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Physicochemical and sensory quality evaluation of chapati (Indian flat bread) produced by utilizing underutilized jering (*Pithecellobium jiringa* Jack.) legume and wheat composite flours

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Abstract

In this study, physicochemical and sensory qualities of substituting jering seed flour into wheat chapatis (unleavened Indian flat bread) were evaluated at different proportions (5, 10, 15, 20 and 100% of jering seed flour). Chapati prepared with 100% of wheat flour was served as control. Results showed wheat-jering composite chapatis had significantly higher protein (12.68-15.55%), ash (1.78-2.32%) and carbohydrate contents (50.78-54.50%) than that of wheat chapatis which served as control (11.49, 1.77% and 51.62%, respectively). As for the fat content, this ranged from 1.19% to 1.03%, corresponding to the levels of jering seed flour substitution. In terms of physical characteristics, the puffed height and extensibility of the composite chapatis decreased progressively as the level of jering seed flour substitution increased. On the other hand, the peak load required to rupture chapatis showed an inverse trend. It increased significantly from 3.26 to 15.96 N. Further, the colour values of composite chapatis showed significant changes when the level of jering seed flour substitution was increased. The L^* and b^* values decreased while a^* value increased. Regarding sensory properties, control wheat chapatis had better acceptability than the composite chapatis. However, all the composite chapatis had significantly higher nutritional values. Based on the generated results, novel chapatis could be formulated by substituting wheat with jering seed flour.

Introduction

In recent years, overreliance of local communities on carbohydrate-rich diets is being witnessed, especially in the developing regions. Apart from this, demand for wholesome and traditional foods has also increased in majority of the regions world over. Developing novel food products by utilizing local plant resources such as that of legumes and seeds assumes higher importance (Bhat *et al.*, 2014; Bhat and Yahya, 2014). Legumes are high in nutrition, especially proteins (much higher than cereals), fibre, minerals and essential vitamins. As such, legumes are ranked second to cereals as an important source of human nutrition (Bhat and Karim, 2009). Besides, regular consumption of legumes is reported to reduce the risk of chronic diseases (Anderson and Major 2002; Bhat and Karim, 2009).

Jering (*Pithecellobium jiringa* Jack.) is a local popular underutilized legume available in local wet markets of Malaysia. Traditionally, jering seeds are consumed raw, roasted or boiled, as well as are recommended as a therapeutic agent to purify blood, treat diabetes, hypertension, remove bladder stones and to cope up with stomach disorders (Ong *et al*., 2011; Shukri *et al*., 2011; Azliza *et al*., 2012; Sridaran *et al*., 2012). Muslim and Abdul Majid (2010) have mentioned that consumption of jering seeds to cause ‘djenkolism’, which can result in acute anuric renal failure (presence of djenkolic acid in the seeds). However, cases of such incidence reported are highly sporadic (Wong *et al*., 2007). Djenkolism can occur only when large amounts of raw jering seeds are ingested with low fluids intake. However, the occurrence can be prevented by appropriate boiling (or thermal treatments) of the seeds which can effectively eliminate the djenkolic acid (Sakhuja and Sud, 1999; Subhadrabandhu, 2001).

Chapati, an unleavened flat bread of Indian origin is popular in majority of the households in Malaysia. Basically, chapati is prepared using whole wheat flour. It is baked at high temperature for a short time period to cause rapid steam formation and eventually results in puffing of the chapati. Previously, researchers have reported on substitution of wheat chapati with rice bran can be used in improving the nutritional and therapeutic status of diabetic patients (Singh *et al*., 2013). Besides, substitution of wheat chapati with chickpea (Gupta and Kawatra, 1992), faba beans (Abdel-aal *et al*., 1993), lentils and chickpea

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Table 1. Formulations for wheat and jering composite flours

Sample*	Wheat flour	Jering Seed Flour
T0 (Control)	100	0
T1	95	5
T2	90	10
T3	85	15
T4	80	20
T5	0	100

* T0: Control (100% of wheat flour only); T1: Formulation with 5% of jering seed (legume) flour; T2: Formulation with 10% of jering seed (legume) flour; T3: Formulation with 15% of jering seed (legume) flour; T4: Formulation with 20% of jering seed (legume) flour; T5: Formulation with 100% of jering seed (legume) flour

(Shahzadi *et al.*, 2005), spinach (Khan *et al.*, 2013) and cereal brans (Dar *et al.*, 2014) were reported. From the reports, it was noticed that the nutritional and textural characteristics of the composite chapatis had improved. However, to our knowledge there is no report available on utilizing of jering seed flour in the development of any bakery products such as chapatis.

Based on this, the main objective to undertake this study was to evaluate the feasibility of substituting wheat chapatis with jering seed flour to enhance its nutritional values. Furthermore, the effects of incorporating jering seed flour into wheat chapatis were evaluated in terms of physicochemical and sensory properties. The findings of this study are expected to popularize this legume to be used as an added ingredient in the basic diet, and can eventually benefit the consumers.

Materials and Methods

Raw materials

Fresh seeds of jering devoid of any physical, mechanical or microbial injuries were purchased from a local wet market in Penang Island (Bayan Baru market). Commercially available whole wheat flour was purchased from the local supermarket (Tesco extra, Penang). All the chemicals used in this study are of analytical grade.

Preparation of jering seed flour

Initially, the hard seed coat of jering seeds was physically removed to obtain the edible cotyledon portion. The cotyledon was placed in stainless steel container and boiled with potable water at a seed to water ratio of 1:5 (w/v) for 30 minutes. Boiling helps to soften the hard cotyledon, as well as can eliminate antinutritional factors (such as djenkolic acid) in jering seeds (Sakhuja and Sud, 1999; Subhadrabandhu, 2001). After boiling, the skin of the cotyledon was manually removed followed by drying at 50°C for 24 h in a drying cabinet (T500 Dryer, AFOS Ltd, UK). Followed by this, the dried cotyledon portion was ground into flour by a commercial kitchen blender (MX-898M, Panasonic, Malaysia). Finally, ground cotyledon powder was screened through a mesh sieve of 250 µm (Retsch Test Sieve, Germany) and the flour obtained was kept in sealed polyethylene bag at 4°C until further analysis.

Preparation of composite flours

The composite flour blends were prepared by substituting whole wheat flour with jering seed flour at different replacement levels (0, 5, 10, 15, 20 and 100%) as shown in Table 1 by using a kitchen blender (MX-898M, Panasonic, Malaysia) for 5 min. Flour sample with 100% of whole wheat flour was served as the control. The flour blends were then kept in sealed polyethylene bags at 4°C until further analysis.

Proximate composition

Proximate analysis of the whole wheat and jering seed flour, as well as the composite chapatis (unleavened flat breads) was performed independently by adopting standard AOAC methods (AOAC, 2000). Moisture content was determined by hot air oven method (AOAC Method 934.01); crude protein by Micro-Kjeldahl method (AOAC Method 960.52); crude fat by Soxhlet extraction method (AOAC Method 963.15); crude fibre by neutralization method (AOAC Method 945.38) and ash content by dry ashing method (AOAC Method 923.03). Carbohydrate content was calculated by difference (AOAC, 2000).

Total carbohydrate (%) = 100 - % (moisture + protein + fat + fibre + ash)

Water absorption

Water absorption of the composite flours was determined subjectively by employing the method outlined by Gujral and Gaur (2002). Water was added to the flour until the dough formed is smooth, non-sticky, easy to handle and appropriate for subsequent sheeting without exhibiting any cracks. Then, the optimum amount of water added was recorded.

Preparation of chapatis

Chapatis were prepared by following the method as reported by previous researchers (Rao and Bharati, 1996; Kadam *et al*., 2012) with slight modifications. The chapati dough was prepared by mixing composite flour with the pre-determined optimum amount of water and salt (1.5%). The dough was covered with a wet cloth and was set aside to rest for 30 minutes at room temperature (25± 1°C). The dough was divided into equal portions and rolled into a round sheet (12 cm in diameter and about 2 mm in thickness). The chapatis were baked on a pan at 210°C for 150 seconds on each side. After baking, chapatis were cooled on a wire rack at room temperature before packing in sealed pouches.

Physical characteristics of chapatis

Puffed height

The height of chapati was immediately measured after puffing (Haridas Rao *et al.*, 1986).

Texture analysis

The textural property of chapati was measured by using a texture analyzer (TA. XT Plus, Stable Micro Systems, UK). The conditions employed were: pre-test speed= 5.0 mm s^{-1}, test speed=2.0 mm s^{-1}, post-test speed=10.0 mm s^{-1}, distance= 60.0 mm and trigger type= auto. Three chapati strips (5 x 2.5 cm) from each chapati were cut from the centre part of chapati. A chapati strip was held at the centre of the two clamps. One clamp was attached to the platform while the other was attached to the moving arm of the texture analyzer. The clamps were allowed to pull the chapati strip apart until it ruptured. The peak force (N), force required to pull the chapati strip into two pieces and extensibility (mm) were recorded (Yadav *et al.*, 2012).

Colour measurement

The colour of the wheat-jering composite chapatis was evaluated by using colorimeter (Minolta Spectrophotometer CM-3500d, Japan). The colorimeter was calibrated with a standard white and black plate. The colour of samples were recorded in terms of L^* (lightness), a^* (green, $-a$ to red, $+a$) and b^* (blue, $-b$ to yellow, $+b$).

Sensory evaluation

The chapati samples were evaluated in terms of colour, aroma, taste, 'aftertaste', texture and overall acceptance by a total of 30 semi-trained panelists from the Food Technology Division, Universiti Sains Malaysia. The samples were evaluated based on a 7-point hedonic scale with 1 representing the least score (dislike extremely) and 7 as the highest score (like extremely). The sensory laboratory was well equipped with good lighting, airflow and was odourless. The samples were presented to the panelists in 3-digit coded sealed pouches. The panelists were instructed to rinse their mouth thoroughly with potable water in between samples evaluations and they were requested to taste the chapati samples one by one.

Statistical analysis

Results generated in this study are expressed as mean ± standard deviation of three independent replications. The statistical significance of the generated results was obtained by subjecting the results to one-way analysis of variance (ANOVA) along with the least significant difference (LSD) test. The level of significance of the mean values was assigned at $P<0.05$.

Results and Discussion

Proximate composition of flours

The proximate composition of whole wheat flour and jering seed flour is depicted in Table 2. From the results, jering seed flour was recorded to contain lower moisture (7.58%), fat (0.41%) and crude fibre (2.03%) as compared to wheat flour (11.32, 1.57 and 2.55%, respectively). The moisture and fat content of jering seed flour were lower than that of bambara groundnut (11.09 and 4.83%, respectively) and chickpea flour (9.53 and 1.24%, respectively) (Alozie *et al.*, 2009; Noor Aziah *et al*., 2012). On the other hand, jering seed flour had higher protein (15.20%) and ash contents (1.34%) than wheat flour (13.38 and 0.84%, respectively). Legumes are usually rich in protein as compared to cereals such as rice (5-8%), millet (7%) and sorghum (10%) (Sivasankar, 2002). Hence, it was expected that jering seed flour (legume flour) to have relatively higher protein content. The higher ash content in jering seed flour suggests that it contains high mineral content than wheat flour. These findings are comparable to the results reported by Fenn *et al.* (2010) wherein legume flour (soybean, yellow pea

Table 2. Proximate composition of whole wheat and jering seed flour

Parameters	Samples	
	Whole Wheat Flour	Jering seed flour
Moisture (%)	11.32 ± 0.03^{b}	7.58 ± 0.01^{a}
Crude protein (%)	13.38 ± 0.39^{a}	15.20 ± 0.31^{b}
Crude fat (%)	1.57 ± 0.05^{b}	0.41 ± 0.02^{a}
Crude fibre (%)	2.55 ± 0.24^{a}	2.03 ± 0.33^{a}
Ash (%)	0.84 ± 0.02^{a}	1.34 ± 0.01^{b}
Carbohydrate (%)	69.33 ± 0.28^{a}	73.44 ± 0.21^{b}

Values are mean ± standard deviation (n=3). Mean values with different superscript lettersabc within the same row differ significantly (P < 0.05).

Table 3. Proximate composition of wheat-jering composite chapatis

Parameters	Samples *					
	T0	T1	T2	T3	T4	T5
Moisture (%)	32.29 ± 0.02^{e}	32.03 ± 0.09^{de}	31.55 ± 0.12^{d}	30.88 ± 0.15^{c}	30.21 ± 0.21^{b}	25.46 ± 0.32^{a}
Crude protein (%)	11.49 ± 0.05^{a}	12.68 ± 0.12^{b}	12.81 ± 0.06^{bc}	12.94 ± 0.08^{c}	13.22 ± 0.06^{d}	15.55 ± 0.07^{e}
Crude fat (%)	1.19 ± 0.03^{d}	1.15 ± 0.03^{cd}	1.09 ± 0.01^{bc}	1.08 ± 0.02^{ab}	1.06 ± 0.01^{ab}	1.03 ± 0.02^{a}
Crude fibre (%)	1.64 ± 0.09^{d}	1.58 ± 0.09^{cd}	1.45 ± 0.07^{bcd}	1.35 ± 0.11^{abc}	1.30 ± 0.04^{ab}	1.13 ± 0.11^{a}
Ash (%)	1.77 ± 0.02^{a}	1.78 ± 0.04^{a}	1.81 ± 0.04^{a}	1.84 ± 0.02^{a}	1.84± 0.01^{a}	2.32 ± 0.07^{b}
Carbohydrate (%)	51.62 ± 0.16^{bc}	50.78 ± 0.06^{a}	51.29 ± 0.20^{b}	51.92 ± 0.20^{cd}	52.38 ± 0.20^{d}	54.50 ± 0.16^{e}

[*] T0: Control chapatis prepared by using whole wheat flour only (100%); T1: Chapatis substituted with 5% of jering seed (legume) flour; T2: Chapatis substituted with 10% of jering seed (legume) flour; T3: Chapatis substituted with 15% of jering seed (legume) flour; T4: Chapatis substituted with 20% of jering seed (legume) flour; T5: Chapatis with 100% of jering seed (legume) flour

Values are mean ± standard deviation (n=3). Means with different superscript lettersabc within the same row differ significantly (P < 0.05).

and chickpea) encompassed higher protein and ash contents than wheat flour. As for the carbohydrate, it was higher in jering seed flour (73.44%) than wheat flour (69.33%). This value is much higher than some of the common legumes such as cowpea, kidney beans or green peas (carbohydrate content ranges from 63.17-68.96%) (Khattab *et al.*, 2009; Bhat and Karim, 2009). This implies that jering seed flour has the potential to serve as a vital source of energy.

Proximate composition of chapatis

The nutritional composition of the wheat-jering composite chapatis substituted with different levels of jering seed flour is shown in Table 3. From the results, control chapatis (sample T0) were low in protein content. However, it increased significantly from 11.49% to 15.55% as the substitution levels of jering seed flour was increased (from 0 to 100%). Similar trend was also recorded for the ash content wherein it increased from 1.77 to 2.32%. This can be attributed to the incorporation of jering seed flour which possesses high protein and ash content as reported in Table 2. These results are in agreement with the findings reported by Khan *et al.* (2012) in which chapatis substituted with soy flour had higher protein (15.29-16.40%) and ash contents (1.93-2.07%) than wheat-based chapatis (13.24% and 1.62%, respectively). Besides, Seleem and Omran

Table 4. Physical and colour measurements of wheat-jering composite chapatis

Samples*	Physical characteristics				Colour measurements		
	Water absorption (%)	Puffed height (cm)	Peak force (N)	Extensibility (mm)	L^*	a^*	b^*
T0	62.00 ± 3.46^{a}	6.67 ± 0.58^{c}	3.26 ± 0.90^{a}	4.58 ± 0.33^{e}	74.07 ± 1.27^{e}	0.48 ± 0.10^{a}	17.96 ± 2.14^{c}
T1	65.33 ± 1.15^{a}	6.67 ± 0.58^{c}	4.24 ± 1.31^{a}	3.74 ± 0.11^{d}	62.61 ± 0.79^{d}	3.45 ± 0.45^{b}	15.63± 1.41^{bc}
T2	70.67 ± 2.30^{b}	6.33 ± 0.58^{c}	5.99 ± 1.86^{a}	3.18 ± 0.15^{cd}	56.74 ± 1.33^{c}	6.04 ± 0.30^{c}	14.51 ± 0.69^{ab}
T3	80.67 ± 1.15^{c}	4.17 ± 0.29^{b}	6.16 ± 2.31^{a}	2.34 ± 0.32^{c}	57.27 ± 1.50^{c}	5.17 ± 0.05^{c}	14.28 ± 0.21^{ab}
T4	88.00 ± 0.00^{d}	3.00 ± 0.00^{ab}	7.00 ± 1.61^{a}	3.00 ± 0.24^{b}	49.85 ± 0.48^{b}	7.26 ± 0.56^{d}	13.38 ± 0.74^{ab}
T5	90.67 ± 1.15^{d}	2.50 ± 0.50^{a}	15.96 ± 1.87^{b}	1.39 ± 0.11^{a}	41.29 ± 0.25^{a}	8.58 ± 0.22^{e}	11.38 ± 0.45^{a}

* T0: Control chapatis prepared by using whole wheat flour only (100%); T1: Chapatis substituted with 5% of jering seed (legume) flour; T2: Chapatis substituted with 10% of jering seed (legume) flour; T3: Chapatis substituted with 15% of jering seed (legume) flour; T4: Chapatis substituted with 20% of jering seed (legume) flour; T5: Chapatis with 100% of jering seed (legume) flour
L^*: Light to dark; a^*: (green, -*a* to red, +*a*) and b^* (blue, -*b* to yellow, +*b*)
Values are mean ± standard deviation (n=3). Means with different superscript lettersabc within the same column differ significantly (P< 0.05).

(2014) reported that flat breads incorporated with bean flour to have higher protein (9.88-10.18%) and ash contents (1.90-2.10%) compared to control wheat flat bread (9.26% and 1.60%, respectively). However, a reverse trend was noted with regard to moisture, fat and crude fibre content. The moisture content of the composite chapatis was significantly (P<0.05) reduced from 32.29 to 25.46%. However, the range is still comparable to that reported by Khaliduzzaman *et al.* (2010) wherein the moisture content of chapatis substituted with potato flour ranged from 27.00 to 34.54%. Similar trend was observed for composite chapatis substituted with cottonseed flour in which the moisture content reduced from 35.60 to 32.64% (Rasool *et al.*, 2005). As for the fat content, it reduced significantly from 1.19 to 1.03% when higher levels of jering seed flour were incorporated. This can be attributed to the low fat content of jering seed flour (see Table 2). The relatively low fat content in composite chapatis is desirable for health-conscious consumers. The fat content in the wheat-jering composite chapatis is comparable to that reported by Sultana *et al.* (2014) wherein the chapatis substituted with jackfruit seed and Bengal gram flour (chick pea) showed 1.28 to 1.67% of fat content. The crude fibre content of composite chapatis was recorded to be reduced (from 1.64 to 1.13%) corresponding to the jering seed flour substitution levels. However, there was no significant differences between crude fibre content of control chapatis (1.64%) and composite chapatis substituted with 5 and 10% of jering seed flour (1.58 and 1.45%, respectively). Compared to the findings reported by Seleem and Omran (2014), it was found that the crude fibre content of wheat-jering composite chapatis is much higher compared to flat breads substituted with beans and sorghum flour which had only 0.43 to 0.79% of crude fibre content.

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Physical characteristics of chapatis

The physical characteristic of wheat-jering composite chapati is presented in Table 4. Based on the results, it was noticed that the water absorption of wheat-jering composite flours had increase significantly (P<0.05) from 62.00 to 90.67% corresponding to the increase in the levels of jering seed flour substitution. This can be attributed to the low moisture and high protein content of the flour. According to Cauvain and Young (2008), flour which is drier and possessing higher protein content generally exhibits higher water absorption capacity. Similar trend has been recorded by previous researchers wherein water absorption of composite flours tends to increase on incorporation of defatted rice bran and bean flour into the chapati formulations (Yadav *et al.*, 2012; Seleem and Omran, 2014).

Table 5. Sensory attributes of chapatis

Parameters	Samples*					
	T0	T1	T2	T3	T4	T5
Colour	5.13 ± 0.51[c]	5.17 ± 0.65[c]	5.47 ± 0.82[c]	4.17 ± 1.09[b]	3.83 ± 0.99[ab]	3.33 ± 0.88[a]
Aroma	5.47 ± 0.63[d]	5.30 ± 0.54[d]	4.30 ± 0.75[c]	3.40 ± 0.93[b]	2.97 ± 0.85[ab]	2.50 ± 0.78[a]
Taste	5.97 ± 0.67[d]	5.03 ± 0.72[c]	4.23 ± 0.82[b]	2.03 ± 0.81[a]	2.23 ± 0.63[a]	1.90 ± 0.55[a]
Aftertaste	6.00 ± 0.53[e]	5.23 ± 0.73[d]	3.83 ± 0.83[c]	2.33 ± 0.80[b]	2.07 ± 0.79[ab]	1.70 ± 0.54[a]
Texture	5.90 ± 0.71[d]	5.27 ± 0.58[c]	4.77 ± 0.57[c]	3.50 ± 0.86[b]	3.00 ± 0.74[ab]	2.63 ± 0.81[a]
Overall acceptability	5.80 ± 0.41[f]	5.10 ± 0.48[e]	4.30 ± 0.54[d]	3.27 ± 0.64[c]	2.70 ± 0.54[b]	2.23 ± 0.68[a]

*T0: Control chapatis prepared by using whole wheat flour only (100%); T1: Chapatis substituted with 5% of jering seed (legume) flour; T2: Chapatis substituted with 10% of jering seed (legume) flour; T3: Chapatis substituted with 15% of jering seed (legume) flour; T4: Chapatis substituted with 20% of jering seed (legume) flour; T5: Chapatis with 100% of jering seed (legume) flour
Values are mean ± standard deviation (n=30). Means with different superscript lettersabc within the same row differ significantly (P < 0.05).

Puffing is a process wherein two crusts in a chapati are separated owing to instant formation and accumulation of steam generated during the baking process. Puffed height is an important parameter to evaluate the quality of chapati (Ram and Nigam, 1981). According to Srivastava *et al.* (2003), puffed height of chapati can be correlated to the protein and gluten contents. From the results, it was noticed that the puffed height of composite chapatis to decrease significantly from 6.67 to 2.50 cm corresponding to increase in the jering seed flour substitution levels. Similar observation is reported by Yadav *et al.* (2012) wherein substitution of whole wheat flour with defatted rice bran reduced the puffed height of composite chapatis. On top of that, Sharma *et al.* (1999) reported that composite chapatis incorporated with 20 to 25% of cowpea flour to exhibit partial puffing while those with 0 to 15% of cowpea flour displayed full puffing. The reduction in puffed height in chapatis substituted with non-wheat flour can be attributed to the poor gluten quality of the dough and low moisture content, thus resulting in slower rate of steam generation (Haridas Rao *et al.*, 1986; Yadav *et al.*, 2012; Parimala and Sudha, 2015).

With regard to textural properties, the peak force to rupture was found to increase progressively corresponding to the jering seed flour substitution levels. The control wheat chapatis showed lowest peak force (3.26 N) whereas the chapati made from 100% of jering seed flour showed highest (15.96 N). On the other hand, the extensibility of the composite chapatis showed a reverse trend. This decreased significantly from 4.58 mm (control wheat chapati) to 3.00 mm (for composite chapati incorporated with 20% of jering seed flour). As for the chapati made of 100% of jering seed flour, it exhibited the least extensibility (1.39 mm). Based on the report by Yadav *et al.* (2012), the lower peak load (3.1 N) and greater extension distance (11.2 mm) before it was ruptured indicates that the control wheat chapati was soft and extensible. Hence, results from this study indicate that control wheat chapati to be much softer and more extensible than the wheat-jering composite chapatis owed to its lowest peak force and highest extensibility. The findings are in accordance with the report of Yadav *et al.* (2012) wherein the peak load of wheat-defatted rice bran composite chapatis increased and extensibility decreased along with the defatted rice bran substitution levels. However, according to the studies by Gujral *et al.* (2004), it was concluded that the texture of rice flour (non-wheat) chapatis can be improved by the addition of hydrocolloids such as guar gum, xanthan, and others.

Colour measurements of chapatis

The colour measurements of the composite chapatis substituted with different levels of jering seed flour is depicted in Table 4. From the results, it was noticed that the lightness *(L^*)* of the composite chapatis displayed a decreasing trend along with the increasing substitution level of jering flour. It decreased from 74.07 (control) to 41.29 (100% substitution level). The reducing values of L^* indicates that the composite chapatis are darker in colour at higher levels of substitution. Apart from that, the same trend was observed for the yellowness *(b^*)* parameter. The b^* value was reduced from 17.96 to 11.38 as the jering seed flour substitution levels increased from 0 to 100%. Comparable findings were reported by Dar *et al.* (2014) wherein the L^* and b^* values of chapatis enriched with different cereal bran (wheat, rice and oat) decreased as the enrichment levels increased. On the other hand, a reverse trend was noticed for redness *(a^*)* parameter, which increased from 0.48 to 8.58. These changes in colour can be attributed to the 'Maillard reactions' which takes place between reducing sugars and amino acids during the baking process (Chevallier *et al.*, 2000). Colour measurements of food products serve an important role as it is one of the characteristics which have direct effect on the initial acceptance and preference of consumers towards the novel food products developed.

Sensory evaluation

The sensory scores of jering-wheat composite chapatis are depicted in Table 5. From the results, it was found that at 5% of jering seed flour substitution level, all the sensory parameters (except for the colour and aroma), were significantly affected as compared to the control wheat chapatis. The sensory scores of all the parameters decreased corresponding to the jering seed flour substitution levels. However, the scores pertaining to the colour increased from 5.13 (wheat chapatis) to 5.47 (chapatis substituted with 10% of jering seed flour). This is due to the reason that the panelists prefer chapatis with slightly darker colour than the control wheat chapatis. This result is comparable to the results reported by Sharma *et al.* (1999) and Khaliduzzaman *et al.* (2010) wherein the incorporation of more than 10% of cowpea flour and 25% of potato flour in the composite chapatis resulted in a decrease of sensory scores for colour. In terms of aroma, significant decrease in mean scores was noted when more than 10% of jering seed flour was incorporated into the composite chapatis. As for the taste, aftertaste (a taste that persists in the mouth after consuming something) and texture, the mean scores were adversely affected with increasing levels of jering seed flour in the chapatis. The control wheat chapatis (100% wheat flour) were rated the highest (5.97, 6.00 and 5.90, respectively) whereas sample T5 (100% jering seed flour) scored the lowest (1.90, 1.70 and 2.63, respectively). The decrease in the mean scores can be attributed to the intense characteristic taste of jering seed flour. However, McWatters and Heaton (1979) have suggested application of household thermal treatments such as steaming on legumes to improve the overall aroma and taste of seed meals. On the other hand, decrease in mean scores for texture can be attributed to the fact that the composite chapatis become harder when more jering seed flour is incorporated into the formulations. Overall, control wheat chapatis were more acceptable by the sensory panelists followed by wheat-jering composite chapatis substituted with 5, 10, 15 and 20% of jering seed flour. It was noticed that the chapatis prepared from 100% of jering seed flour were rated the lowest for all sensory attributes evaluated. This could be due to the fact that the chapatis were darker, harder and exhibiting the characteristic flavour and aftertaste of jering seed which were found to be unfavourable. Our observations were in agreement with those reported by Ameh *et al.* (2013) in which the overall acceptance of wheat-rice bran composite breads decreased as more rice bran was incorporated into the bread.

Conclusions

In this study, for the first time we attempted to develop novel chapatis by substituting wheat with jering seed flour. Although 100% wheat chapati was organoleptically more acceptable than the composite chapatis, the latter was nutritionally better with higher protein and ash content with reduced fat content. This indicates that jering seed flour possesses higher potential to act as an alternative functional ingredient in wheat products. The reported work is expected to encourage the utilization of composite flour by blending local underexplored legumes such as jering into wheat products. This will eventually benefit consumers as well as able to extend commercial opportunity for this product.

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