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Physico-Chemical and Sensory Evaluation of Breads Supplemented with Pumpkin Flour

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Abstract: The objective of this project was to determine the physico-chemical and sensory characteristics of bread supplemented with four different levels (control, 5%, 10%, and 15%) of pumpkin flour. The physical (weight, loaf volume, specific volume and oven spring) and chemical (moisture, protein, fat, fibre and ash) attributes were determined in the raw pumpkin, pumpkin flour (PF), control and supplemented breads. Sensory attributes were conducted on the control and supplemented breads. Increasing the level of substitution from 5% to 15% pumpkin flour significantly ($p<0.05$) increased the ash and crude fiber. However, there was a significant decrease ($p<0.05$) in protein and fat content. Loaf volume and specific volume of treated bread were significantly different ($p<0.05$) to that of the control treatment. Sensory evaluation results indicated that bread with 5% PF was rated the most acceptable and was not significantly different in terms of acceptability compared to the control.

Keywords: Pumpkin, pumpkin flour, bread, texture, colour, sensory

INTRODUCTION

Pumpkins from genus *Cucurbita* of the family Cucurbitaceae which includes squash and cucumbers are grown throughout the tropical and sub tropical countries. There are three common types of pumpkin world-wide, namely *Curcurbita pepo*, *Curcurbita maxima* and *C. moschata* (Lee *et al.*, 2003). Pumpkins are found in many shapes, sizes and colours. The miniature pumpkins tend to be *C. pepo* (Jack-o-lantern types) and the giant types 'Boston Marrow' and 'Mammoth' which tend to be *C. maxima* varieties, while the buff-coloured sugar-pie or 'Dickinson' variety and *Cucurbita moschata* are excellent for processing into pie. All pumpkins have hard shells when mature. *C. moschata* is the most commonly eaten variety of pumpkin in both Asia and the United States. The yellow-orange characteristic colour of pumpkin is due to the presence of carotenoids. Carotenoids, which are natural pigments responsible for the yellow, orange and red colour of many foods, are intensely investigated mainly because of their health promoting effects. Pumpkin provides a valuable source of carotenoids and ascorbic acid which have major roles in nutrition as provitamin A and as an antioxidant respectively. Current research indicates that a diet rich in foods containing beta-carotene may reduce the risk of developing certain types of cancer and offers protection against heart disease. The carotenoid content in Spanish pumpkin was reported higher than that of other pumpkin varieties and even higher than that of beta-carotene in carrots (Wu and Jin, 1998). The yellow colour of the powder can be used as natural colourant.

Pumpkins are consumed in a variety of ways such as fresh or cooked vegetables, as well as being stored frozen or canned (Figueredo

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et al., 2000). Pumpkin can be processed into flour which has a longer shelf-life. Pumpkin flour is used because of its highly-desirable flavour, sweetness and deep yellow-orange colour. It has been reported to be used to supplement cereal flours in bakery products, for soups, sauces, instant noodle and spice as well as a natural colouring agent in pasta and flour mixes. Pumpkin is rich in carotene, vitamins, minerals, pectin and dietary fiber (Djutin, 1991). Hence, supplementation of PF would improve the nutritional quality of bread (Ptitchkina *et al.*, 1998). Fluted pumpkin seed flour has been used as a protein supplement in a variety of local foods (Giami and Bekebain, 1992; Sunday and Issac, 1999). El-Soukkary (2001) reported that *in-vitro* protein digestibility of bread improved with addition of pumpkin seed proteins.

The aim of this study was to determine the physico-chemical attributes of fresh pumpkin and PF, and to determine the effects of adding different levels of PF on the physico-chemical and the sensory properties of bread.

MATERIALS AND METHODS

Preparation of Pumpkin Flour

Pumpkin fruits (*Cucurbita moschata*) were obtained from a market in Gelugor, Penang. The rind, fibrous matter and seeds were removed and the flesh cut into small pieces followed by soaking for 45 minutes in 0.2% (w/v) sodium metabisulphite and rinsing under running tap water. The pumpkin pieces were then cut into slices of 2-3 mm thickness using a slicer (Robot Coupe CL25), and dried in a ventilated dryer (Afos, Model Mini, No. CK 80520, England) to a moisture content of 10 - 12% at 60°C for 24 hours. The resulting PF was passed through a mesh sieve of size 0.25 µm at 14000 rpm (Retsch, Jerman). The flour was then kept in an airtight container and stored in a chiller prior to use.

Bread Ingredients

All ingredients such as bread flour (11.13% moisture content, 14.27% crude protein, 0.96% crude fat, 0.72% crude fibre, 0.52% ash and 73.12% carbohydrate), sugar, salt, yeast, improver (Freemat), shortening, milk powder and emulsifier (Glyceryl Monostearate-GMS) were procured from Sunshine Trading Company in Siam Road, Penang.

Preparation of Bread

The bread was prepared using the sponge and dough method (AACC, 2000) with slight modifications. Yeast weighing 15 g, 20 ml water and 20 g sugar were mixed and allowed to rest for 10 mins. Twenty grams of bread flour was added into the mixture until a foamy paste developed. The sponge was put into a proofer (Bakbar E81, New Zealand) for 15 mins, at 30°C and 85% relative humidity (RH).

The sponge mixture was then transferred into a heavy-duty mixer (Kitchen Aid-KSM 900, USA), remixed with the dough mixture without shortening for 25 min starting from low speed 2 to high speed 4 until a smooth dough was formed. The shortening was added after 10 min. The dough was then allowed to rest for 30 min in the proofer and then molded in a molder (Tyrone, BS-2220, Taiwan). The molded dough was then placed onto an aluminium vessel and proofed for 35 min at 30°C and RH, 85%. Baking was carried out for 20 min at 170°C in an electric oven (Salva). The loaves were then taken out of the tins, cooled at ambient temperature for 1 h prior to sealing in polyethylene bags and were later stored at 25°C.

Proximate Analysis

Chemical composition such as moisture content, crude protein, crude fat, crude fiber and ash was determined according to AOAC (1990) standard method. Moisture was determined using hot air oven at 100-105°C for 4 hours (AOAC, Method 925.40). Protein content (% N x 6.25) was determined by the Kjedahl method (AOAC, Method 955.04). Crude fat test was carried out based on Soxhlet Extraction Method utilizing petroleum ether 40°C – 60°C (AOAC, Method 920.39). The ash content was measured according to dry ashing procedure (AOAC, Method 923.03) while dietary fibre was determined according to the procedure of AOAC, Method 7.504. Carbohydrate content was determined by difference. Total caloric content was determined by calculation. All analyses were carried out in triplicate.

Physical Analysis

Measurement of Bread Volume

Loaves were weighed 1 h after removal from the oven (cooling). Volume (ml) was determined by rapeseed displacement method; specific volume (cm^3/g) was then calculated by dividing volume by weight; and oven spring (cm) was calculated by the difference between loaf height before and after baking. Triplicate measurements were taken.

Colour Measurement

Crust and crumb colour were measured using The Minolta Spectrophotometer CM-3500d (Osaka, Japan). Samples were cut into cubes of 2 x 2 x 2 cm and placed in the colorimeter. The colour attributes Hunter L, a, b and H values were recorded using the Spectramagic software version 2.11, 1998. L* defines lightness, a* denotes the red/green value and b* the yellow/blue value. The L* axis has the following boundaries: L=100 (white or total reflection) and L=0 (black or total absorption). Along the a* axis, a colour measurement movement in the -a direction depicts a shift toward green; + a movement depicts a shift toward red. Along the b* axis, -b movement represents a shift towards blue; +b shows a shift towards yellow. Four measurements were taken from each sample.

Sensory Evaluation

Loaves were cooled for 1-2 h at room temperature (25°C) in a sealed plastic bag. The bread was then cut into 2 x 3 x 5 cm slices using a bread knife. Sensory evaluation was performed using 15 panelists comprising of graduate students and staff members of the Food Technology Division in Universiti Sains Malaysia. Samples were randomly assigned to each panelist. The panelists were asked to evaluate each loaf for appearance, crumb texture, crust and crumb colour, taste, odour and overall acceptability. A 9-point hedonic scale was used where 1 = dislike extremely to 9 = like extremely.

Statistical Analysis

The results were analyzed using Analysis of Variance (ANOVA) and Multiple Range Tests with the SPSS version 10.05 Software. The means of the results were compared using Tukey's test. All tests were conducted at the 5% significance level.

RESULTS AND DISCUSSION

Table 1 shows the formulation of the pumpkin bread for the various treatments. Results indicated that fresh pumpkin was significantly ($p<0.05$) higher in moisture and lower in fat, protein, ash and crude fiber content than PF (Table 2). This result was similar to that reported by Tee (1985) and Macrae (1993). The PF in this study was lower in moisture content than those reported by Bothast *et al.* (1981). Bothast *et al.* (1981) reported that PF is susceptible to fungus and mold growth when the moisture content was above 14%. The pumpkin flour indicated higher levels of protein, ash, crude fiber and fat compared to its fresh form. Ptitchkina *et al.* (1998) reported that in their study, the protein and ash value in pumpkin powder was 9.0% and ash 3.8%, respectively.

Table 3 shows the proximate composition for different levels of PF. There were no significant ($p>0.05$) differences in fat content between the control and 5% PF bread, but bread with 10% and 15% PF showed significantly reduced fat content as compared to the control. This might be attributed to the lower fat content in PF (0.8%) as compared to the wheat flour (0.96%). Substituting higher levels of PF in bread thus reduces the fat content. The level of PF in bread is correlated

Table 1: Formulation of pumpkin bread

<table>
<tr><th>Ingredients</th><th>Control</th><th>5%</th><th>10%</th><th>15%</th></tr>
<tr><td>Bread flour (g)</td><td>500</td><td>475</td><td>450</td><td>425</td></tr>
<tr><td>Composite flour (PF) (g)</td><td>-</td><td>25</td><td>50</td><td>75</td></tr>
<tr><td>Water (6 °C) (ml)</td><td>200</td><td>212.5</td><td>225</td><td>237.5</td></tr>
<tr><td>Sugar (g)</td><td colspan="4">33</td></tr>
<tr><td>Yeast (g)</td><td colspan="4">15</td></tr>
<tr><td>Salt (g)</td><td colspan="4">10</td></tr>
<tr><td>Improver (Freemat) (g)</td><td colspan="4">5</td></tr>
<tr><td>Shortening (g)</td><td colspan="4">30</td></tr>
<tr><td>Milk powder (g)</td><td colspan="4">20</td></tr>
<tr><td>Emulsifier (GMS) (g)</td><td colspan="4">1</td></tr>
</table>

Table 2: Proximate composition of fresh pumpkin and pumpkin flour

Composition (%)	Fresh Pumpkin	Pumpkin Flour
Moisture	92.24 ± 0.01^{a}	10.96 ± 0.12^{b}
Fat	0.15 ± 0.03^{a}	0.80 ± 0.07^{b}
Protein	0.98 ± 0.06^{a}	9.65 ± 0.10^{b}
Ash	0.76 ± 0.13^{a}	5.37 ± 0.14^{b}
Crude fiber	0.56 ± 0.08^{a}	0.81 ± 0.07^{b}
Carbohydrate	5.31 ± 0.04^{a}	72.41 ± 0.09^{b}

Mean in a row with similar superscript are not significantly different at α=0.05
Values are the Means ± SD and n=3 for each group

Table 3: Proximate composition of bread for different levels of pumpkin flour

Composition (%)	Control	5%	10%	15%
Moisture	32.02 ± 0.54^{bc}	32.63 ± 0.50^{c}	34.25 ± 0.08a^{b}	35.32 ± 0.06^{a}
Fat	2.59 ± 0.01^{a}	2.55 ± 0.01^{a}	2.48 ± 0.01^{b}	2.44 ± 0.01^{b}
Protein	15.72 ± 0.04^{a}	15.17 ± 0.09^{b}	14.71 ± 0.02^{c}	14.47 ± 0.06^{c}
Ash	1.83 ± 0.07^{d}	2.09 ± 0.01^{c}	2.26 ± 0.02^{b}	2.43 ± 0.03^{a}
Crude fiber	1.56 ± 0.02^{d}	2.46 ± 0.03^{c}	2.62 ± 0.01^{b}	2.90 ± 0.04^{a}
Carbohydrate	46.28 ± 0.14^{a}	45.10 ± 0.21^{b}	43.68 ± 0.05^{c}	42.44 ± 0.05^{d}
Calorie (kcal/100g)	271.31^{a}	264.03^{b}	255.88^{c}	249.60^{d}

Mean in a row with similar superscript are not significant different at α =0.05
Values are the Means ± SD and n=3 for each group

with the moisture content. Increase in the level of PF increased the moisture content. This might be attributed to the higher water absorption capacity in the composite flour compared to wheat flour which was in agreement with the results of Sunday (1992). Mansour *et al.* (1999) reported that addition of pumpkin and canola proteins to wheat flour resulted in an increase in water absorption. According to Wang *et al.* (2000), higher total fibre in the non-wheat flour interact relatively well with a large amount of water through the hydroxyl group existing in the fibre structure. The protein composition in the PF supplemented bread showed significantly ($p<0.05$) lower values than the control bread because the commercial blend of wheat flour has higher protein content (14.27%) than the pumpkin flour (9.65%). Hence, incorporation of pumpkin powder in the bread resulted in reduction of protein and fat content due to the declining amount of bread flour in the formulation. This result was in agreement with those reported by Ermakov (1987) and Ensminger *et al.* (1994). The ash and crude fiber were observed to differ significantly between bread of the control and PF treated bread. However, the ash and crude fiber composition in the supplemented bread were found to be significantly higher as compared to those of the control. According to Ptitchkina *et al.* (1998), pumpkin flour contains high IDF which include cellulose (40.4g/100g), hemicelluloses (4.3g/100g) and lignin (4.3g/100g). Substitution of PF to wheat flour also showed reduction in total carbohydrate content of the bread (Table 3). This indicated that bread flour (73.12%) was the main contributor to the carbohydrate content in bread. This result is similar to those reported by Khan *et al.* (1975), Hansmeyer *et al.* (1976), Rasco *et al.* (1989) and Salama *et al.* (1992) where sesame flour was added to wheat flour. Increasing levels of PF (0-15%) significantly ($p<0.05$) increased the weight of loaf among samples (Table 4). This might be attributed to the higher fibre content which increased the water absorption capacity of the PF. The 5% PF bread had the highest loaf volume and specific volume as compared to the other samples. A similar observation was reported by Ptitchkina *et al.* (1998) where the addition of 0.5 -1.0% PF showed a massive increase in loaf volume which decreased with further level of PF. The moisture content of the breads was a major factor affecting loaf volume. Increasing water level in the formulation by 10 and 20% increased the loaf volumes in bread (Gallagher *et al.,* 2003). Incorporation of 5% PF in this study resulted in higher specific volume (5.99 cm^3) than the value (4.17 cm^3) reported by Ptitchkina *et al* .(1998).

Pumpkin flour has a lighter colour (higher L value), less red colour (low a value) and increased yellowness (higher b value) than fresh pumpkin (Table 5). There was no significant ($p>0.05$) difference in the Hue values between the fresh pumpkin and PF. The colour of the fresh pumpkin and PF was nearer to the yellow quadrant. The discoloration of the fresh pumpkin was prevented by soaking the pumpkin pieces in 0.2% (w/v) sodium metabisulphite before hot air- drying. The yellow colour of the pumpkin could have been caused by the carotenoids (Wu and Jin, 1998) as pumpkin is a rich source of β-carotene. The visual characterization of the colour correlates well with the increased supplementation of PF. The discoloration during drying and milling of the flour may be related to non enzymatic browning (Feng and Tang, 1998).

The colour for the bread was significantly affected ($p<0.05$) by the addition of PF (Table 6). The colour of the crust showed a significant decrease ($p<0.05$) in L and H values of PF supplemented bread. The colour change occurred from light-brown (control) to darker-brown (15% PF bread). This may be because loaves containing additional glucose had a darker crust. This condition is attributed to Maillard browning caused by the reaction between wheat proteins and the added sugar (Fayle and Gerrard, 2002) and caramelization which are influenced by the distribution of water and the reaction of added sugars and amino acids (Kent and Evers, 1994). According to Hodge (1967), Maillard reaction, is related to temperature, time and the presence of water (moisture). Colour appeared to be a very important criterion for the initial acceptability of the baked product by the consumer. Moreover, as the development of colour occurs classically during the later stages of baking, it can be used to judge completion of the baking process. Surface colour depends both on the physico-chemical characteristics of the raw dough (i.e. water content, pH, reducing sugars and amino acid content) and on the operating

Table 4: Mean weight, volume, specific volume and oven spring of bread incorporated with different levels of pumpkin flour

Parameter	Control	5%	10%	15%
Weight (g)	151.45 ± 0.21^{d}	153.25 ± 0.64^{c}	155.95 ± 0.21^{b}	157.45 ± 0.21^{a}
Volume (ml)	901.00 ± 1.41^{b}	914.50 ± 0.71^{a}	867.50 ± 0.71^{c}	769.50 ± 0.71^{d}
Specific Volume (cm^{3})	5.95 ± 0.00^{b}	5.99 ± 0.01^{a}	5.56 ± 0.01^{c}	4.89 ± 0.00^{d}
Oven Spring (cm)	1.53 ± 0.04^{a}	1.35 ± 0.21^{a}	0.70 ± 0.14^{b}	0.60 ± 0.14^{b}

Means in a row with similar superscript are not significant different at α=0.05
Values are the Means ± SD and n=3 for each group

Table 5: Means of colour assessment of fresh pumpkin and pumpkin flour

Parameter	Fresh Pumpkin	Pumpkin Flour
L	66.44 ± 0.82^{a}	72.27 ± 0.16^{b}
a	15.11 ± 0.87^{a}	14.36 ± 0.02^{b}
b	45.85 ± 0.31^{a}	55.98 ± 0.03^{b}
c	46.55 ± 0.45^{a}	55.82 ± 0.19^{b}
Hue, ∏	74.42 ± 0.29^{a}	75.78 ± 0.16

Means in a row with similar superscript are not significant different at α=0.05
Values are the Means ± SD and n=4 for each group

Table 6: Means crust and crumb colour of bread with different level of pumpkin flour

Parameter	Control	5%	10%	15%
Crust colour				
L	66.17 ± 0.32^{a}	58.52 ± 0.40^{b}	53.27 ± 0.43^{c}	49.52 ± 0.48^{d}
a	12.64 ± 0.40^{a}	15.76 ± 1.24^{b}	18.09 ± 0.33^{c}	19.85 ± 0.16^{d}
b	34.51 ± 0.76^{a}	38.98 ± 0.71^{b}	40.36 ± 0.09^{c}	41.49 ± 0.08^{d}
c	34.76 ± 0.36^{a}	38.89 ± 0.63^{b}	40.43 ± 0.10^{c}	41.52 ± 0.15^{d}
Hue, ∏	70.07 ± 0.21^{a}	69.10 ± 0.18^{b}	66.21 ± 0.34^{c}	63.86 ± 0.26^{d}
Crumb colour				
L	70.96 ± 0.28^{a}	66.30 ± 0.22^{b}	64.06 ± 0.33^{c}	61.77 ± 0.61^{d}
a	-0.80 ± 0.05^{a}	1.29 ± 0.12^{b}	2.95 ± 0.17^{c}	5.49 ± 0.11^{d}
b	10.87 ± 0.35^{a}	35.76 ± 0.77^{b}	44.41 ± 0.58^{c}	53.79 ± 0.26^{d}
c	10.77 ± 0.80^{a}	35.61 ± 0.55^{b}	43.80 ± 0.90^{c}	53.75 ± 0.17^{d}
Hue, ∏	94.53 ± 0.38^{a}	87.96 ± 0.25^{b}	86.20 ± 0.16^{c}	84.20 ± 0.09^{d}

Means in a row with similar superscript are not significant different at α=0.05
Values are the Means ± SD with n=4 for each group

conditions applied during baking (i.e. temperature, air speed, relative humidity, modes of heat transfer) (Zanoni *et al.*, 1995). It was observed that the colour of the crumb sample significantly ($p<0.05$) increased in redness (a value) and yellowness (b value) but decreased in L value with higher percentage of PF (Table 6). This might be attributed from the yellow colour imparted by the PF.

Table 7: Means of sensory attributes of bread incorporated with different level of pumpkin flour

Parameter	Control	5%	10%	15%
Crust colour	6.00 ± 1.67^{a}	6.07 ± 0.88^{a}	5.67 ± 0.81^{a}	5.33 ± 0.90^{a}
Crumb colour	6.13 ± 0.99^{ab}	7.67 ± 0.49^{c}	6.67 ± 0.49^{b}	5.73 ± 0.70^{a}
Moistness	5.60 ± 0.51^{ab}	6.07 ± 0.80^{a}	5.33 ± 0.49^{bc}	5.00 ± 0.38^{c}
Softness	5.93 ± 0.80^{ab}	6.47 ± 0.83^{a}	5.53 ± 0.64^{bc}	5.20 ± 0.41^{c}
Aftertaste	5.73 ± 0.59^{a}	6.13 ± 0.52^{a}	5.20 ± 0.41^{b}	4.87 ± 0.35^{b}
Overall acceptability	6.60 ± 0.74^{ab}	6.93 ± 0.59^{a}	6.13 ± 0.35^{bc}	5.73 ± 0.46^{c}

Mean in a row with similar superscript are not significant different at α=0.05
Values are the Means ± SD and n=15 for each group

Data of sensory evaluation (Table 7) indicated that the consumer preferred the crust colour of the 5% PF bread and the control as both samples were not significantly different (p>0.05). The crumb colour of the 5% PF bread was significantly different (higher) to the other samples. For moistness, softness, after taste and overall acceptabilities, the 5% PF bread and the control differed significantly from the 10% and 15% PF bread. This might be due to the stronger pumpkin odour and after taste flavour in both the 10% and 15% PF bread. The 5% PF bread was preferred and since the specific volume for 5% PF bread was the highest among the different levels of PF studied, it gives a more significant softness in bread. Since, soft texture is a quality sought after in bread, the 5% PF bread fulfilled the criteria.

CONCLUSION

From the results it can be concluded that it is feasible to produce bread with good nutritional value and sensory characteristics from PF supplementation to wheat flour. The addition of 5% PF resulted in bread with high loaf volume and good overall acceptability. The sensory evaluation also indicated that 5% PF bread was the most acceptable bread.

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