by several other studies (Yusnita *et al.*, 2011; Amir *et al.*, 2013; Feili *et al.*, 2013). According to Hung *et al.* (2007), the adverse effect of the gluten dilution on the bread volume which was caused by the partial substitution of wheat flour can be overcome by increasing the water content of the dough.

Sensory evaluation

The sensory evaluation scores for colour, aroma, taste, firmness, elasticity and overall acceptability of HFB samples (HFB0, HFB5, HFB10, HFB20) and the commercial sample (GWB) are summarised in Table 6. HFB0 served as the control bread, while GWB served as the market counterpart. In terms of colour, HFB10 had the highest score (7.30) as compared to other samples and its score was significantly higher at $p < 0.05$ than HFB0 and HFB20. Moreover, the panellists awarded slightly higher score for HFB10 than GWB. The low scores of colours for HFB0 and HFB20 was most probably because the colour was either too dark or too white which was not the preference of the consumers.

Similar to the score of colours, HFB10 had the highest scores in terms of aroma among all the other bread samples. Although its score was insignificantly higher ($p > 0.05$) than HFB0, HFB5 and GWB, it was significantly higher ($p < 0.05$) than HFB20. GWB had the best score (7.33) for taste among the other bread samples. It was significantly better ($p < 0.05$) than HFB20 but insignificantly higher ($p > 0.05$) than the other bread samples. The undesirable taste of HFB20 was most probably caused by the extensive use of CCP in the baking process. CCP had strong aroma and taste of corn so if it was added too much into the formulation, the taste and aroma of the bread would

Table 6. Sensory evaluation of high fibre bread added with corncob powder and the commercial counterparts.

Parameters	HFB0	HFB5	HFB10	HFB20	GWB
Colour	5.93 ± 1.89^{bcd}	6.37 ± 1.94^{ad}	7.30 ± 1.02^a	5.13 ± 2.42^{bd}	7.17 ± 1.64^{ac}
Aroma	6.37 ± 1.90^{ad}	6.43 ± 1.96^{ac}	7.23 ± 1.04^a	5.90 ± 1.63^{bcd}	7.13 ± 1.46^a
Taste	6.43 ± 1.99^{ad}	6.30 ± 2.02^{ae}	6.67 ± 1.69^{ac}	5.80 ± 1.71^{bcde}	7.33 ± 1.12^a
Firmness	6.43 ± 1.81^{ac}	6.20 ± 1.56^{bc}	6.00 ± 1.46^{bc}	5.13 ± 1.85^b	7.45 ± 0.99^a
Elasticity	6.20 ± 2.02^{ac}	6.00 ± 1.64^{bc}	5.60 ± 1.79^{bc}	4.83 ± 1.75^b	7.23 ± 1.04^a
Overall Acceptability	6.30 ± 1.74^{bc}	6.07 ± 2.10^{bc}	7.00 ± 0.79^{ac}	5.23 ± 1.59^b	7.47 ± 1.20^a

HFB0: Control; HFB5: high fibre bread substituted with 5% corncob powder; HFB10: high fibre bread substituted with 10% corncob powder; HFB20: high fibre bread substituted with 20% corncob powder. Data are means of triplicate ($n = 3$) ± standard deviation. Means in the same row with different superscripts are statistically significant ($p < 0.05$).

be altered and become undesirable. Besides, the low scores of HFB20 in terms of firmness (5.13) and elasticity (4.83) were also ascribed to the low content of gluten which reduced its ability of holding the gas in the dough and subsequently reduced the elasticity of the bread (Pyler, 1973). Hence, the scores of firmness and elasticity were indirectly proportional to the content of CCP in the bread. On the contrary, GWB had the highest scores for firmness (7.45) and elasticity (7.23) among all the bread samples but they were insignificantly higher than HFB0 at $p > 0.05$. As compared to all samples, the score of overall acceptability for HFB10 (7.00) was the highest but insignificantly lower than GWB (7.47) at $p > 0.05$. In order to consider a bread sample to be acceptable, its score of overall acceptability must be higher than 5. Thus, all bread samples in this sensory evaluation were considered as acceptable since all scores of overall acceptability were higher than 5. Furthermore, the scores also suggested that it was possible to increase the fibre content of bread with CCP while still maintaining high acceptability from the consumers at the same time. Notably, the sensory acceptance test served as the pre-launch market test of the product. From the results, HFB10 appeared to have high potential to compete in the current bread market as it was comparable with GWB and had insignificant difference, at $p > 0.05$. GWB was one of the popular bread brands in the market in terms of colour, aroma, taste and overall acceptability.

Conclusion

HFB with 10% amount of CCP was chosen to be a successful food product after the sensory evaluation. It was found that there was no significant difference ($p > 0.05$) between HFB10 and its commercial counterpart (GWB) for most of the sensory properties other than firmness and elasticity. Notably, excessive amount of CCP in the HFB formulation had significant deteriorating effect ($p < 0.05$) on texture, volume and colour of the bread. Therefore, it was essential to choose the correct amount of CCP to be incorporated into the bread formulation. From all the results obtained, CCP was concluded to have high potential to be utilised in other food products in order to improve their nutritional properties particularly in terms of fibre content, and physicochemical and sensory properties.

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