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The Physicochemical Properties and Sensory Evaluation of Bread Made with a Composite Flour from Wheat and Tempoyak (Fermented Durian)

Fazilah Ariffin, Mohd Arif Baharom, Bhupinder Kaur and Maizura Murad

Food Science Division, School of Industrial Technology, Universiti Sains Malaysia, 11800, Penang Malaysia

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Corresponding Author:
Fazilah Ariffin
Food Science Division, School of Industrial Technology,
Universiti Sains Malaysia,
11800, Penang Malaysia
Tel: +60-4-6535208/2260
Fax: +604-6573678
Email: fazilah@usm.my

Abstract: Composite flour from wheat flour and Tempoyak Flour (TF) was produced in this study. Three different bread formulations from the composite flour were produced, containing 5% TF (TF5), 10% TF (TF10) and 15% TF (TF15). Bread samples were analyzed for their physicochemical properties and sensory characteristics compared with control bread made from 100% wheat flour. The resistant starch content increased significantly ($p<0.05$) with a higher level of TF. The increasing TF level in the bread formulations significantly decreased ($p<0.05$) the glycemic index. The use of TF in bread decreased the loaf volume, specific volume and oven spring; however, it increased the loaf weight. The results of a Texture Profile Analysis (TPA) showed that the hardness of the breads varied significantly and increased with increasing TF in the formulation. However, substitution of TF at 5% did not affect the cohesiveness or chewiness of bread compared with the 10 and 15% substitutions. The results of the hedonic analysis demonstrated that all treatments and the control had no significant differences ($p>0.05$) in aroma. The use of up to 10% TF is acceptable according to the overall acceptance scores of the panelists.

Keywords: Tempoyak, Composite Flour, Bread, Resistant Starch, Glycemic Index

Introduction

Durio zibethinus Murr., also known as durian, is a favorite fruit in Southeast Asia, especially in Malaysia. It's delicious flavor, attractive fragrance and good nutritional values has given durian a prominent position among commercial fruits in the market. Durian is rich in carbohydrates, proteins, fats, minerals and vitamins (Bai-Ngew *et al*., 2014). Durian pulp contains vitamin C of 19.7 mg 100 g^{-1}, some vitamins of the B complex and β-carotene (23 μg 100 g^{-1}) (Devalaraja *et al*., 2011). However, the market of durian is restricted due to its fruiting season, difficulty in transportation (only certain regions have good quality durian) and shelf life, which is limited to only 2 to 5 days at room temperature (Anabesa *et al*., 2006; Chin *et al*., 2007).

Another popular use of durian is for tempoyak, a traditional Malaysian food. Tempoyak can be stored for 2 to 3 years after its production at temperatures below 4°C (Grandjar, 2000). Tempoyak is made by fermenting overripe or low quality durian pulp in a closed container for 3 to 4 days at room temperature (Grandjar, 2000; Amin *et al*., 2004). Tempoyak has the same odor and taste as durian. Tempoyak is sour and salty, though the sour taste is more dominant (Grandjar, 2000; Amin *et al*., 2004). Tempoyak is usually eaten fresh with rice or added into cooking dishes. The use of tempoyak adds flavor to recipes and condiments.

Drying tempoyak into a powder form is desirable as the dehydration of fruits and vegetables reduces cost, increases convenience and has excellent product stability (Jangam *et al*., 2011). In dry form, tempoyak can be maintained at room temperature without cold storage. Moreover, Tempoyak Flour (TF) offers broader and easier blending in applications.

Tempoyak flour have the potential to be used as composite flours to make bakery products as demonstrated by previous studies, in which cassava flour (Eriksson *et al*., 2014; Nwosu *et al*., 2014), jackfruit seed flour (Chowdhury *et al*., 2012; Hossain *et al*., 2014), locust bean flour (Sankhon *et al*., 2013), chickpea (Hefnawy *et al*., 2012), maize and brown rice flour (Islam *et al*., 2011) has been combined with wheat flour to produce bakery products.

Consumption of bread is an excellent way to increase one's intake of dietary fiber. The development of bread supplemented with TF could increase the value of both durian and tempoyak, preventing its waste after the fruiting season and also enrich the nutritional value of bread. However, scientific information regarding composite flours made with TF and its application in bakery products is scarce.

This study investigated the potential application of composite flours from wheat and TF in bread. TF was mixed at 5, 10 and 15% concentrations with wheat flour to produce the composite flours. The objective of this study was to evaluate the physicochemical and sensory properties of bread supplemented with TF.

Materials and Methods

Preparation of Tempoyak Flour

Tempoyak was produced using the conventional methods of Steinkraus (1995). Low quality and over-ripe durian was purchased from the dealer at Teratai Farm in Segamat, Johor, Malaysia. The pulp was carefully separated from the seed. Sugar and salt were added to the pulp to initiate the fermentation process. The mixture was held for 4-7 days at room temperature (37°C) (Steinkraus, 1995). The ratio of sugar to salt was 10:3 for 2 kg of durian pulp. At the end of the fermentation process, the durian pulp became tempoyak. The drying process of tempoyak to form TF was conducted based from the method of Ngalani (1989) using a hot air oven at 65°C for 48 h. The tempoyak, with 2 mm thickness, was spread on aluminum foil (20×30 cm). After drying, the tempoyak flakes were ground. The ground tempoyak was then sieved (0.245 μm aperture) and stored in an air tight container for bread production.

Bread-Making Procedure

Bread was made by using a sponge-dough procedure following the method of Cauvain (2007). There were four bread formulations in this study with ingredients listed in Table 1. All ingredients were purchased from a local supplier in Pulau Pinang, Malaysia. The control was made using 100% wheat flour and the other formulations were made by using 5% TF and 95% wheat flour (TF5), 10% TF and 90% wheat flour (TF10) and 15% TF and 85% wheat flour (TF15). The wheat flour and TF were mixed prior to bread production. The sponge was prepared by mixing yeast, sugar and water and allowed to ferment for approximately 10 min at 27°C at 75% relative humidity. Then, the composite flour (mixture of wheat flour and TF) and improver were added to the sponge. The mixture was further fermented for 15 min. Additional ingredients were added to the sponge mixture using a mixer (Spar Mixer Model HL-11010) for 4 min at intermediate speed and 6 min a higher speed to form the dough. The dough was punched down for 3 min to remove any remaining gasses. The dough was folded manually and placed in a baking pan (12×25 cm).

Table 1. Formulations of wheat bread supplemented with TF

Ingredients	TF0	TF5	TF10	TF15
Wheat Flour (%)	54.35	51.63	48.91	46.2
(% of total flour)	-100%	-95%	-90%	-85%
Tempoyak Flour (%)	0	2.72	5.43	8.15
(% of total flour)	0%	-5%	-10%	-15%
Yeast (%)	1.85	1.85	1.85	1.85
Salt (%)	0.92	0.92	0.92	0.92
Water (%)	24.46	24.46	24.46	24.46
Brown Sugar (%)	9.89	9.89	9.89	9.89
Vegetables Fat (%)	4.95	4.95	4.95	4.95
Improver (%)	1.11	1.11	1.11	1.11
Milk powder (%)	2.47	2.47	2.47	2.47

TF0 (control) = 100% wheat flour, TF5 = 5% TF + 95% wheat flour, TF10 = 10% TF + 90% wheat flour, TF15 = 15% TF + 85% wheat flour

The dough in the baking pan was proofed for 50 min and then baked at 170°C for 20 min in an oven (Bakbar Versatile Bench Top Turbofan Oven E32). Breads were analyzed for their proximate composition, mineral content, total starch, glycemic index, TPA and hedonic sensory qualities.

Proximate and Crude Fiber Analysis

The proximate composition of the bread samples was determined using standard procedures of the Association of Official Analytical Chemists (AOAC, 2000). Moisture content was determined using the oven method, crude protein content was determined using the Kjeldahl method, fat content was measured with the Soxhlet method and ash content was determined using the dry ashing method. Carbohydrate content was calculated by difference. Crude fiber was determined by acid and alkali digestion methods.

Mineral Content

Essential minerals, such as sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn) and cuprum (Cu), of the wheat flour, TF and bread samples were determined using the method of Rupérez (2002). Briefly, 1 g dried sample was weighed into a microwave digester tube and mixed with 6 ml HNO_3 and 1 mL H_2O_2 (30%). Each sample was digested in a microwave digester (Millestone Ethos 900) for 15 min and cooled in the digester for 20 min. Approximately 5 mL of Lanthanum chloride solution was added to 25 mL of the diluted sample for the determination of calcium and magnesium. Standard solutions for the essential minerals were prepared in at least 3 different concentrations in the range of 0.10 to 5 ppm, based on the minerals and samples. Mineral contents in samples were determined using Atomic Absorption Spectroscopy (AAS) (Perkin Elmer 4100ZL, USA).

Resistant Starch Content

The resistant starch content was determined according to the method of Goni *et al*. (1996). Briefly, 100 mg dried and defatted samples were weighed into 250 mL centrifuge tubes and 10 mL KCH-HCl buffer (pH 1.5) and 0.20 mL pepsin solution were added to each tube. Solutions were incubated in a water bath (40°C) for 60 min. Samples were cooled to room temperature before 9 mL of 0.10 M Tris-maleate buffer (pH 6.9) and 1 mL of alpha-amylase solution were added. Solutions were then incubated at 37°C for another 16 h. Samples were centrifuged (15 min, 3000 g) in a Hettich Universal 30 RF centrifuge (Tuttlingen, Germany) and the supernatants were discarded. The residues were moistened with 3 mL of distilled water and then 3 mL of 4 M KOH was added. Approximately 5.50 mL 2 M HCl and 3 mL 0.40 M sodium acetate buffer (pH 4.75) and 80 µL amyloglucosidase were added. Solutions were incubated in a 60°C water bath for 45 min. Samples were then centrifuged (15 min, 3000 *g*) and the supernatant was collected and saved in a volumetric flask. A standard curve was prepared from a glucose solution (10-60 ppm) and the absorbance was read at 500 nm. The resistant starch content was calculated as the product of Free Glucose (FG) from resistant hydrolysis with amyloglucosidase using a correction factor glucose–polysaccharide of 0.9.

Glycemic Index (GI)

The *in vitro* kinetics of starch digestion was determined according to the method of Goni *et al.* (1996). Samples of approximately 50 mg were combined with 10 mL HCl-KCl buffer (pH 1.50). The samples were homogenized for 2 min using a vortex (Stuart, Bibby Scientific Limited, Stone, Staffordshire, UK). A 0.20 mL pepsin solution containing 1 mg pepsin in 10 mL HCl–KCl buffer (pH 1.50), was added to each sample. Samples were incubated at 40°C in a water bath for 60 min with constant shaking. The digest was diluted to 25 mL by adding 15 mL Tris-maleate buffer (pH 6.9). Starch hydrolysis was initiated by adding 5 mL tris-maleate buffer containing 2.60 IU porcine pancreatic α-amylase. The mixture was incubated in a 37°C water bath with moderate agitation. Approximately 1 mL samples were taken from each flask every 30 min from 0 to 3 h. The α-amylase was inactivated immediately by holding the flask in a boiling water bath for 5 min. Then, 3 mL of 0.40 M sodium acetate buffer (pH 4.75) followed by 60 µL amyloglucosidase from *Aspergillus niger* was added and the mixture was incubated at 60°C for 45 min.

The glucose concentration was determined using a glucose oxidase-peroxidase kit (Sigma-Aldrich, G3660-1CAP). The rate of starch digestion was expressed as a percentage of the total starch hydrolyzed at different times (30, 60, 90, 120, 150 and 180 min). A non-linear model was applied to describe the kinetics of the starch hydrolysis (Goni *et al*., 1996). The first order equation had the form $C = C\infty\,(1 - e^{-kt})$ and the areas under the Hydrolysis Curve (AUC) were calculated using the following equation:

$$AUC = C\infty\left(t_f - t_0\right) - \left(C\infty / k\right)\left[1 - exp\left(tf - t0\right)\right]$$

C = Percentage of starch hydrolyzed at time t
C∞ = Equilibrium percentage of starch hydrolyzed after 180 min
k = Kinetic constant
t = Time
t_f = Final time (180 min) and
t_0 = Initial time (0 min)

The Hydrolysis Index (HI) was obtained by dividing the area under the hydrolysis curve of each sample by the corresponding area of a reference sample. The estimate of Glycemic Index (GI) was calculated using this equation:

$$GI = 39.71 + \left(0.549 \times HI\right)$$

Frei *et al*. (2003)

Volume and Weight of Loaves

Bread loaf volume was determined using the rapeseed displacement method (AOAC, 2000). Briefly, a container was filled with rapeseed and the volume of the rapeseed was measured using a measuring cylinder (V_1). Then, the bread sample was placed into the container and the volume of the rapeseed with the bread sample was measured and noted as V_2. The analysis was performed with triplicate samples. The volume of each loaf was calculated using the equation:

$$Loaf\ volume = V_1 - V_2\left(mL\right)$$

Loaf weight was determined using the AACC (2000). The weight of bread loaves was measured in gram units using normal weighing methods. Each loaf was weighed one hour after the cooling process. Specific volume (mL/g) was determined by dividing the loaf volume by the loaf weight. Oven spring (cm) was calculated using the differences between loaf heights before and after baking.

Texture Profile Analysis (TPA)

TPA values (hardness, elasticity, cohesiveness, gumminess and chewiness) were measured using a TA-XT plus (Stable Micro Systems, Surrey, UK) with a 25 kg load cell following the method of Szczesniak (1963). Samples were cut into 1×1 cm squares and compressed using a probe (P 1.51, 11/2 inch diameter aluminum cylinder) at a constant rate of 5 mm/sec. The compression distance was 60%, with a 5 mm/sec pre-test and post-test speed. Hardness was defined by the peak force required for the first compression. Elasticity was defined by the distance of the sample back to its original height during time overlap between the end of the first compression and the beginning of the second compression. Cohesiveness was calculated as the ratio of the area under the curve of the second compression to the area under the curve of the first compression. Gumminess was calculated by multiplying hardness and cohesiveness and chewiness was calculated as the product of gumminess and elasticity.

Sensory Evaluation

A hedonic sensory evaluation was performed using the method of Lawless and Heymann (1999) with 30 panelists, who were students of the Food Technology Division USM. Seven attributes were evaluated by the panel including crumb color, crust color, aroma, taste, softness, moistness and overall acceptance. A nine item hedonic scale was used (9-like extremely, 8-like very much, 7-moderately like, 6-slightly like, 5-like/dislike, 4-dislike slightly, 3-dislike moderately, 2-dislike very much and 1-dislike extremely). Prior to the analysis, 4 types of coded samples were given to the panelists with a cup of plain water (used as a mouth rinse before they evaluated each sample). The sample was sliced into pieces 10×2 cm and placed on a plate coded with a 3 digit random number. The prepared samples were wrapped in plastic to avoid the loss of moistness.

Statistical Analysis

SPSS software (SPSS 17.0 for Windows, SPSS Inc., Chicago, IL, USA) was used to evaluate the data. All analyses were performed in triplicate. Analytical variation was established through a one-way Analysis Of Variance (ANOVA). Data were reported as the means ± standard deviations. Comparison of means was performed using Duncan's multiple-range test with a 0.05 level of significance. For the results of the sensory evaluation, Turkey's multiple-range test was used with a 0.05 level of significance.

Results

Proximate Composition, Crude Fiber and Resistant Starch Content

The proximate composition, crude fiber and resistant starch content of the bread samples are presented in Table 2. There was no significant difference (p>0.05) in moisture content between the control, TF5 and TF10, which were 4.23–4.61%. However, the TF15 had a significantly lower (p<0.05) moisture content (3.92%) than that of the other samples. The crude protein content of the samples exhibited a trend similar to the moisture content; TF15 had a significantly lower (p<0.05) protein content (0.79%) than the other bread formulations (0.95–0.99%) and there was no significant difference (p>0.05) in crude protein contents between the control, TF5 and TF10. It appears that the addition of TF increased the fat content of the bread. There was no significant difference (p>0.05) in the ash content of the treated samples; however, the ash content of the control sample (4.18%) was significantly higher (p<0.05) than the treated samples. The carbohydrate content of the control and TF15 were significantly higher (p<0.05) than TF5 and TF10. There was no significant difference (p>0.05) between the control and treated samples in the crude fiber content. Resistant starch content varied significantly (p<0.05) among the bread samples.

Mineral Content

The major elements found in tempoyak were potassium, magnesium and calcium with 601, 103.50 and 20 mg 100 g^{-1} sample, respectively. Sodium, iron, copper and zinc were also present in trace amounts. Results showed that potassium (1187.03 mg 100 g^{-1} sample), magnesium (205.45 mg 100 g^{-1} sample) and calcium (41.12 mg 100 g^{-1} sample) were significantly (p<0.05) higher in Tempoyak Flour (TF) as compared to tempoyak. Figure 1 shows the major mineral content found in bread incorporated with TF. The iron, zinc and copper content in samples containing TF at different concentration (0, 5, 10 and 15%) were in a range of 0.95-1.63, 0.41-1.06 and 0.32-0.57 mg 100 g^{-1} sample, respectively. Generally, potassium and calcium contents in bread were observed to increase significantly (p<0.05) as amount of TF increased. The control sample had a significantly (p<0.05) higher amount of magnesium than treated bread. The TF5 was significantly (p<0.05) lower in magnesium content than the control, TF10 and TF15.

Glycemic Index (GI)

Figure 2 shows the GI of the bread samples. The GI value varied significantly (p<0.05) among the bread samples. The GI value decreased with the increased percentage of TF. The control sample had the highest GI value (63.72), while TF15 had the lowest (54.11).

Quality Parameters of Loaf Bread

Table 3 shows the quality parameters of the loaf bread samples. The data shows that the bread volume of all samples varied significantly (p<0.05). The volume of the control sample (1012 mL) was significantly higher (p<0.05) than all treated samples. By increasing the percentage of TF in the bread, the formation of the gluten network was reduced.

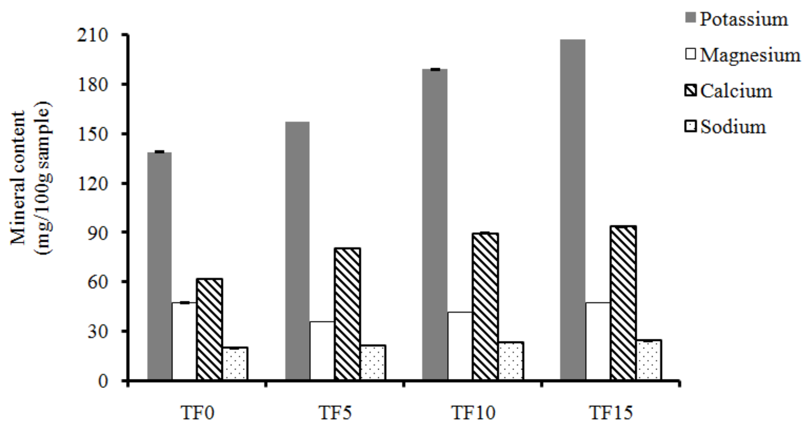

Fig. 1. Mineral content of bread samples Values are mean of each triplicate analyses with ± standard deviation. TF0 (Control) = 100% wheat flour, TF5 = 5% TF + 95% wheat flour, TF10 = 10% TF + 90% wheat flour, TF15 = 15% TF + 85% wheat flour

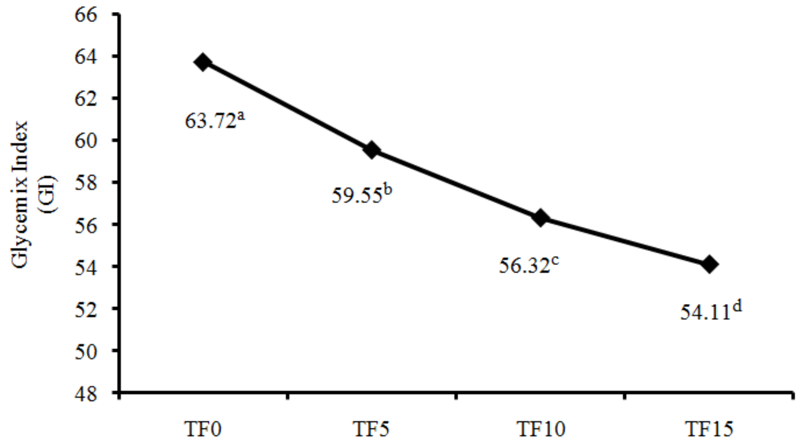

Fig. 2. Glycemix index of bread samples Values are mean of each triplicate analyses with ± standard deviation. Different letters in the same column indicate significant differences (p<0.05). TF0 (Control) = 100% wheat flour, TF5= 5% TF + 95% wheat flour, TF10 = 10% TF + 90% wheat flour, TF15 = 15%

Table 2. Proximate composition, crude fibre and resistant starch content (%) of bread samples

Composition (%)	TF0	TF5	TF10	TF15
Moisture	4.61^{a}±0.12	4.54^{a}±0.07	4.23^{a}±0.13	3.92^{b}±0.07
Crude Protein	0.99^{a}±0.05	0.97^{a}±0.15	0.95^{a}±0.04	0.79^{b}±0.15
Fat	3.70^{c}±0.18	6.27^{a}±0.21	6.33^{a}±0.09	5.27^{b}±0.07
Ash	4.18^{a}±0.02	3.16^{b}±0.16	3.20^{b}±0.03	3.27^{b}±0.11
Carbohydrate	86.52^{a}±0.08	85.06^{b}±0.13	85.29^{b} ±0.01	86.75^{a}±0.03
Crude Fibre	7.93^{a}±0.10	7.88^{a}±0.01	7.60^{a}±0.20	7.81^{a}±0.08
Resistant starch	2.85^{d}±0.10	3.63^{c}±0.04	5.39^{b}±0.02	7.01^{a}±0.21

Values are mean of each triplicate analyses with ± standard deviation. Different letters in the same row indicate significant differences (p<0.05). TF0 (Control) = 100% wheat flour, TF5 = 5% TF + 95% wheat flour, TF10 = 10% TF + 90% wheat flour, TF15 = 15% TF + 85% wheat flour

Table 3. Quality parameters of loaf bread

Parameter	TF0	TF5	TF10	TF15
Loaf volume (mL)	1012.00^{a}±2.25	860.00^{b}±1.23	810.00^{b}±2.03	780.00^{b}±4.09
Specific Volume (mL/g)	4.59^{a}±0.02	3.87^{b}±0.04	3.57^{b}±0.03	3.34^{b}±0.04
Loaf Weight (g)	220.04^{d}±0.89	221.84^{c}±2.23	226.69^{b}±1.54	233.24^{a}±2.57
Oven Spring (cm)	4.70^{a}±0.01	3.83^{b}±0.06	3.47^{b}±0.05	3.34^{b}±0.12

Values are mean of each triplicate analyses with ± standard deviation. Different letters in the same row indicate significant differences (p<0.05). TF0 (Control) =100% wheat flour, TF5 = 5% TF + 95% wheat flour, TF10 = 10% TF + 90% wheat flour, TF15 = 15% TF + 85% wheat flour

Table 4. TPA value of four different bread formulations

Parameter	TF0	TF5	TF10	TF15
Hardness (kg)	0.73^{d}±0.05	0.78^{c}±0.04	0.82^{b}±0.01	0.88^{a}±0.02
Elasticity	10.05^{d}±0.08	10.59^{a}±0.03	10.39^{b}±0.05	10.19^{c}±0.07
Cohesiveness (ratio)	0.56^{b}±0.02	0.59^{b}±0.03	0.60^{a}±0.01	0.61^{a}±0.02
Gumminess	0.41^{b}±0.03	0.46^{b}±0.03	0.49^{b}±0.01	0.54^{a}±0.02
Chewiness (g)	4.12^{b}±0.29	4.87^{b}±0.02	5.09^{a}±0.10	5.50^{a}±0.22

Values are mean of each triplicate analyses with ± standard deviation. Different letters in the same row indicate significant differences (p<0.05). TF0 (Control) = 100% wheat flour, TF5 = 5% TF + 95% wheat flour, TF10 = 10% TF + 90% wheat flour, TF15 = 15% TF + 85% wheat flour

Table 5. Hedonic scores for different bread formulation

Attributes	TF0	TF5	TF10	TF15
Crumb Colour	5.71^{a}±0.47	4.43^{b}±1.26	5.82^{a}±0.54	4.41^{b}±0.70
Crust Colour	4.81^{b}±1.13	5.22^{a}±1.15	3.21^{c}±1.58	3.12^{c}±1.05
Aroma	5.47^{a}±0.50	5.19^{a}±1.29	5.10^{a}±1.86	5.05^{a}±1.51
Taste	5.62^{a}±0.82	5.81^{a}±1.32	4.92^{b}±1.56	5.58^{a}±1.88
Softness	6.43^{a}±1.73	6.43^{a}±0.87	5.57^{b}±1.36	5.23^{b}±1.49
Moistness	6.85^{a}±1.36	5.55^{b}±1.81	5.56^{b}±1.60	5.04^{b}±1.47
Overall Acceptance	6.53^{a}±0.97	6.41^{a}±1.65	6.00^{a}±1.28	4.62^{b}±1.76

Values are mean of each triplicate analyses with ± standard deviation. Different letters in the same row indicate significant differences ($p<0.05$). TF0 (Control) = 100% wheat flour, TF5 = 5% TF + 95% wheat flour, TF10 = 10% TF + 90% wheat flour, TF15 = 15% TF + 85% wheat flour

Texture Properties

Table 4 shows the TPAs value for each formulation of bread. The hardness of the bread varied significantly ($p<0.05$) and the hardness increased with increasing TF in the formulation. This result is related to the moisture content of each formulation. A significant difference ($p<0.05$) in the elasticity was found for all different formulations of bread. The cohesiveness and chewiness of TF10 and TF15 were significantly higher ($p<0.05$) than that of the control and TF5. The 5% substitution of TF did not affect cohesiveness and chewiness of bread compared with the 10 and 15% substitutions.

Sensory Evaluation

Table 5 shows the results obtained from the hedonic analysis of all the bread products. For crumb color, the control and TF10 had significantly higher scores ($p<0.05$) than the TF5 and TF15. Panelists scored the crumb color of the control and TF10 from neutral to like slightly and the crumb color of TF5 and TF15 were scored from dislike slightly to neutral. For the crust color evaluation, TF5 had the highest score, from neutral to like slightly. In the aroma evaluation, there was no significant difference ($p>0.05$) between bread samples. However, the control sample (5.47) scored the highest in the aroma evaluation. The control sample and TF5 were significantly higher ($p<0.05$) in softness scores than TF10 and TF15. This indicates that consumers prefer softer bread; the instrumental hardness values of the control and TF5 were lower than TF10 and TF15 (Table 4). For the moistness evaluation, the control was significantly higher ($p<0.05$) than the treated samples. This result is in agreement with the results obtained from the chemical analysis of moisture content (Table 2). The overall acceptance scores of the bread were not significantly different ($p>0.05$) in the control, TF5 and TF10.

Discussion

The difference in moisture content in bread may due to the higher percentage of TF in the TF15. This result is consistent with that of Sankhon *et al.* (2013) for wheat bread supplemented with locust bean flour. That study reported that the higher the amount of locust bean flour used in the formulation, the lower the moisture content of the bread. Similar results were also reported by Wang *et al.* (2002) as inulin fiber added to wheat dough bread. The lower protein content in TF15 is most likely due to the addition of TF, which has lower protein content than wheat flour. Pyler (1988) reported that TF contained 2.5% protein, which is lower than whole wheat flour (6-18%).TF5 and TF10 were significantly higher ($p<0.05$) in fat content (6.27 and 6.33%, respectively) than that of the control and TF15. According to Souci *et al*. (1994), TF has a higher fat content compared to wholemeal flour. The higher level of TF in the bread resulted in a higher resistant starch content. This most likely because TF has a higher resistant starch content than wheat flour; wheat flour only contains 1.47% resistant starch (Sankhon *et al*., 2013). Sankhon *et al.* (2013) also reported that resistant starch content in wheat and parkia bread was increased as lower temperatures and longer baking times applied. The degree of milling, heating, freezing, drying and moisture level during baking also contribute to the formation of resistant starch. During fermentation, short-chain fatty acids consisting of acetate, propionate and butyrate are produced by the colon microflora in the intestine (Besten *et al*., 2013). These short chain fatty acids have the potential to reduce ulcers and colon cancer and, at the same time, promote the metabolism of lipid and cholesterol (Wong *et al*., 2006; Sharma *et al*., 2008). Sajilata *et al.* (2006) reported that resistant starch has protective effects against colon disease, attributed to the role of butyric acid as the major energy substrate for the colon.

Gorinstein *et al.* (2011) reported that the main minerals present in durian were potassium and calcium. They also reported that potassium is abundant in most studied fruits and plays an important role in fruit quality. The higher mineral content in the TF is likely because the drying process concentrates the minerals (the surface area per volume is increased as the particle size of TF becomes smaller). The similar results was reported by Asif-Ul-Alam *et al.* (2014), the lower moisture content of banana flour resulted in higher minerals content in the study of different drying process of banana flour. Tempoyak alone, as a wet sample, had a high moisture content resulting in a lower proportion of minerals. Durian is a good source of potassium, magnesium, sodium and calcium (Gorinstein *et al*., 2011). Trinidad *et al*. (2006) reported that wheat bread has higher zinc and iron contents and lower calcium contents than bread produced from composite flour with coconut.

According to Atkinson *et al.* (2008), food with a GI value less than 55 is categorized as a low GI food; therefore, TF15 can be considered a low GI food. Low GI foods are beneficial for individuals suffering from impaired glucose tolerance (Frei *et al*., 2003). The reduction in the GI value may be due to several factors, such as resistant starch, viscous fiber, intact cereal grains, organic acid produced in fermentation, fats and dairy protein (Foster-Powell *et al*., 2002). Resistant starch lowers the GI value by reducing the glucose rate in the blood (Hu *et al*., 2004). Hence, the bread substituted with TF, which was rich in resistant starch and had a low fat content, is suitable to lower the GI value. High resistant starch and dietary fiber contents in food will also help to lower the GI value. As the rate of starch hydrolysis is low, the insulin level will also become lower. The reduced insulin response will delay the glucose absorption, thus reducing the risk of diabetes.

Rouille *et al.* (2005) defines loaf volume as the space occupied by the bread loaf. Gas retention is the main factor contributing to the loaf volume and crumb structure of bread. Gluten is essential for gas retention capacity in dough (Singh and MacRitchie, 2001). Wheat flour contains 12.5-15.7% protein, which is higher than the protein in TF and a high amount of protein is required to form the gluten network (Różyło and Laskowski, 2011). Moreover, the interaction between gluten and fiber will weaken the gluten formation and result in a lower bread volume (Wang *et al*., 2002). Specific volumes of bread are a characteristic quality parameter that indicates dough inflating ability and oven spring (Giannou and Tzia, 2007). The specific volume of the control sample (4.59 mL g^{-1}) was significantly higher (p<0.05) than all treated samples; however, there was no significant difference (p>0.05) in the loaf specific volume among the treated samples (3.34-3.87 mL g^{-1}). The similar results were reported by Sankhon *et al.* (2013) in wheat bread incorporated with different concentration of locust bean flour. Shittu *et al.* (2007) reported that the quantity and quality of the protein in the flour, as well as proofing time, affects the specific volume. The specific volume was reduced when TF was added to the bread formulation and this was most likely because the TF reduced the interaction between gluten and fiber and inhibited free expansion during the fermentation process. The specific volumes of breads prepared from composite flours such as commercial gluten flour, non-diary gluten-free flour and diary gluten-free flour were 11-41% less than those of bread made from wheat flour (Moore *et al*., 2004). The higher percentage of TF significantly increased (p<0.05) the loaf weight of the breads. This is most likely due to the higher water holding capacity of TF than wheat flour. Some studies have reported that dried durian has a good water holding capacity, thus the presence of durian fiber in bread dough enhances water absorption (Rosell *et al*., 2001). However, an increased level of hydration is required when dietary fibers are added to the food formulation (Chowdhury *et al*., 2012). The presence of hydroxyl groups in fiber allows more water interaction through hydrogen bonding (Rosell *et al*., 2001). Oven spring showed the same trend as loaf volume; the loaf oven spring of the control sample (4.70 cm) was significantly higher (p<0.05) than the treated samples (3.34-3.83 cm). The incorporation of TF in the bread formulations reduced the loaf oven spring of the breads. This result is in agreement with those of Wang *et al.* (2002) who used many types of fibers in the composite flour bread formulations. They found that bread with a high percentage of fiber resulted in a lower oven spring value. This phenomenon is due to the reduction in dough viscosity and the increase in resistance to expansion with the addition of TF (Nwosu *et al*., 2014).

The moisture content contributes to the hardness characteristic of breads and tends to result in low elasticity in the bread (Khalil *et al*., 2000). Eriksson *et al.* (2014) reported that the acceptable substitution for composite flour was below 20%; over that value, the dough will be more viscous and have difficulty in expanding, resulting in a hard and compressed bread. Some additional factors that may contribute to the cohesiveness characteristic are storage temperature and condition, relative humidity and packaging materials. For the gumminess characteristic, only TF15 was significantly higher ($p<0.05$) than the other formulations.

In the bakery products, a uniform color and a golden brown crust are often desirable (Hossain *et al*., 2014). TF10 and TF15 had the lowest scores (3.12-3.21) for crust color, as most panelists preferred a lighter color of crust. In addition, the color of processed product is often expected to be as similar as possible to the raw material (MacDougall, 2002). This most likely due to the panelists' familiarity with white bread. The taste of durian in the bread produces a special sensation. The taste score of the control sample was not significantly different ($p>0.05$) than that of TF5 and TF15. This indicates that the addition of TF at approximately 10 and 15% did not affect the taste score of the consumer. Panelists judged the softness of the control and TF5 from like slightly to like moderately, while TF10 and TF15 were scored from neutral to like slightly. This may due to the addition of TF that caused the collapse of the gluten matrix and a change in the disulfide bond composition between the tempoyak and gluten proteins, resulting in oxidation and hardness of the gluten and harder bread (Shogren *et al*., 2003). This result is in line with the findings of Khalil *et al.* (2000) where higher percentages of tapioca flour used in formulations resulted in harder textures. The decreased in moisture content of bread as percentage of TF increased might be due to the lower ability of the dough to bind with water, resulting in the collapse of the gluten structure and a loss of moisture (Sciarini *et al*., 2010). The substitution of more than 10% TF was not preferred by the panelists (dislike slightly to neutral). This may due to the taste of durian in the bread substituted with more than 10% TF. According to Shogren *et al.* (2003), bread with a high substitution of soy flour had a strong correlation between the taste of the bread and the overall acceptance of the bread produced.

Conclusion

The development of bread with composite flour with TF could increase the value of durian and tempoyak and also enrich the nutritional value of bread. The major minerals in all bread samples included calcium, sodium, magnesium and potassium. The higher the TF in the formulation, the higher the calcium and potassium found in the bread. The resistant starch increased with an increased percentage of TF, indicating a good potential for resistant starch. The bread made with 15% TF showed the lowest GI value (54.11), which is suitable for individuals with impaired glucose tolerance.

The incorporation of TF in bread increased the weight and decreased the volume, specific volume and oven spring of the bread. The color of the crumb and crust of the bread tend to be darker with an increasing percentage of TF. The use of TF in bread affected the texture; hardness increased with an increase of TF in the formulation. Substitution of up to 10% of the wheat flour with TF did not affect the overall acceptance judged by the panelists. Future studies should be conducted to examine ways to improve the shelf-life of the product, suitable additives and the packaging materials for this bread.

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Author's Contributions

All authors of this research article have directly participated in the planning, execution and data analysis and manuscript preparation.

Ethics

This article is original and contains unpublished material. All of the authors have read and approved the manuscript and no ethical issues involved.

References

Amin, A.M., Z. Jaafar and L.K. Ng, 2004. Effect of salt on tempoyak fermentation and sensory evaluation. J. Biol. Sci., 4: 650-653. DOI: 10.3923/jbs.2004.650.653

AACC, 2000. Approved ethods of the American Association of Cereal Chemists. 10th (Edn.), AACC, St. Paul, Minn., ISBN-10: 1891127128, pp: 1200.

Anabesa, M.A., D. Voria, E.B. Esguerra and M. Sarcos, 2006. Postharvest behaviour and storage life of 3 durian cultivars with varying maturity, waxing and temperature. Philippine J. Crop Sci., 31: 29-46.

Asif-Ul-Alam, S.M., M.Z. Islam, M.M. Hoque and K. Monalisa, 2014. Effects of drying on the physicochemical and functional properties of green banana (*Musa sapientum*) flour and development of baked product. Am. J. Food Sci. Technol., 2: 128-133. DOI: 10.12691/ajfst-2-4-4

AOAC, 2000. Official methods of analysis of the AOAC. 17th Edn., Association of Official Analytical Chemists, Arlington, Va., ISBN-10: 0935584242.

Atkinson, F.S., K. Foster-Powell and J.C. Brand-Miller, 2008. International tables of glycemic index and glycemic load values: 2008. Diabetes Car., 31: 2281-2283. DOI: 10.2337/dc08-1239

Bai-Ngew, S., N. Therdthai, P. Dhamvithee and W. Zhou, 2014. A study of the effect of the drying process on the composition and physicochemical properties of flours obtained from durian fruits of two ripening stages. Int. J. Food Sci. Technol., 49: 230-237. DOI: 10.1111/ijfs.12303

Besten, G., K. Eunen, A.K. Groen, K. Venema and D.J. Reijngoud *et al*., 2013. The role of short-chain fatty acids in the interplay between diet, gut microbiota and host energy metabolism. J. Lipid Res., 54: 2325-2336. DOI: 10.1194/jlr.R036012

Cauvain, S.P., 2007. Bread-Making Processes. In: Technology of Breadmaking, Cauvain, S.P. and Young, L.S. (Eds.), Springer Science and Business Media, New York, ISBN-10: 0387385657, pp: 21-49.

Chin, S.T., S.A.H. Nazimah, S.Y. Quek, Y.B. Che Man and R.A. Rahman *et al*., 2007. Analysis of volatile compounds from Malaysian durians (*Durio zibethinus*) using headspace SPME coupled to fast GC-MS. J. Food Comp. Analysis, 20: 31-44. DOI: 10.1016/j.jfca.2006.04.011

Chowdhury, A.R., A.K. Bhattacharyya and P. Chattopadhyay, 2012. Study on functional properties of raw and blended jackfruit seed flour (a non-conventional source) for food application. Ind. J. Nat. Prod. Resour., 3: 347-353. nopr.niscair.res.in/handle/123456789/14815

Devalaraja, S., S. Jain and H. Yadav, 2011. Exotic fruits as therapeutic complements for diabetes, obesity and metabolic syndrome. Food Res. Int., 44: 1856-1865. DOI: 10.1016/j.foodres.2011.04.008

Eriksson, E., K. Koch, C. Tortoe, P.T. Akonor and C. Oduro-Yeboah, 2014. Evaluation of the physical and sensory characteristics of bread produced from three varieties of cassava and wheat composite flours. Food Public Health, 4: 214-222. DOI: 10.5923/j.fph.20140405.02

Foster-Powell, K., S.H. Holt and J.C. Brand-Miller, 2002. International table of glycemic index and glycemic load values. Am. J. Clin. Nut., 76: 5-56. PMID: 12081815

Frei, M., P. Siddhuraju and K. Becker, 2003. Studies on the *in vitro* starch digestibility and the glycemic index of six different indigenous rice cultivars from the Philippines. Food Chem., 83: 395-402. DOI: 10.1016/S0308-8146(03)00101-8

Giannou, V. and C. Tzia, 2007. Frozen dough bread quality and textural behaviour during prolonged storage e prediction of final product characteristics. J. Food Eng., 79: 929-934. DOI: 10.1016/j.jfoodeng.2006.03.013

Goni, I., L. Garcia-Diaz, E. Manas and F. Saura-Calixto, 1996. Analysis of resistant starch: A method for foods and food products. Food Chem., 56: 445-449. DOI: 10.1016/0308-8146(95)00222-7

Gorinstein, S., S. Poovarodom, H. Leontowicz, M. Leontowicz and J. Namiesnik *et al*., 2011. Antioxidant properties and bioactive constituents of some rare exotic Thai fruits and comparison with conventional fruits: *In vitro* and *in vivo* studies. Food Res. Inter., 44: 2222-2232. DOI: 10.1016/j.foodres.2010.10.009

Grandjar, I., 2000. Fermentation of the Far East. In: Encyclopedia of Food Microbiology, Robinson, R.K., C.A. Batt and P.D. Patel (Eds.), Academic Press, San Diego, ISBN-10: 0122270703, pp: 767-773.

Hefnawy, T.M.H., G.A. El-Shourbagy and M.F. Ramadan, 2012. Impact of adding chickpea (*Cicer arietinum* L.) flour to wheat flour on the rheological properties of toast bread. Food Res. Inter., 19: 521-525.

Hu, P., H. Zhao, Z. Duan, Z. Linlin and D. Wu, 2004. Starch digestibility and the estimated glycemic score of different types of rice differing in amylose contents. J. Cereal Sci., 40: 231-237. DOI: 10.1016/j.jcs.2004.06.001

Hossain, M.T., M.M. Hossain, M. Sarker, A.N. Shuvo and M.M. Alam *et al*., 2014. Development and quality evaluation of bread supplemented with jackfruit seed flour. Int. J. Nut. Food Sci., 3: 484-487. DOI: 10.11648/j.ijnfs.20140305.28

Islam, M.Z., M. Shams-Ud-Din and M.A. Haque, 2011. Studies on the effect of brown rice and maize flour on the quality of bread. J. Bangladesh Agril. Univ., 9: 297-304. DOI: 10.3329/jbau.v9i2.11044

Jangam, S.V., C.L. Law and A.S. Mujumdar, 2011. Drying of foods, vegetables and fruits.

Khalil, A.H., E.H. Mansour and F.M. Dawoud, 2000. Influence of malt on rheological and baking properties of wheat–cassava composite flours. LWT-Food Sci. Technol., 33: 159-164. DOI: 10.1006/fstl.1999.0629

Lawless, H.T. and H. Heymann, 1999. Sensory Evaluation of Food: Principles and Practices. 1st Edn., Springer Science and Business Media, New York, ISBN-10: 083421752X, pp: 848.

MacDougall, D.B., 2002. Colour in Food: Improving Quality. 1st Edn., Woodhead Publishing, Boca Raton, Fla., ISBN-10: 1855735903, pp: 378.

Moore, M.M., T.J. Schober, P. Dockery and E.K. Arendt, 2004. Textural comparison of gluten-free and wheat based doughs, batters and breads. Cereal Chem., 81: 567-575. DOI: 10.1094/CCHEM.2004.81.5.567

Ngalani, J.A., 1989. Promotion of the plantain: Study of getting, characterization and use of flours–Conversation in freshly. PhD Thesis, University of Sciences and Techniques of Languedoc.

Nwosu, N.J., C.I. Owuamanam, G.C. Omeire and C.C Eke, 2014. Quality parameters of bread produced from substitution of wheat flour with cassava flour using soybean as an improver. Am. J. Res. Comm., 2: 99-118.

Pyler, E.J., 1988. Baking: Science and Technology. 1st Edn., Siebel Publishing Company, Chicago, ISBN-10: 0982023901.

Rosell, C.M., J.A. Rojas and C. Benedito de Barber, 2001. Influence of hydrocolloids on dough rheology and bread quality. Food Hydrocoll., 15: 75-81. DOI: 10.1016/S0268-005X(00)00054-0

Rouille, J., J.M. Bonny, G. Della Valle, M.F. Devaux and J.P. Renou, 2005. Effect of flour minor components on bubble growth in bread dough during proofing assessed by magnetic resonance imaging. J. Agric. Food Chem., 53: 3986-3994. DOI: 10.1021/jf047953r

Różyło, R. and J. Laskowski, 2011. Predicting bread quality (bread loaf volume and crumb texture). Polish J. Food Nut. Sci., 61: 61-67. DOI: 10.2478/v10222-011-0006-8

Rupérez, P., 2002. Mineral content of edible marine seaweeds. Food Chem., 79: 23-26. DOI: 10.1016/S0308-8146(02)00171-1

Sajilata, M.G., S.S. Rekha and R.K. Pushpa, 2006. Resistant starch-A review. Comprehensive Rev. Food Sci. Food Safety, 5: 1-7. DOI: 10.1111/j.1541-4337.2006.tb00076.x

Sankhon, A., I. Amadou and W.R. Yao, 2013. Application of resistant starch in bread: Processing, proximate composition and sensory quality of functional bread products from wheat flour and African locust bean (*Parkia biglobosa*) flour. Agric. Sci., 4: 122-129. DOI: 10.4236/as.2013.45B023

Sciarini, L.S., P.D. Ribotta, A.E. León and G.T. Pérez, 2010. Influence of gluten-free flours and their mixtures on batter properties and bread quality. Food Bioprocess Tech., 3: 577-585. DOI: 10.1007/s11947-008-0098-2

Sharma, A., B.S. Yadav and Ritika, 2008. Resistant starch: Physiological roles and food applications. Food Rev. Int., 24: 193-234. DOI: 10.1080/87559120801926237

Shittu, T.A., A.O. Raji and L.O. Sanni, 2007. Bread from composite cassava-wheat flour: I. Effect of baking time and temperature on some physical properties of bread loaf. Food Res Int., 40: 280-290. DOI: 10.1016/j.foodres.2006.10.012

Shogren, R.L., A.A. Mohamed and C.J. Carriere, 2003. Sensory analysis of whole wheat/soy flour breads. J. Food Sci., 68: 2141-2143. DOI: 10.1111/j.1365-2621.2003.tb07033.x

Singh, H. and F. MacRitchie, 2001. Application of polymer science to properties of gluten. J. Cereal Sci., 33: 231-243. DOI: 10.1006/jcrs.2000.0360

Souci, S.W., W. Frachmann and H. Kraut, 1994. Food Composition and Nutrition Tables. 5th Edn., Medpharm Scientific Publishing, Stuttgart CRC Press, ISBN-10: 0849375509, pp: 1091.

Steinkraus, K.H., 1995. Handbook of Indigenous Fermented Foods. 2nd Edn., Revised and CRC Press, ISBN-10: 0824793528, pp: 792.

Szczesniak, A.S., 1963. Classification of textural characteristics. J. Food Sci., 28: 385-389. DOI: 10.1111/j.1365-2621.1963.tb00215.x

Trinidad, T.P., A.C. Mallillin, D.H. Valdez, A.S. Lloyola and F.C. Akali-Mercado *et al*., 2006. Dietary fibre from coconut flour: A functional food. Innov. Food Sci. Emerg. Technol., 7: 309-317. DOI: 10.1016/j.ifset.2004.04.003

Wang, J., C. Rosell and C.B. Barber, 2002. Effect of the addition of different fibres on wheat dough performance and bread quality. Food Chem., 79: 221-226. DOI: 10.1016/S0308-8146(02)00135-8

Wong, J.M.W., R. de Souza, C.W.C. Kendall, A. Emam and D.J.A. Jenkins, 2006. Colonic health: Fermentation and short chain fatty acids. J. Clin. Gastroenterol., 40: 235-243. PMID: 16633129