FULL LENGTH ARTICLE

Effect of apple pomace on quality characteristics of brown rice based cracker

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KEYWORDS
Brown rice; Apple pomace; Crackers; Antioxidants; Minerals

Abstract Formulation of gluten free crackers based on brown rice flour from two varieties and apple pomace was studied during the present investigation. Pomace flour blends were prepared by incorporating 0%, 3%, 6% and 9% apple pomace in brown rice flour. Viscosity profile showed decrease in pasting properties except pasting temperature which increased with increase in pomace level. The hunter colour value (L*) and fracture force of crackers are decreased with increase in pomace level. The crackers were investigated and compared for composition, antioxidant properties (DPPH, total phenolic content, total flavonoid content, reducing power), minerals and sensory properties. The increased amount of apple pomace in the flour formulation resulted in higher antioxidant properties, total dietary fibre and minerals in the final product. Based on the present study, pomace based rice crackers have good potential for consumer and regarded as health promoting functional food, especially for coeliac disease patients.

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1. Introduction

Snack foods are an integral part of the diet and have been over a period of time commercially exploited on large scale. Crack-

ers are the popular snack products which have appreciable demand amongst the consumers (Maneerote et al., 2009; Sedej et al., 2011). Cereals occupy an important place in human nutrition as major proportion of population consumes it all over the world and mostly exploited for cracker formulation. However, coeliac disease patients are unable to consume cereal products that contain gluten proteins. Rice is one of the most suitable cereal crops for gluten-free products because it has a low level of prolamine. It also possesses unique nutritional, hypoallergenic and bland taste properties (Ali et al., 2014; Mir and Bosco, 2014).

Since majority of minerals and phytochemicals are concentrated in the bran layer of the whole grain (Abdul-Hamid
et al., 2007), it is supposed that products based on the use of whole raw materials might be considered as food with high antioxidant and mineral potential. Recent studies have shown that brown rice had a wide range of biological activities, including antioxidant, anticarcinogenic, antiallergic activities, antiatherosclerosis and amelioration of iron deficiency anaemia of the body (Deng et al., 2013).

Consumer interest is increasing in functional foods and this has led to the demand of such products in the market. Therefore, different sources have been incorporated as raw material into cereal products which have health benefits (Masoodi and Chauhan, 1998; Wang et al., 2012). Apple pomace, a fruit industry by-product is one of the potential food ingredients used in bakery products (Rupasinghe et al., 2008; Zarein et al., 2015). Phytochemicals present in apple pomace have been associated with many health enhancing benefits e.g. cancer cell proliferation, lipid oxidation decrease and lower cholesterol level (O’Shea et al., 2012). In addition, apple pomace fibres are known to consist of bioactive compounds such as flavonoids, polyphenols and carotenoids and also have been considered as a source of better quality dietary fibre (Fernandez-Ginez et al., 2003). Lu and Foo (2000) indicated that the polyphenols, which are mainly responsible for the antioxidant activity, are present in apple pomace and hence could be a cheap and readily available source of dietary antioxidants. Several authors have reviewed the importance of dietary fibre (O’Shea et al., 2012). Dietary fibres from different sources have been used to replace cereal flour in the preparation of bakery products (Foschia et al., 2013). Therefore, the present work was undertaken to formulate and study the influence of apple pomace on the chemical, antioxidant and sensory properties of rice crackers.

2. Materials and methods

2.1. Raw materials

The paddy varieties K-332 and Khosar were procured from the Sher-e-Kashmir University of Agriculture Science and Technology, Kashmir, India. The grains were dried and dehusked in a THU-34A Stake Testing Rice Husker (Stake, Japan) to obtain brown rice. Flour was obtained by grinding the brown rice using Mini Grain Mill (A11B, IKA Inc.) and sifting the material through 300 μm sieve and kept in a refrigerator at about 4 °C for further analysis. Fresh apples obtained from local market of Pondicherry were washed well with water to remove the adhering dust. The apples were cut into small pieces and crushed into the juicer mixer (Crompton Greaves, CG-BX, India). The juice was squeezed completely from the pulp and pomace was dried in tray drier at 40 °C and ground with grinder mill and sieved into a fine powder. Commercially available sugar, vegetable fat, salt and baking powder were brought from the local market of Pondicherry. Carboxymethyl cellulose sodium salt was obtained from the Merck, Mumbai, India.

2.2. Preparation of rice cracker

The rice cracker formulation was brown rice flour (100 g), sugar (10 g/100 g), salt (3 g/100 g), fat (30 g/100 g), carboxymethyl cellulose (2 g/100 g), baking powder (0.8 g/100 g), water (optimum) and apple pomace powder (0 g/100 g, 3 g/100 g, 6 g/100 g and 9 g/100 g).

The dry ingredients except sugar were mixed in a mixer, whilst the liquid ingredients and sugar were mixed separately to form emulsion. The emulsion was incorporated into the dry ingredients and mixed by high speed mixer. Dough was wrapped in polyethylene bags and left to rest at room temperature for 30 min to ensure uniform distribution of liquids. The dough was then manually sheeted to 2.5 mm thickness and cut by pressing mould into 35 mm diameter. Baking was done in a double deck baking oven (T26/DDO, Technico, Chennai, India) at 170 °C for 10 min. After cooling for 5 min to room temperature, the crackers were wrapped in plastic container and kept at room temperature for further investigation.

2.3. Pasting properties of pomace-rice flour blends

Pasting characteristics of rice flour-pomace blends were determined by using Rapid Visco Analyzer (Starch master 2, Newport Scientific Pty. Ltd, Warriewood, Australia). Powder sample of 3 g was weighed in RVA canisters followed by addition of 25 ml of water. The prepared slurry in the canister was heated to 50 °C and stirred at 160 rpm for 10 s to enable the complete dispersion. The slurry was held at 50 °C for 1 min and temperature was raised to 95 °C for 7.5 min and subsequently held at 95 °C for 5 min. The slurry was cooled at 50 °C for 7.5 min, and then held at 50 °C for 2 min. Pasting temperature, peak viscosity, holding viscosity, final viscosity, breakdown viscosity and setback viscosity were determined.

2.4. Colour of rice cracker

The cracker colour was determined by CIE colour scales \( L^*, a^* \) and \( b^* \) using Hunter Lab digital colorimeter (Model D25M, Hunter Associates Laboratory, Reston, USA). Calibration with black and white standards was performed before colour measurement. The total colour difference (\( \Delta E \)) was estimated as:

\[
\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}
\]

where

\[
\Delta L = L_{sample} - L_{standard}
\]

\[
\Delta a = a_{sample} - a_{standard}
\]

\[
\Delta b = b_{sample} - b_{standard}
\]

2.5. Texture of rice cracker

The fracture force test was measured using a Texture Analyzer (TA) TA-HD plus, Stable Micro Systems, Surrey, UK. The cracker samples were rested on the platform supported at two points and the blade was attached to the crosshead of the instrument. The peak force from the resulting curve was considered as the fracture force of the biscuit. The average force was calculated for five cookies and reported as fracture force (g).

2.6. Composition

Fat and protein of the samples were determined according to the standard methods of AACC (2000).
2.7. Total dietary fibre

Soluble, insoluble and total dietary fibre content of the samples was measured according to the method described by Asp et al. (1983). Sample (1.0 g) was homogenized in 20 ml of sodium phosphate buffer (0.1 M, pH 6.0) and was treated with heat stable α-amylase (Termamyl) (90 °C, 15 min) and then digested with pepsin (40 °C, 60 min) and incubated with pancreatin (40 °C, 60 min). Soluble and insoluble dietary fibres were separated by filtration. The filtrate was subjected to ethanol precipitation and filtered to obtain soluble dietary fibre and both the precipitates were dried overnight at 105 °C and were incinerated at 500 °C for 6 h. Total dietary fibre was then calculated as combined value of soluble and insoluble dietary fibre.

2.8. Antioxidant properties of rice cracker

2.8.1. Preparation of extract

10 g of each powdered sample was extracted for 8 h with 50 ml of acidified methanol in an electrical shaker (Technico, India) at 30 °C. Extract was centrifuged at 1000xg for 15 min and the supernatant was stored in a sealed container at −4 °C until used for further analysis.

2.8.2. Determination of total phenolic content

Total phenolic content of samples was determined using the Folin–Ciocalteu method (Liu and Yao, 2007) with some modifications. 200 μl of extract was mixed with 1 ml of Folin–Ciocalteu reagent diluted to 1:10 with water. The mixture was shaken vigorously and 1 ml of 10% Na2CO3 was added and the final volume was made up to 5 ml with distilled water. After the mixture was left to stand for 2 h at room temperature, the absorbance at 765 nm was measured using a UV–Vis Spectrophotometer (UV-1800, Shimadzu, Japan). The results of total phenolic content were expressed as mg gallic acid equivalents per g of extract.

2.8.3. Determination of total flavonoid content

Total flavonoid content of extract was determined according to the method reported by Jia et al. (1998). Extract (250 μl) was diluted with 1.25 ml of distilled water and afterwards 75 μl of 5% NaNO2 solution was then added. The mixture was allowed to stand at room temperature for 6 min followed by the addition of 150 μl of 10% AlCl3. This mixture was allowed to stand for further 5 min and added with 0.5 ml of 1 M NaOH. The solution was shaken vigorously and the absorbance was measured at 510 nm. The results were expressed as μg catechin equivalents per g of brown rice. All the measurements were done in triplicates.

2.8.4. Determination of DPPH radical scavenging activity

(DPPH)

DPPH radical scavenging activity was determined using the method described by Blois (1958). A portion (0.1 ml) of the extract solution was well mixed with 3.9 ml of methanol and 1.0 ml of 2,2-diphenyl-1-picrylhydrazyl (DPPH) solution (1.0 mM in methanol). The mixture was kept in dark at ambient temperature for 30 min and the reduction in the absorbance was read at 517 nm.

2.8.5. Determination of reducing power

The reducing power of extract was measured according to the method reported by Yen and Duh (1993) with some modifications. Extract (2.5 ml) was mixed with 2.5 ml of 0.2 M sodium phosphate buffer (pH 6.6). The diluted sample was then mixed with 2.5 ml of 1% potassium ferricyanide and the mixture was incubated at 50 °C for 20 min. Trichloroacetic acid (2.5 ml, 10%,) was added to the mixture, followed by centrifugation at 6000g for 10 min. The upper solution (2.5 ml) was mixed with distilled water (2.5 ml) and 0.5 ml of ferric chloride (1.0%). The absorbance was measured at 700 nm. All the measurements were done in triplicates.

2.9. Mineral analysis of rice cracker

Mineral analysis was determined using the method of Mir et al. (2015). The analysis was performed using WD-XRF (Wavelength dispersive spectrometer-X ray fluorescence), Bruker AXS, S4-Pioneer Germany. Two grams of the samples was crushed and mixed with 0.5 g boric acid (granulated) with a mortar and pestle. The prepared sample was then made into a 34 mm diameter pellet with the help of a 40 ton hydraulic press machine (10 ton pressure, 20 min pressing time). The pellets were then introduced in the sample slots of WD-XRF and analysed for the composition of elements in the samples.

2.10. Sensory evaluation of rice cracker

Sensory evaluation of the product was conducted based on appearance, colour, flavour, texture and overall acceptability. A panel of 15 members was selected to evaluate the sensory properties of crackers. The sensory evaluation was performed in laboratory with clean sensory cabinets containing fresh water. The panellists were instructed to evaluate the above attributes of the samples and to rate each attribute. A nine point hedonic scale with 1 (dislike extremely), 5 (neither like nor dislike), 9 (like extremely) was used for the study.

2.11. Statistical analysis

The data were analysed statistically using SPSS 18.0 (SPSS Inc., Chicago, USA,) and the means were separated using the Duncan multiple range test (P < 0.05). All the data are presented as the mean with the standard deviation.

3. Results and discussion

3.1. Pasting properties of pomace-rice flour blends

Perusal of data presented in Table 1 revealed that pasting properties of apple pomace-rice flour blends differ significantly (P < 0.05). The increased pomace level in the flour blend resulted in decrease of peak viscosity, breakdown viscosity, setback viscosity and holding viscosity, whereas, the pasting temperature increased. The increased level of pomace decreased the pasting profile due to the increase of fibre content in pom-
ace-rice flour blends. Results showed that the peak viscosity of K-332 rice flour (2529 cP) was higher as compared to Khosar flour (2332 cP). The peak viscosity in cereal flour is mainly attributed to gelatinization of starch granules. Variety K-332 flour-pomace blends exhibited comparatively higher peak viscosity (1682–2529 cP) than Khosar flour-pomace blend (1425–2332 cP). Similarly, holding viscosity, final viscosity, breakdown and setback viscosity of K-332 rice flour were higher as compared to Khosar flour. Hung et al. (2007) studied the pasting properties of wheat flour and reported lower peak viscosities for whole wheat flour as compared to white wheat flour due to the high amount of dietary fibre and low amount of starch present in the samples. Increase in pomace levels progressively may decrease the starch content and thereby affecting the pasting properties. Moreover, the high fibre content has a tendency to bind more water, resulting in less available water for starch and consequently the reduced swelling as indicated by the low pasting profile and the decrease in starch granule rupturing. However, pasting temperature increased from 87.40 to 90.00 °C in K-332 flour-pomace blend and from 87.90 to 91.55 °C in Khosar flour-pomace blend with the increase in pomace substitution level. The variation in pasting temperature may be due to the effect of different gelation temperature of the fibre portion (Sudha et al., 2007). The results are in agreement with Sogi et al. (2002), who studied the pasting properties of wheat flour-tomato seed protein blends.

### 3.2. Colour of cracker

The $L^*$, $a^*$ and $b^*$ value of rice crackers which corresponds to lightness, redness and yellowness, respectively showed variation based on the inclusion of pomace level (Table 2). $L^*$ value of rice crackers decreased significantly ($P < 0.05$) with increase in the incorporation of pomace. In contrast, $a^*$ and $b^*$ values increased significantly ($P < 0.05$) with the increase in pomace level. The total colour difference ($AE$) of rice crackers prepared from Khosar flour-pomace blend (9.07–15.39) was higher as compared to K-332 flour-pomace blend (7.39–10.79). However, the rice crackers showed increase in colour difference with increased inclusion of pomace in both types of rice varieties. The difference in colour values may be attributed due to the incorporation of pomace which has brownish colour that increases the colour value in crackers. Also the colour variation is due to the apple pomace which is rich in polyphenols and acts as a substrate for enzymatic browning (Sudha et al., 2007). Similar findings have been reported for biscuits incorporated with mango peel powder by Ajila et al. (2008).

### 3.3. Texture of cracker

Fracture force of rice crackers varied significantly ($P < 0.05$) with the incorporation of pomace level (Table 2). Fracture force was obtained from the maximum force required to break the product which correlates with the bite hardness that could be expected whilst eating the product. The fracture force varied from 1667.54 to 2042.19 g for K-332 flour-pomace based rice crackers, whereas 1687.71–1831.57 g for Khosar flour based rice crackers. The fracture force values of rice crackers decreased with the increase in pomace level. The apple pomace contains high quantity of soluble fibre which may decrease the hardness of rice cracker by acting as lubricant and produces a crispier rather than a harder snack (Van der Sman and Broeze, VAN der Sman and Broeze).

### Table 2: Effect of pomace-flour blends on the physical properties of crackers.

<table>
<thead>
<tr>
<th>Rice cultivar</th>
<th>Replacement level (%)</th>
<th>$L^*$</th>
<th>$a^*$</th>
<th>$b^*$</th>
<th>$\Delta E$</th>
<th>Fracture force (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-332</td>
<td>0</td>
<td>53.63 ± 0.76&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.05 ± 0.19&lt;sup&gt;c&lt;/sup&gt;</td>
<td>27.32 ± 0.16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>–</td>
<td>2042.19 ± 35.19&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>46.74 ± 0.35&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12.17 ± 0.16&lt;sup&gt;d&lt;/sup&gt;</td>
<td>28.88 ± 0.08&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.39 ± 0.35&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1899.84 ± 36.33&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>45.16 ± 0.21&lt;sup&gt;c&lt;/sup&gt;</td>
<td>14.13 ± 0.09&lt;sup&gt;e&lt;/sup&gt;</td>
<td>29.16 ± 0.07&lt;sup&gt;e&lt;/sup&gt;</td>
<td>9.61 ± 0.79&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1785.25 ± 23.82&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>44.47 ± 0.28&lt;sup&gt;d&lt;/sup&gt;</td>
<td>14.84 ± 0.12&lt;sup&gt;d&lt;/sup&gt;</td>
<td>30.34 ± 0.10&lt;sup&gt;d&lt;/sup&gt;</td>
<td>10.79 ± 0.73&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1667.54 ± 15.75&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Khosar</td>
<td>0</td>
<td>56.09 ± 0.11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.21 ± 0.14&lt;sup&gt;d&lt;/sup&gt;</td>
<td>28.18 ± 0.18&lt;sup&gt;e&lt;/sup&gt;</td>
<td>–</td>
<td>1831.57 ± 27.82&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>47.27 ± 0.28&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12.31 ± 0.36&lt;sup&gt;d&lt;/sup&gt;</td>
<td>28.91 ± 0.34&lt;sup&gt;d&lt;/sup&gt;</td>
<td>9.07 ± 0.11&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1736.77 ± 14.52&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>45.01 ± 0.17&lt;sup&gt;c&lt;/sup&gt;</td>
<td>13.79 ± 0.02&lt;sup&gt;e&lt;/sup&gt;</td>
<td>29.47 ± 0.13&lt;sup&gt;e&lt;/sup&gt;</td>
<td>11.67 ± 0.65&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1755.84 ± 24.94&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>41.38 ± 0.09&lt;sup&gt;d&lt;/sup&gt;</td>
<td>14.67 ± 0.05&lt;sup&gt;d&lt;/sup&gt;</td>
<td>29.22 ± 0.17&lt;sup&gt;e&lt;/sup&gt;</td>
<td>15.39 ± 0.43&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1687.71 ± 12.03&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Values are expressed as mean ± standard deviation. Means in the same column for each cultivar with different letters were significantly different at $P < 0.05$. 

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2013). O’Shea et al. (2012) also reported that the increased level of apple pomace decreased the hardness of puffed snack.

### 3.4. Composition of cracker

Composition of rice crackers prepared with different apple pomace levels was shown in Table 3. Non-significant (P < 0.05) variation was found in fat content of pomace-rice flour based crackers. The protein content of crackers decreased progressively with the increase in pomace level from 0% to 9%. The protein content for control cracker was highest (7.10%) and decreased to (5.88%) at 9% pomace level for K-332 flour-pomace blend. Similarly, for Khosar based cracker it was 7.67% and 6.57% for control and 9% substitution level, respectively. The results showed significant increase in dietary fibre content in rice crackers incorporated with pomace as compared to their corresponding control. The total fibre content of control crackers was significantly (P < 0.05) lower (3.10% and 3.01%) as compared to 9% pomace supplement (7.61% and 7.41%) for K-332 and Khosar variety, respectively. Similarly soluble dietary fibre content increased significantly in K-332 variety based rice cracker from 0.17% to 2.94% and in Khosar based cracker from 0.25% to 3.07% with the increase of pomace content from control to 9%, respectively. The higher fibre content in the 9% pomace based cracker is due to the inclusion of maximum apple pomace content in the flour blend. The soluble fibre is highly increased due to the higher content of apple pomace in the rice cracker which contains the high amount of soluble fibre. The total dietary fibre content was increased from control (0.47%) to 14.2% at 25% of apple pomace substitution in cake (Sudha et al., 2007).

### 3.5. Antioxidant properties of cracker

The results showed significant (P < 0.05) increase in total phenolic content progressively with the increase of pomace level in rice crackers (Table 4). The rice cracker prepared from 9% apple pomace showed 0.61 mg GAE/g of phenolic content for K-332 and 0.58 mg GAE/g for Khosar flour based cracker, whereas, rice cracker prepared from 9% apple pomace blend showed 0.82 and 0.75 mg GAE/g phenolic content for K-332 and Khosar based cracker, respectively. The highest amount of total phenolic content found in the 9% level, may be due to the components derived from apple pomace as it is rich in polyphenols. However, there was some loss of polyphenols during baking, still there is an increase in percentage of polyphenol in crackers incorporated with apple pomace. Total flavonoid content of rice crackers increased significantly (P < 0.05) with incorporation of apple pomace. With the increase in pomace level, crackers showed enhanced flavonoid content from 55.49 µg catechin equivalent/g to 63.16 µg catechin equivalent/g and from 41.96 µg catechin equivalent/g to 53.88 µg catechin equivalent/g from control to 9% pomace level for K-332 and Khosar flour-pomace blend crackers, respectively. Apple skin is rich in flavonoids (Rupasinghe et al., 2008), so the incorporation of pomace may increase the level of flavonoids in rice crackers.

### Table 3 Effect of apple pomace-flours blends on the composition of crackers.

<table>
<thead>
<tr>
<th>Rice cultivar</th>
<th>Replacement level (%)</th>
<th>Protein (g/100 g)</th>
<th>Fat (g/100 g)</th>
<th>Soluble fibre (g/100 g)</th>
<th>Insoluble fibre (g/100 g)</th>
<th>Total fibre (g/100 g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-332</td>
<td>0</td>
<td>7.10 ± 0.48</td>
<td>17.33 ± 0.36</td>
<td>0.17 ± 0.07</td>
<td>2.93 ± 0.06</td>
<td>3.10 ± 0.05</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>6.59 ± 0.16</td>
<td>16.28 ± 0.68</td>
<td>0.91 ± 0.04</td>
<td>3.48 ± 0.08</td>
<td>4.39 ± 0.12</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>6.37 ± 0.12</td>
<td>17.10 ± 0.54</td>
<td>1.79 ± 0.09</td>
<td>4.09 ± 0.07</td>
<td>5.88 ± 0.14</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>6.27 ± 0.15</td>
<td>17.05 ± 0.29</td>
<td>2.94 ± 0.09</td>
<td>4.67 ± 0.10</td>
<td>7.61 ± 0.07</td>
</tr>
<tr>
<td>Khosar</td>
<td>0</td>
<td>7.67 ± 0.31</td>
<td>17.46 ± 0.22</td>
<td>0.25 ± 0.04</td>
<td>2.75 ± 0.11</td>
<td>3.01 ± 0.09</td>
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<tr>
<td></td>
<td>3</td>
<td>7.23 ± 0.16</td>
<td>17.38 ± 0.24</td>
<td>1.20 ± 0.03</td>
<td>3.56 ± 0.05</td>
<td>4.76 ± 0.07</td>
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<td></td>
<td>6</td>
<td>6.70 ± 0.27</td>
<td>16.89 ± 0.45</td>
<td>2.20 ± 0.06</td>
<td>3.94 ± 0.09</td>
<td>6.15 ± 0.11</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>7.57 ± 0.34</td>
<td>16.66 ± 0.40</td>
<td>3.07 ± 0.08</td>
<td>4.34 ± 0.14</td>
<td>7.41 ± 0.10</td>
</tr>
</tbody>
</table>

Values are expressed as mean ± standard deviation. Means in the same column for each cultivar with different letters were significantly different at P < 0.05.

### Table 4 Effect of apple pomace-flours blends on the antioxidant properties of crackers.

<table>
<thead>
<tr>
<th>Rice cultivar</th>
<th>Replacement level (%)</th>
<th>Total phenolic content (mg GAE/g)</th>
<th>Total flavonoid content (µg catechin equivalent/g)</th>
<th>DPPH (% inhibition of DPPH radical)</th>
<th>Reducing power (µmol AAE/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-332</td>
<td>0</td>
<td>0.61 ± 0.03</td>
<td>55.49 ± 1.13</td>
<td>51.70 ± 1.94</td>
<td>8.30 ± 0.67</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.70 ± 0.07</td>
<td>59.03 ± 0.90</td>
<td>53.99 ± 2.26</td>
<td>9.12 ± 0.26</td>
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<tr>
<td></td>
<td>6</td>
<td>0.75 ± 0.05</td>
<td>60.18 ± 1.34</td>
<td>57.80 ± 2.21</td>
<td>11.66 ± 0.77</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>0.82 ± 0.04</td>
<td>63.16 ± 1.05</td>
<td>61.53 ± 1.70</td>
<td>12.15 ± 0.35</td>
</tr>
<tr>
<td>Khosar</td>
<td>0</td>
<td>0.58 ± 0.01</td>
<td>41.96 ± 1.27</td>
<td>47.80 ± 2.48</td>
<td>7.89 ± 0.41</td>
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<tr>
<td></td>
<td>3</td>
<td>0.66 ± 0.07</td>
<td>45.69 ± 0.89</td>
<td>51.24 ± 1.68</td>
<td>10.40 ± 0.20</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>0.70 ± 0.02</td>
<td>50.55 ± 1.88</td>
<td>53.05 ± 0.87</td>
<td>11.08 ± 0.28</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>0.75 ± 0.03</td>
<td>53.88 ± 1.65</td>
<td>56.12 ± 2.19</td>
<td>11.25 ± 0.76</td>
</tr>
</tbody>
</table>

Values are expressed as mean ± standard deviation. Means in the same column for each cultivar with different letters were significantly different at P < 0.05.
The DPPH is a stable free radical commonly used to determine the radical scavenging activity or antioxidant properties. The inclusion of pomace in rice flour mixtures resulted in rice crackers with increased DPPH radical scavenging activity (Table 4). The highest DPPH scavenging capacity was shown by crackers incorporated with 9% pomace, which may be attributed due to their highest phenolic content compared to the control crackers. DPPH radical scavenging capacity of crackers significantly increased from 51.70% to 61.53% and 47.80% to 56.12%, from control to 9% pomace level for K-332 and Khosar based flour, respectively. The thermal processing of cereals like baking also results in synthesis of substances with antioxidant properties such as Maillard reaction products which increases the DPPH radical scavenging activity (Lindenmeier and Hofmann, 2004; Sensoy et al., 2006). Reducing power of a substance is related to its electron transfer ability and may therefore serve as a significant indicator of its potential antioxidant activity. Literature also reported that the reducing power of bioactive compounds is associated with antioxidant activity (Mathew et al., 2013). Significant (P < 0.05) increase in reducing power has been observed with progressive increase in pomace incorporation level in the cracker (Table 4). The reducing power varied from 8.30 to 12.15 μmol AAE/g for K-332 and from 7.89 to 11.25 μmol AAE/g for Khosar rice flour-pomace cracker, respectively. The Khosar–pomace flour blend showed non-significant (P < 0.05) variation in reducing power amongst different pomace levels, whereas, the pomace level in K-332 flour based significantly (P < 0.05) changed the reducing power of cracker. The increase in reducing power in crackers may be due to the formation of maillard browning pigment during baking. The formation of maillard products depends upon the composition of food material used for the preparation of crackers (Gujral et al., 2013).

### 3.6. Mineral composition of cracker

The mineral analysis of pomace based rice crackers estimated by WD-X-ray fluorescence is shown in Table 5. The crackers were observed to be highest in chlorine (216.06 and 205.55 mg/100 g) followed by potassium (91.29 and 77.25 mg/100 g), phosphorus (54.16 and 53.77 mg/100 g), sodium (35.15 and 30.61 mg/100 g) and sulphur (17.25 and 15.66 mg/100 g) for K-332 and Khosar based cracker, respectively. The Khosar–pomace flour blend showed non-significant (P < 0.05) variation in reducing power amongst different pomace levels, whereas, the pomace level in K-332 flour based significantly (P < 0.05) changed the reducing power of cracker. The increase in reducing power in crackers may be due to the formation of maillard browning pigment during baking.

### Table 5

**Effect of apple pomace on quality characteristics of brown rice based cracker.**

<table>
<thead>
<tr>
<th>Rice Cultivar</th>
<th>Replacement level (%)</th>
<th>Calcium (mg/100 g)</th>
<th>Magnesium (mg/100 g)</th>
<th>Potassium (mg/100 g)</th>
<th>Sodium (mg/100 g)</th>
<th>Phosphorus (mg/100 g)</th>
<th>Zinc (mg/100 g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-332</td>
<td>0</td>
<td>5.25 ± 0.16</td>
<td>3.56 ± 0.03</td>
<td>3.67 ± 0.04</td>
<td>9.75 ± 0.16</td>
<td>54.16 ± 1.32</td>
<td>1.81 ± 0.03</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>5.90 ± 0.24</td>
<td>3.26 ± 0.16</td>
<td>3.87 ± 0.06</td>
<td>11.25 ± 0.26</td>
<td>50.96 ± 1.18</td>
<td>1.91 ± 0.03</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>6.71 ± 0.24</td>
<td>3.54 ± 0.16</td>
<td>4.07 ± 0.08</td>
<td>11.30 ± 0.24</td>
<td>47.75 ± 1.25</td>
<td>1.94 ± 0.05</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>8.26 ± 0.06</td>
<td>3.47 ± 0.04</td>
<td>4.38 ± 0.08</td>
<td>14.95 ± 0.62</td>
<td>41.24 ± 2.15</td>
<td>2.16 ± 0.05</td>
</tr>
<tr>
<td>Khosar</td>
<td>0</td>
<td>4.72 ± 0.11</td>
<td>3.06 ± 0.08</td>
<td>2.05 ± 0.09</td>
<td>9.31 ± 0.07</td>
<td>53.77 ± 1.88</td>
<td>1.71 ± 0.06</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>5.12 ± 0.12</td>
<td>3.54 ± 0.18</td>
<td>2.40 ± 0.11</td>
<td>9.07 ± 0.10</td>
<td>49.78 ± 0.46</td>
<td>1.73 ± 0.06</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>5.78 ± 0.27</td>
<td>3.54 ± 0.18</td>
<td>2.78 ± 0.14</td>
<td>9.24 ± 0.09</td>
<td>46.38 ± 0.41</td>
<td>2.05 ± 0.06</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>8.26 ± 0.18</td>
<td>3.02 ± 0.10</td>
<td>4.19 ± 0.14</td>
<td>8.41 ± 0.12</td>
<td>41.12 ± 0.32</td>
<td>2.18 ± 0.05</td>
</tr>
</tbody>
</table>

Values are expressed as mean ± standard deviation. Means in the same column for each cultivar with different letters were significantly different at P < 0.05.
Effect of apple pomace on quality characteristics of brown rice based cracker. Journal of the Saudi Society of Agricultural Sciences (2015), http://dx.doi.org/10.1016/j.jssas.2015.01.001

Table 6 Sensory characteristics of crackers supplemented with apple pomace.

<table>
<thead>
<tr>
<th>Rice cultivar</th>
<th>Replacement level (%)</th>
<th>Appearance</th>
<th>Flavour</th>
<th>Colour</th>
<th>Texture</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-332</td>
<td>0</td>
<td>7.51 ± 0.05a</td>
<td>6.72 ± 0.04a</td>
<td>7.31 ± 0.01a</td>
<td>7.98 ± 0.06a</td>
<td>7.39 ± 0.04b</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>7.63 ± 0.04a</td>
<td>7.42 ± 0.06b</td>
<td>7.24 ± 0.05b</td>
<td>7.79 ± 0.05b</td>
<td>7.52 ± 0.06a</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>7.21 ± 0.06b</td>
<td>7.70 ± 0.03a</td>
<td>7.16 ± 0.02a</td>
<td>7.73 ± 0.03a</td>
<td>7.45 ± 0.07ab</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>6.87 ± 0.03c</td>
<td>7.67 ± 0.04a</td>
<td>6.80 ± 0.03a</td>
<td>7.67 ± 0.03a</td>
<td>7.25 ± 0.04c</td>
</tr>
<tr>
<td>Khosar</td>
<td>0</td>
<td>7.26 ± 0.02b</td>
<td>6.99 ± 0.04a</td>
<td>7.35 ± 0.04a</td>
<td>7.94 ± 0.01a</td>
<td>7.39 ± 0.03b</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>7.44 ± 0.07a</td>
<td>7.65 ± 0.03b</td>
<td>7.31 ± 0.01a</td>
<td>7.85 ± 0.03b</td>
<td>7.57 ± 0.05b</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>7.19 ± 0.02b</td>
<td>7.75 ± 0.05ab</td>
<td>7.28 ± 0.01b</td>
<td>7.84 ± 0.05b</td>
<td>7.51 ± 0.03a</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>6.94 ± 0.04a</td>
<td>7.79 ± 0.02a</td>
<td>6.98 ± 0.03a</td>
<td>7.80 ± 0.02b</td>
<td>7.38 ± 0.02b</td>
</tr>
</tbody>
</table>

Values are expressed as mean ± standard deviation. Means in the same column for each cultivar with different letters were significantly different at P < 0.05.

3.7. Sensory evaluation of cracker

Sensory parameters of rice crackers incorporated with pomace were evaluated based on appearance, flavour, colour, texture and overall acceptability (Table 6). The appearance score was highest in 3% pomace blend and decreased from 3% to 9% pomace level. The scores for cracker colour decreased significantly as it changed from creamish yellow to brown colour with the increase in pomace level. The crispness value of crackers decreased with the increase in pomace level and showed highest in control sample. The sensory value for flavour is increased with increase in pomace level up to 6%. Sudha et al. (2007) reported that with the increase in levels of apple pomace, cakes had developed the pleasant flavour. Compared with control samples, sensory scores of rice cracker incorporated with pomace do not showed much variation in overall acceptability. The results of overall sensory showed that the crackers have desirable sensory properties and were acceptable at consumer level.

4. Conclusion

From the results of the present study, it can be concluded that apple pomace based brown rice flour crackers were sensory acceptable. Apple pomace addition changes the pasting properties of brown rice flour-pomace blends. Crackers prepared from 9% pomace level have significantly higher antioxidant properties mostly polyphenols and dietary fibre. 9% pomace level cracker expressed significantly higher radical scavenging activity, total phenolic and flavonoid content. The pomace based cracker contains higher dietary fibre especially insoluble fibre than control samples. The variation in colour and texture was obtained with the incorporation of apple pomace. Crackers also showed rich in minerals especially chlorine, potassium, phosphorus and sulphur. Thus the brown rice and the pomace proven as a good source of nutritional and functional components and therefore can be used in other bakery products as functional ingredient.

Conflict of interest

The authors do not have conflict of interest.

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References


