Physicochemical, sensorial and nutritional profiling of multigrain flour based chapatti

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ABSTRACT

Chickpea is a significant legume crop due to high protein and dietary fiber contents. Sorghum and millet are not only nutritionally comparable but these are also superior to major cereals with respect to energy, protein, vitamins and minerals. Wheat flour was substituted with chickpea (20, 40 and 60%), millet (15, 30 and 45%) and sorghum (15, 30 and 45%). Maximum energy value was observed in chapattis prepared from flour containing 15% millet flour (651 Kcal/100 g). A decreasing trend in sugar content (glucose, fructose and sucrose), hardness and color of composite flour chapattis was observed by increasing the level of supplementation. Chapatti prepared with 20% chickpea, 15% millet and 15% sorghum flour showed maximum acceptability. Conclusively, the chapattis prepared from composite flour chapatti constitute less sugar content as compared to normal wheat flour chapatti; hence, it may prove beneficial for hyperglycemic individuals.

Keywords: Chickpea, composite flour, chapatti, diabetes.

INTRODUCTION

In this era, therapeutic potential of food is gaining its revival as consumer’s diet preference is continuously changing. It has now been regarded as a cornerstone in the management of chronic ailments such as obesity, cardiovascular disease and has opened new pathways for the processors to develop functional foods. The rapid urbanization, sedentary life style and changes in dietary habits lead towards the present endemic situation of diabetes across the world (Bisoi et al., 2012). Cereals are the prime food globally, thus, it can be a viable strategy to incorporate and modify the staple diet. This concept incited pragmatic research on supplementing flour from other cereals and legumes (Popkin et al., 2001). In Pakistan, wheat is the staple crop and mostly consumed in the form of flat bread known as chapatti. About 80% of wheat is utilized for preparation of “rotis” or “chapattis” (Gujral and Pathak, 2002).

Sorghum (Sorghum bicolor) ranks 5th in the world cereals grain production (Audilakshmi et al., 2010). It is an imperative staple food in developing countries and considered as an important cereal in numerous parts of the world (Smith and Frederiksen, 2000). Various studies revealed that sorghum has cholesterol-lowering properties, anti-carcinogenic activity and can reduce the risk of heart diseases. Tannins in sorghum significantly lower the working of digestive enzymes and decreased the estimated glycemic indices (EGI). Starchy endosperm of sorghum may be less digestible because of limiting access to the interior portion due to hard peripheral endosperm (Kil et al., 2009).

Millet (Pennisetum glaucum) ranks 4th in the world cereals grain production. It contains a plethora of nutrients that is, 60 to 70% carbohydrates, 7 to 11% protein, 1.5 to 5% fat, 2 to 7% crude fiber, vitamins and minerals along with numerous bioactive meioties (Shahidi and Chandrasekara, 2013). Grains of millet are superior to major cereals regarding the energy value, protein, vitamins and minerals. They release sugars very slowly and thus have a low glycemic index (GI) and hence can be used in therapeutic diet of diabetics (Chethan and Malleshi, 2007).
Table 1: Sugar content of composite flour pattis (g/100 g).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Glucose</th>
<th>Fructose</th>
<th>Sucrose</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₀</td>
<td>3.48±0.17</td>
<td>0.16±0.01</td>
<td>2.57±0.12</td>
</tr>
<tr>
<td>T₁</td>
<td>3.10±0.15</td>
<td>0.84±0.04</td>
<td>0.59±0.02</td>
</tr>
<tr>
<td>T₂</td>
<td>1.04±0.05</td>
<td>1.82±0.09</td>
<td>2.84±0.14</td>
</tr>
<tr>
<td>T₃</td>
<td>0.47±0.02</td>
<td>3.18±0.15</td>
<td>0.78±0.03</td>
</tr>
<tr>
<td>T₄</td>
<td>0.20±0.06</td>
<td>0.28±0.01</td>
<td>0.41±0.02</td>
</tr>
<tr>
<td>T₅</td>
<td>0.02±0.04</td>
<td>ND</td>
<td>0.07±0.01</td>
</tr>
<tr>
<td>T₆</td>
<td>ND</td>
<td>0.02±0.01</td>
<td>0.05±0.02</td>
</tr>
<tr>
<td>T₇</td>
<td>0.02±0.01</td>
<td>0.02±0.01</td>
<td>0.15±0.01</td>
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<tr>
<td>T₈</td>
<td>0.02±0.01</td>
<td>ND</td>
<td>0.03±0.01</td>
</tr>
<tr>
<td>T₉</td>
<td>0.02±0.01</td>
<td>0.03±0.01</td>
<td>ND</td>
</tr>
</tbody>
</table>

a, b, c Value in columns and rows with different superscript letters were statistically significant (p< 0.05), while values sharing the letters are non-significant from each other and values with no superscript showing non-significant effect. Where: Ti = 80% whole wheat flour + 20% chickpea flour T₁ = 60% whole wheat flour + 40% chickpea flour T₂ = 40% whole wheat flour + 60% chickpea flour T₃ = 85% whole wheat flour + 15% millet flour T₄ = 70% whole wheat flour + 30% millet flour T₅ = 55% whole wheat flour + 45% millet flour T₆ = 85% whole wheat flour + 15% sorghum flour T₇ = 70% whole wheat flour + 30% sorghum flour T₈ = 55% whole wheat flour + 45% sorghum flour.

Chickpea (Cicer arietinum L.) is a main legume crop cultivated in the temperate and tropical regions. It is important due to high protein and dietary fiber contents (Bibi et al., 2007). Composite flour technology denotes the process of mixing wheat flour with other cereals or legumes to accomplish better quality of available raw material and impart nutritional and functional characteristics (Shahzadi, 2004). Therefore, composite flour technology for wheat flour with other cereals and legumes has been used effectively to improve nutrition in developing countries. Chapatti prepared from composite flour can be included in the diet for more effective better management of diabetes and also beneficial to keep away from further secondary complications. The present study was designed to develop composite flour chapatti as a value added product for diabetic patients and to evaluate its physicochemical and sensory attributes.

MATERIALS AND METHODS

Procurement of raw material

Wheat, sorghum, millet and chickpea were procured from Ayub Agricultural Research Institute (AARI), Faisalabad, Pakistan. All the required chemicals (Merck, Germany) and reagents were procured from local market.

Sample preparation

All the grains were cleaned to remove dust, stones and straws and milled into flour by using laboratory milling machine. Different composite flours were prepared by mixing the milled grains/flours in different concentrations (Table 1).

Analysis of composite flour

Chemical analysis

Supplemented flours were analyzed for moisture, ash content, crude fat, crude fiber, crude protein and nitrogen free extract and minerals (sodium, potassium, zinc, magnesium and iron) according to methods described in AACC (2000).

Water activity

An electronic Hygropalm water activity meter (Rotronic instrument corporation NY. USA) was used for estimating the water activity following the procedure as described in AOAC (2006). The flour sample was placed in the cup and probe inserted into the sample that is connected with digital display unit. Thereafter, enter key was pressed and water activity displayed on display unit along with temperature.

Preparation of composite flour chapattis

Chapattis were prepared from composite flours and whole wheat flour (taken as control) according to the method described by Rao et al. (1986). First of all, the dough was prepared by adding water in 200 g of flour and subsequent mixing for 3 min in the mixer (National Mfg. CO. Lincoln,
Nebraska). Thereafter, the dough was allowed to rest for 1 h at room temperature. After that the dough pieces were rounded to shape them into chapattis on a specially designed platform so that each chapatti was of uniform thickness and diameter. Baking of chapattis was carried out on thermostatically controlled hot plate at 200 to 210°C for 1.5 min.

**Analysis of composite flour chapattis**

Supplemented flour chapattis were analyzed for their caloric values, sugar content, texture analysis, color and sensory attributes.

**Caloric values**

Caloric values of the chapattis were determined by using Oxygen Bomb Calorimeter (IKA- WERKE, C2000 Basic, GMBH and CO., Germany) as described by Krishna and Ranjhan (1981). Sample was taken in the metallic decomposition vial. The vial was unscrewed and fastened by a cotton thread onto the middle of the ignition wire with a loop before loading the sample. Thereafter, the screw cap was tightened. The decomposition vial was guided into the filler head to the open measuring cell cover until it was in place. The start button was pushed and the measuring cell cover closed. The sample within the vial was burnt through electric spark and heat produced was displayed in the form of a graph denoting the temperature against time on digital panel of Bomb Calorimeter; this gave number of calories per gram of a sample.

**Sugar contents through HPLC**

Sugar contents (glucose, fructose and sucrose) were determined through HPLC by using the method as described by MironesSa (2013). Sample (10 g) was boiled for 20 min in 100 ml of 60% ethanol and then centrifuged at 4000 rpm for 15 min. After cooling the supernatant was concentrated at the rotary evaporator and filtered using Whatman 42 paper. The filtered material was passed through a filtering membrane of 0.2 pm. Chromatographic determinations were done in a HPLC system equipped with refractive index detector. The working parameters were: column - waters with aminopropyl-bonded phase - C18, 100 mm x 4.6 mm, 4 pm particle diameter; eluent to acetonitrile: water solution (with 0.125% w/v of sodium chloride added to minimize the interference from NaCl) = 75:25; flow rate 0.6 ml/min; room temperature 30°C; injected volume 20 pL.

**Texture analysis**

Hardness of each chapatti was determined following the method as described by Gujral and Pathak (2002) with some modifications using Texture Analyzer (TA-XT 2 plus, Stable Microsystem, Surrey, UK) with a 5 kg load cell.

**Color measurement**

The color values of chapatti prepared from each treatment was determined with the help of Color Meter (Neohuauas Neotec, Germany) according to the method described by Rocha and Morais (2003). The color of chapatti was determined by placing the sample under the photocell and L*, a* and b* values of samples were noted.

**Sensory evaluation of chapattis**

To assess the quality and acceptability of the chapattis, they were presented to a panel of six trained judges (3 males and 3 females) having expertise in sensory evaluation from the National Institute of Food Science and Technology. Panelists were round about 28 to 40 years of age with sound health and good sensory attributes. The test was carried out in a well-ventilated, odorless and quiet location. The sensory evaluation was carried out on 9 points hedonic scale for color, taste, aroma, chew ability, folding ability and overall acceptability characteristics according to the method described by Land (1988).

**Statistical analysis**

Significance difference among the treatments of final data was determined by using analysis of variance technique (ANOVA) under completely randomized design (CRD) on SPSS (Statistical Package for Social Sciences, version 10.0.1, 1999). The means of all treatments were compared by using Tukeys (HSD) test (Steel et al., 1997).

**RESULTS AND DISCUSSION**

**Chemical analysis of composite flours**

The means for chemical composition of supplemented flours revealed significant variations (Figure 1). Highest value of moisture content (9.52%) was observed in T₃ (40% whole wheat flour + 60% chickpea flour) and lowest moisture content (7.44%) was noted in T₅ (55% whole wheat flour + 45% millet flour). The ash content of composite flours ranged from 1.66 to 2.11%. Crude fat varied from 1.95 to 6.77% with maximum crude fat in flour supplemented with 60% chickpea flour as chickpea is a substantial source of fat.

Crude fiber content of different treatments show that highest fiber content (5.40%) was found in T₅ containing 45% millet flour. Protein content in composite flour
ranged from 8.45 to 16.68%. The variation in protein content is due to varying amount of chickpea, sorghum and millet in the flour. The means for nitrogen free extract (NFE) varied from 61.91 to 75.65% among all the composite flours. The results of the present study were well supported by the findings of Shahzadi et al. (2005) who reported similar results for proximate composition in wheat-chickpea composite flours. Similarly, Beswa (2008) found that incorporation of millet at 10 and 20% in wheat flour enhanced its crude fiber, crude protein and NFE content, respectively. The result was in line with the finding of Ragae et al. (2006). Yousif et al. (2012) observed that by supplementing cereals into wheat flour increased their proximate composition. From Table 2, it could be inferred that mineral contents in composite flours were significantly affected by increasing the concentrations of chickpea, sorghum and millet.

Mineral concentration was enhanced by increasing the level of all the cereals and legume flour into wheat flour. The sodium and potassium content of composite flours ranged from 1.71 to 5.88 mg/100 g and 570 to 976 mg/100 g, respectively. In the case of magnesium, T6 flour sample acquired highest value (568.92 mg/100 g). The mean value regarding iron content of different treatments depicted that it ranged from 2.05 to 12.74 mg/100 g while highest zinc content was observed in flour containing 60% chickpea flour (8.40 mg/100 g). The results of the present study were in accordance with the findings of Campos-Vega et al. (2010) who reported that zinc content in chickpea ranged from 8 to 10 pg/g. Nambiar et al. (2011)
observed similar iron content in millet as (8 to 11 mg/100 g). The results of the present study were in agreement with the findings of Charalampopoulos et al. (2002).

**Water activity**

The data pertaining to water activity revealed significant (p<0.05) variation among all the composite flour samples (Figure 2). Maximum value was observed in T9 containing 45% sorghum flour (0.58) while minimum value was found in T1 having 20% chickpea flour (0.44). The value of water activity decreased as the concentration of other cereals flour increased. Ghribi et al. (2015) reported water activity (0.44) in desi chickpea flour.

**Analysis of composite flour chapattis**

**Caloric value**

When a material is completely oxidized in a bomb calorimeter the amount of heat released is called the gross energy of a material and measured in calories. Caloric value of all the chapattis revealed significant (p<0.05) variations. The mean values (Figure 3) for caloric value of chapattis of different treatments showed that the highest value (651.40 kcal) was found in T4 (85% whole wheat...
flour + 15% millet flour) while minimum energy value was observed in chapattis prepared from flour containing 60% chickpea flour (442.80 kcal). Belino et al. (2015) also reported similar results for caloric value in wheat-chickpea composite flour bakery products.

**Sugar content**

Three major sugars (glucose, fructose and sucrose) in composite flour chapattis containing chickpea, sorghum and millet flour depicted significant (p<0.05) variations. The mean values (Table 1) for glucose content of chapattis showed that the highest value (3.48 g/100 g) was found in T0 and lowest value (0.02 g/100 g) was found in T5, T7 and T9. The mean values for fructose content (Table 1) showed that T6 and T7 had same content (0.02 g/100 g) for fructose. The highest value (3.18 g/100 g) was found in T5. Maximum sucrose content (2.84 g/100 g) was found in chapattis prepared from T2 and minimum content (0.03 g/100 g) was observed in chapattis prepared from T9. Escarnot et al. (2012) and Nandini and Salimath (2001) observed similar sugar contents in wheat flour supplemented with sorghum and bajra.

**Texture analysis**

Table 2 shows the mean for hardness of composite flour chapattis. Highest value (0.91 kg) for hardness was found in chapattis prepared from T3 and lowest values (0.13 kg) was found in T6 (85% whole wheat flour + 15% millet flour). Thus, the value of hardness increased when the concentration of all other flours increased in wheat flour. The present study was in agreement with the observations of Iqbal (2013) who reported similar increasing trend in the hardness of wheat-chickpea composite flour bakery product.

**Color analysis**

The color values were determined with color meter that gives three values (L, a* and b*). Table 3 shows the means for (L, a* and b*) in chapattis. Maximum values (50.58) for L* were observed in T6 containing 100% wheat flour while minimum value was found in chapattis prepared from flour containing 45% sorghum flour (42.03). Moreover, a* values ranged from -0.006 to 3.66 among all the composite flour chapattis, while b* value vary from 16.84 to 28.80 in all composite flour chapattis. The result of the present study is in accordance with the findings of Sharma and Gujral (2014) who reported that color of chapattis increased when prepared from composite flour (wheat flour replaced with barley at level of 28, 54 and 84 g/100 g).

**Sensory analysis of chapattis**

The results for sensory characteristics revealed significant (p<0.05) variations. The mean values of color showed (Table 3) that the highest score (7.8) was found in chapattis prepared from wheat flour supplemented with 15% sorghum flour and lowest score (5.0) was found in chapattis prepared from wheat flour supplemented with 45% millet flour. The score for taste of different treatments ranged from 7.8 to 5.0. The taste was found to be higher in T0 containing 100% wheat flour and lower in T6 containing 45% millet flour. A decreasing trend of score for breakability (5.40 to 7.60) was observed with an increase in the supplementation rate of chickpea, sorghum and millet.

Folding ability is one of the preferred textural parameter of chapatti in ease with which it can be folded to form a
scoop for picking up the curry. Maximum score (7.40±0.54) for folding ability was found in T₀ (100% wheat flour) and minimum score (5.20±1.30) was found in T₂ (60% whole wheat flour + 40% chickpea flour). The chapattis prepared from T₀ (100% wheat flour) flour sample acquired highest score (7.80±0.44) for chew ability and decreased by increasing the concentration of other flours.

The results of the present study were in accordance with the findings of Khetarpaul and Goyal (2009) who reported similar score for chew ability of chapatti prepared from composite flour and Shahzadi (2004) who observed similar decreasing trend in sensory attributes by increasing the quantity of chickpea. A decreasing trend of score for breakability is evident with an increase in the supplementation rate of chickpea, sorghum and millet.

Conclusion

The consumer preference regarding food is continuously changing. Functional foods are meant to be consumed as part of the regular diet and in some cases, one or more supplementary ingredients are added into food to improve health benefits. The present study was conducted to explore the hypoglycemic worth of chickpea, sorghum and millet.

It is concluded that chapattis prepared from selected composite flour provide more dietary fiber and less carbohydrates, thus, can be supportive for hyperglycemic individuals. Further, research is needed to find the bioactive potential of chapattis prepared with different grains which could help the people of subcontinent especially from India and Pakistan in attaining their staple food with nutrition and functionality.

REFERENCES