Enrichment of wheat flour bread to enhance physicochemical and sensory attributes using broccoli powder

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ABSTRACT

Enrichment of wheat flour with dehydrated broccoli powder has positive effects on the nutritional value of bread. In present study, broccoli powder was prepared by dehydrating the broccoli and then added in wheat flour in variable proportions (1%, 3%, 5% and 7%) to check its impact on physico-chemical, rheological and sensory attributes of enriched bread. Results from this study showed that there was significant increase in fiber, protein and total phenolic contents by adding dehydrated broccoli powder. While moisture, ash and crude fat contents showed non-significant effects. Nitrogen free extract showed decreasing trend by increasing broccoli powder in wheat flour. Physical analysis such as loaf volume, specific volume, weight loss, texture showed significantly decreasing effect with the exception of loaf weight. Color analysis and rheological analysis of enriched bread also showed significant effect. The scores assigned to the sensory attributes of broccoli bread including loaf volume, color of crust, color of crumb, grain size, taste, aroma and texture firstly increased up to a level (1% addition), then decreased significantly by increasing concentration of broccoli powder while, scores regarding overall acceptability of bread prepared from composite flour enriched with broccoli powder were 7.08, 7.41, 6.41,5.16 and 3.33(out of 9) for T0, T1, T2, T3 and T4 (out of 9). Result concluded that adding broccoli powder higher than 1% resulted in unacceptable textural and sensory properties of bread.

Key words: Broccoli Powder, Bread, Enrichment, proximate, sensory

INTRODUCTION

Wheat is taken as primary source of carbohydrates, proteins, vitamins and minerals (Hoseney et al., 1988). Pakistan is one of the major wheat producing country in the world and contributes 2.1% to the GDP of country (GOP, 2014). Wheat flour is one of the major conventional ingredients in bread making due to its gluten fraction (Mongi et al., 2011). Among cereal baked products, bread plays a significant role to fulfill the dietary needs of people around the world (Cayot, 2007). More than 4000 years ago, man has learned the art of bread making (Cauvain, 2004). The key purpose of bread making is to convert cereal flour into palatable, delicious and digestible food item (Dewettinck et al., 2008). Bread contains high amount of starch and complex carbohydrates that play an important role in the diet of people. The most appealing advantage of the bread is its availability in fresh form round the clock (Rosell et al., 2007). Due to its routine usage and provision of almost 50% of total energy intake, bread can be used as a carrier of healthy ingredients (Akhtar et al., 2009).

Enrichment of bread with natural bio-active components and increase the nutritional value of bread has been the main focus of scientists for many years (Ixtaina et al., 2008). Bread provides a good matrix for enrichment with key nutrients and helps to deliver it to the consumer (Hathorn et al., 2008). However, bread is not considered as a rich source of anti-oxidants, dietary fiber and protein, so vegetables like broccoli are good choice to overcome these deficits (Chlopicka et al., 2012). Vegetables are most important components of our life and their regular use may prevent from different diseases (Temple and Kaiser, 2003). Despite this fact only 30% of adults fulfill the daily recommended intake of vegetables (Hobbs et al., 2014). Broccoli (Brassica oleracea L. var. Italica) belongs to the genus Brassica and family Brassicaceae. It is a medicinal therapeutic vegetable and has gained utmost attention due to its health promoting effects in recent years (Ana et al., 2013). According to Mukherjee and Mishra (2012), broccoli is a vegetable crop with significant area under cultivation both in Asia and Europe with great popular graph in United states of America, actually native to Italy and introduced in USA in 1920 by Italian immigrants.

Dietary fibre enriched bakery products are becoming more popular these days due to having more health benefits (Ktenioudak and Gallagher, 2014). Regarding composition of broccoli floret powder, it contains 2.42 g water, 24.57g protein, 5.85g fat, 11.13g dietary fiber, 2.68g ash, 53.62g carbohydrates, 364 kcal energy,
4.65 mg Zn, 0.44mg Cr, 2.56mg K, 6.56mg Fe. However, in fresh form, it contains 89.30% water. It is also a rich source of thiamine, niacin, pantothenic acid, riboflavin, vitamin B6 and selenium (Madhu and Kochhar, 2014). The objectives of the present study were to dehydrate the broccoli and convert into powder and formulation of broccoli enriched bread by adding different proportions of broccoli powder to check its impact on physico-chemical, rheological and sensory attributes of bread.

MATERIAL AND METHODS

Procurement of raw materials

The present research was carried in the Post Graduate Research Laboratory, National Institute of Food Science and Technology, University of Agriculture, Faisalabad. Wheat was purchased from Ayub Agricultural Research Institute (AARI), Faisalabad, Pakistan, while bread ingredients and broccoli was procured from reputed stores in Faisalabad. Wheat grains were milled through Brabender Junior Quadrumat Mill for flour.

Dehydration of broccoli

Broccoli florets were washed and cut into pieces of 2cm diameter and blanched for 15 seconds in boiling water. Then blanched broccoli pieces were placed and dried in a conventional dehydrator at 70-75 ºC until dried. These dried pieces were ground in a household grinder to produce a fine powder (Sharma et al., 2011).

Bread preparation

Bread was prepared using the standard formulation given in Table 2 for all the treatments by using standard procedure as outlined in AACC method No. 10-10B (AACC, 2000). Ingredients were mixed for 5-10 minutes in a Hobart A-200 Mixer to form dough and allowed to ferment at 30 ºC and 75% R.H. for 180 minutes. First and second punches were made after 120 and 150 minutes, respectively. The dough was molded and panned into 100g test pans, and final proofing was done for 45 minutes at 35 ºC and 85% R.H. The bread was baked at 232 ºC for 13 minutes.

Analysis of bread

The prepared bread was analyzed for their physical, chemical and organoleptic properties.

Chemical analyses

The bread samples were tested for moisture content by using hot air oven at 105 ± 5ºC following the procedure described in AACC (2000) method No. 44-15A. The crude protein content in bread samples were determined by Kjeldahl’s method as described in AACC (2000) method No. 46-10. The Soxhlet apparatus was used for the determination of crude fat following the AACC (2000) method No. 30-25. The dry fat free bread samples were analyzed for crude fiber content following the procedure mentioned in AACC (2000) method No. 32-10. Each bread sample was analyzed for ash content by following the procedure outlined in AACC (2000) method No. 08-01. The nitrogen free extract was calculated by the following relation: NFE = 100 – (% Moisture+% Crude Protein+% Crude Fat+% Crude Fiber+% Ash Content).

Physical analyses

The color of bread was determined with the help of color meter color test II, serial no. 95808, made in Germany) according to method of Lara et al., (2010). Loaf weight of the bread was determined by following the procedure as presented by Das et al. (2012). Loaf volume was measured by rapeseed displacement method (Greene and Bovell-Benjamin, 2004). The specific volume of the bread was determined followed by Peressini and Sensidoni (2009). The specific volume $cm^3/g = \frac{loaf volume of bread}{weight of bread}$

Weight loss

Dough and baked loaf were weighed and percent weight loss calculated followed by Majzoobi et al. (2011).

\[
%\ Weight\ loss = \frac{Weight\ of\ raw\ bread – Weight\ of\ baked\ bread}{Weight\ of\ baked\ bread} \times 100
\]

Texture analysis

Textural analysis of bread was carried out by using Texture Analyzer (TA-XT2 plus Texture Analyzer Stable Micro Systems, serial no. 12028, made in UK) according to method of Piga et al., (2005).

Viscoelastic properties

The viscoelastic properties of wheat and broccoli powder composite flour were recorded by using a Rapid Visco-Analyser RVA-4SA (Newport Scientific Pvt. Ltd, Warned, NSW, Australia) interfaced with a personal computer equipped with thermo cline for windows software. Pasting profile was measured by AACC method (AACC, 2000). The total phenolic content was determined by Folin-Ciocalteu method (Ashoush and Gadallah, 2011).

Sensory analysis

The experimental breads from different treatments were rated using 9-point hedonic score system (9= like...
extremely; 1 = dislike extremely) by taste panel. Sensory evaluation performa was made in accordance to Lawless and Heymann, (1998). They were asked to express their opinion about the end product by giving score to attributes like color, flavor, texture, moistness, tenderness, shape and overall acceptability. During sensorial evaluation, breads of different treatments were placed in transparent plates, labeled with random codes.

Statistical analysis
The data of each parameter was subjected to statistical analysis to determine the level of significance (Steel et al., 1997).

RESULTS AND DISCUSSION
Proximate analysis of bread
Proximate analysis of each treatment was done and means values are shown in Table 2. Moisture content showed non-significant variation in different treatments. The lowest moisture content was observed in T3 (32.26%) and maximum in T4 (34.15%). The non-significant trend is due to lower moisture content present in dried broccoli powder. Similar trend was shown by Das et al. (2011) while using broccoli powder. Crude protein contents showed increasing trend significantly by increasing the concentration of broccoli powder as T4 (14.13%) contained maximum and T0 (10.20%) contained minimum value for crude protein. The results confirmed the higher amount of protein present in broccoli than wheat flour. Filipčev et al. (2015) showed similar findings regarding crude protein. The trend regarding crude fiber showed significantly increasing effect by increasing the concentration of broccoli powder. Maximum value for crude fiber was showed by T4 (1.61%) and minimum by T0 (0.80%). Analysis of variance regarding crude fat showed non-significant difference due to the fact that broccoli is low in fat and it has low glycemic index. T0 showed maximum value (2.31%) and T0 showed minimum value (2.10%) for crude fat. Similar results for crude fibre and crude fat are reported by Filipčev et al., (2015). The results showed that T0 has 2.11% ash contents followed by T1 2.28%, T2 2.35%, T3 2.44% and T4 has 2.51%. It reveals that the ash content of bread increases by increase in broccoli powder level. The mean value of NFE content of different formulated bread was 51.33%, 50.77%, 48.87%, 48.34% and 45.29% of T0, T1, T2, T3 and T4 respectively. The results showed that NFE contents decreased with the increased level of dehydrated broccoli powder in bread.

Physical analysis of broccoli enriched bread
Mean values regarding the physical analysis of enriched bread are shown in Table 3. Means regarding loaf volume of enriched bread showed significant decreased in volume by increasing the concentration of broccoli powder as maximum decrease in volume was observed in T4 (280 cm3) which contained 7% broccoli and minimum was observed in T0 (340 cm3) which was control bread. As broccoli contains higher contents of crude fiber than that of wheat that is why it absorbs more moisture and this ultimately affects the gluten network, and lowers CO2 gas retention capacity of bread which causes decrease in bread volume. Das et al., (2012) showed the similar trend regarding loaf volume. The analysis of variance regarding the loaf weight showed significant effect by increasing the concentration of broccoli powder, the weight of bread increased. Maximum increase in weight was observed in T4 (140.51 g) and minimum in T0 (121.44 g). It is due to increase in amount of water absorbed by broccoli powder during dough making and its retention to a large extent in baking process increased loaf weight. Similar trend regarding loaf weight is given by Rakcejeva et al., (2011). Mean values regarding specific volume of broccoli powder composite bread showed significant effect. Specific volume of enriched bread is decreased by increasing broccoli powder concentration. Minimum value for specific volume was exhibited by T1 (2.09 cm3/g) and maximum by T0 (2.83 cm3/g). Broccoli powder absorbed more moisture that lowers moisture level which effects specific volume of the bread. By increasing the concentration of broccoli powder, weight loss is reduced. Minimum weight loss was observed in T4 (17.01%) and maximum in T0 (23.88%). Weight loss is inversely proportional to the loaf weight, as the broccoli powder enrichment increased bread loaf weight so it resulted in decreased weight loss.

In color analysis, L* value (lightness or luminance) significantly decreased by increasing the broccoli powder concentration. T0 obtained max. (65.32) and T4 showed minimum value (50.11) for lightness which shows that bread became darker as broccoli powder concentration is increased as shown by Das et al. (2012). a* value (greenish to reddish) showed significantly increasing trend by increasing broccoli powder. T4 (-1.18) was greener than other 4 treatments and T0 (-4.32) was least green. By adding dehydrated broccoli powder, b* value (bluish to yellowness) increased non-significantly. Filipčev et al. (2015) also showed similar trend for bread color analysis. The analysis of variance regarding the texture of bread showed significant effect and force of
deformation increased by increasing the amount of broccoli powder. Mean values for texture analysis showed maximum value for T_4 (2.53 Kg) and minimum for T_0 (1.52 Kg). Texture depends upon gluten formation and moisture level in bread, as broccoli powder absorbs higher amount of water and deteriorates the gluten network, so the texture became harder (Table 4).

**Table 1. Treatment plan**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Flour (%)</th>
<th>Broccoli Powder (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T_0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>T_1</td>
<td>99</td>
<td>1</td>
</tr>
<tr>
<td>T_2</td>
<td>97</td>
<td>3</td>
</tr>
<tr>
<td>T_3</td>
<td>95</td>
<td>5</td>
</tr>
<tr>
<td>T_4</td>
<td>93</td>
<td>7</td>
</tr>
</tbody>
</table>

**Table 2. Standard Formulation of Bread**

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Quantity (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat flour</td>
<td>100</td>
</tr>
<tr>
<td>Yeast</td>
<td>2</td>
</tr>
<tr>
<td>Sugar</td>
<td>5</td>
</tr>
<tr>
<td>Salt</td>
<td>2</td>
</tr>
<tr>
<td>Shortening</td>
<td>5</td>
</tr>
<tr>
<td>Water</td>
<td>According to water absorption capacity</td>
</tr>
</tbody>
</table>

Results regarding viscoelastic properties of broccoli bread showed significant effect on bread as different viscoelastic parameters showed decreasing trend by increasing the broccoli powder concentration. Peak viscosity results showed maximum value for T_0 (9274.4) and minimum in T_4(7261.8). Caballero et al. (2008) also showed similar trend for peak viscosity. Break down viscosity showed max. value in T_0 (5052.0) while minimum in T_4 (4170.7). Mean values regarding final viscosity showed significantly decreasing effect by increasing broccoli powder. Max. value was observed in T_0 (8456.8) and min. in T_4 (7002.2). Alamri et al., (2013) reported the similar trend in their research for rheological characteristics. Analysis of variance regarding setback viscosity showed significant effect and showed max. value in T_0 (3309.6) and min. value in T_4 (2283.6). Pasting temperature at which starch granules begin to swell and gelatinize due to water uptake showed nonsignificant effect. The highest value was (64.48°C) for T_0 and minimum in T_4 (63.07 °C) (Table 4).

**Total phenolic contents (TPC) in bread**

Broccoli is a medicinal plant and has considerable quantity of phenolic contents, recognized as a rich source of versatile bio-active compounds such as flavonoids, glucosinolates, phenolic acids etc. (Dziki et al., 2014). Total phenolic contents assay is an accurate index of antioxidant content in bread samples (Kaur and Kapoor, 2002). Table 4 shows that by increasing the concentration of broccoli powder, phenolic contents were also increased. Maximum value for TPC was exhibited by T_4 (66.25mg/100g) with 7% broccoli and minimum value was observed in T_0 (25.03). Findings of TPC are near to the previous findings of Dziki et al. (2014).

**Sensory evaluation of broccoli powder enriched bread**

Results for sensory evaluation of broccoli powder enriched bread are given in Table 5. Mean values regarding crust color of bread showed highest value for T_1 (6.75) and lowest for T_4 (4.08). Crust color affected significantly and became darker by increasing broccoli powder concentration. Dziki et al. (2014) reported the similar trend for crust color. Mean values for crumb color of T_1 scored higher (7.41) than other treatments and minimum score obtained by T_4 (3.58). Crumb color became greener as the concentration of broccoli increased in wheat flour bread. The grain size referred to the structure of crumb which greatly affected by the addition of broccoli powder by increasing concentration grain size become irregular. The highest score was achieved by T_1 (7.41) and lowest by T_4 (4.10). Taste is the main character that greatly influences the consumer’s choice. Maximum score for taste was obtained by T_1 (7.50) and minimum by T_4 (3.41). Broccoli is somewhat bitter in taste so by increasing its amount it starts producing off taste. Mean values regarding bread texture showed significant differences by adding broccoli powder. The maximum score was achieved by T_1 (7.33) and minimum by T_4 (5.08). Aroma is also an important property of bread which influences the consumer’s acceptance of food. Means values for aroma showed significant effect as by increasing broccoli concentration aroma became un-pleasant. T_0 obtained maximum scores (7.33) while T_4 obtained minimum score (3.58) for aroma. Bread Volume mainly depends on gluten network formation and moisture level. By
increasing the concentration of broccoli, more deterioriation of gluten network was observed and more water was bound which ultimately disturbed the volume. T₀ was ranked with highest score (7.08) while T₃ (3.33) obtained minimum score. For overall acceptability, bread enriched with 1% broccoli powder (T₁) ranked first and bread with 3% broccoli powder (T₂) was somehow acceptable but other two breads with the addition of 5% (T₃) and 7% (T₄) broccoli powder were found unacceptable.

**CONCLUSION**

Broccoli is a good source of nutrition and considered as a medicinal plant and jewel of nutrition. It is rich
source of dietary fiber, protein and phenolic contents. Bread provides a good matrix for enrichment. Broccoli is added to bread due to its unique nutritional properties. In present study, it was added in different proportions (1%, 3%, 5% and 7%). The bread prepared with 1% broccoli powder showed better characters than supplemented with 3, 5 and 7% broccoli powder. The addition of broccoli powder increases the protein, fiber and total phenolic contents of bread but negatively affected the rheological and some physical parameters. Addition of broccoli in bread can be used to increases the nutritional value of bread and by this way vegetable consumption can be improved.

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Conflict of interest
The authors have no conflict of interest.

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(Brassica oleracea var. Italica plenca) leaf and floret powder. Biosci. Discovery, 5: 45-49.


