DEVELOPMENT AND QUALITY CHARACTERISTICS OF NUTRITIONALLY ENHANCED POTATO RICE BASED CHAKLI-AN INDIGENOUS SNACK FOOD

SUKHPREET KAUR* AND POONAM AGGARWAL
Department of Food Science and Technology, Punjab Agricultural University, Ludhiana-141004, Punjab, INDIA
e-mail: sukhpreetnagra1@gmail.com

INTRODUCTION

Potato contains carbohydrates (16%), proteins (2%), minerals (1%), dietary fibre (0.6%) and negligible amount of fat (Kaur et al., 2012). Apart from being a significant source of starch, potatoes are considered as a potential antioxidant source in human nutrition. Phenolic acids, ascorbic acid, carotenoids and flavanoids are the major bioactive compounds known in potato for their antioxidant (Lokendrajit et al., 2013), anti-inflammatory and antimicrobial properties (Ah-Hen et al., 2012). The scavenging activity of these compounds is mainly due to their redox properties, which allow them to act as reducing agents, hydrogen donors, and singlet oxygen quenchers (Ezekiel et al., 2013). Research has shown that their consumption can prevent many of the chronic diseases associated with cancer, inflammation, atherosclerosis and ageing caused by free radicals and oxygen (Ah-Hen et al., 2012, Ezekiel et al., 2013, Kaur and Kapoor 2002).

Potato production has significantly increased in recent years in many developing countries, particularly India, making it to the position of second largest potato producing country in the world. Despite the increasing production, bulk of the crop incurs heavy post harvest losses due to its perishable nature and inadequate storage facilities in our country. Diversification of potato utilization can solve this problem to some extent (Misra and Kulshrestha, 2003).

Fresh potatoes can be processed into several low cost value added deep fat fried products other than already existing processed potato products (chips and French fries). Deep-fatfried snacks are listed for their crunchy texture and fried aroma (Kulkarni et al., 1994). The demand of such deep fried snacks is increasing continuously mainly due to convenience, improved living standards, urbanization growth, preference of new generation for fast foods and rise in per capita income. Chakli is one such popular rice (Oryza sativa) based traditional deep-fat fried snack product which is manufactured on cottage scale in rural areas of South India (Sebestian et al., 2005). It is prepared using different cereal (wheat, rice) and legume (Bengal, green and black gram) blends.

Potato processing has considerable potential to reduce post-harvest losses and to generate income through the manufacture of value-added food products. Also, rice is the second most widely consumed cereal in India after wheat (Balakrishna and Satyanarayana, 2013; Kumari et al., 2014). So it is worthwhile to study the possibility of incorporating potato to a rice based snack chakli that can easily become a highly nutritional snack food by partial substitution of rice flour with potato to increase its phytochemical content. Also, data on phytochemical content and antioxidant activities of savoury snacks commonly consumed in India is scanty. Jayalakshmi and Neelkanthan, (1987) tried to improve its nutritional quality by using sorghum-soya blends and reported that soya flour could be incorporated

ABSTRACT

Potatoes (boiled and dehydrated) of three varieties were incorporated at 45% to a traditional Indian rice based deep-fat fried snack product namely chakli to study its effect on organoleptic, physicochemical, phytochemical and shelf life quality. The control products were without potato. Results indicated that the fat absorbed by control chakli was 20.57%. Potato incorporation in chaklis resulted in increased fat content (27.67-30.70%). Control chaklis had 9.20% protein content that was found to be significantly higher than that of potato incorporated chaklis (7.27-7.62%). Bioactive compounds including ascorbic acid, total phenolics and total antioxidant activity increased significantly on incorporation of potato. Between the cultivars, chakli enriched with Kufri Pukhraj, a table variety which is considered unfit for processing, displayed the highest ascorbic acid content (14.31 mg/100g), total phenolics (80.51 mg GAE/100g) and total antioxidant activity (73.66%). Results indicated that nutritionally enriched chakli can be developed from both fresh potato mash as well as dehydrated potato flour which provides significantly more bioactive compounds and antioxidant activity and high acceptability ratings than traditional rice chaklis (control). Development of value added potato products with enhanced nutrition may potentially boost consumption.

KEY WORDS
Potato, Potato flour, Chakli
Phytochemicals
Antioxidant activity
Supplementation

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*Corresponding author
up to 50 percent level for making deep fat fried chaklis. In another study conducted by Sebestian et al. (2005), the acceptability of rice and black gram dhal based chakli was enhanced by incorporating ragi at 5 percent level. Thus, the aim of this work was to develop chaklis enriched with different potato cultivars and to evaluate the quality characteristics of the developed product in order to assess its physicochemical, phytochemical, antioxidant and shelf life properties. Further, to promote processing in the rural areas as a cottage industry, these products can be taken up by unemployed youth and rural women since these products are easy to prepare and require no investment on processing machinery.

MATERIALS AND METHODS

Raw materials
Two potato cultivars known for better quality characteristics (Kufri Chipsona-1, Kufri Chandramukhi) and one commonly cultivated variety (Kufri Pulhrja) were produced from Vegetable Crops Department of the University and were used for production of chaklis. Began gram flour, rice flour from broken kernels and spices (cumin seeds, coriander, red chilli powder, carom seeds) were purchased locally. Frying was done with refined soybean oil and was purchased locally.

Preparation of raw material
Chaklis were prepared by incorporating both fresh boiled potato mash as well as dehydrated potato flour. One part of the harvested tubers of each cultivar was used for preparation of potato mash. The remaining part of tubers was used for the preparation of potato flour.

For preparation of boiled potato mash, fresh potato tubers (1 kg) of each cultivar were washed, peeled, cut into four quarters and pressure cooked in water (2L) for 5 min. The boiled potatoes were cooled and mashed.

Dehydrated potato flour was prepared by cooking 2-3 mm thick potato slices (approximately 500g) in boiling water (1L) containing 0.25% potassium metabisulphite for 10 min to prevent enzymatic darkening (Marwaha and Pandey, 2006). Immediately after cooking, potato slices were cooled under running tap water. The sulphited slices were drained, loaded in trays and dried in hot air cabinet drier at 60°C ± 5°C for 5 to 6 hr. The dried potato slices were ground in an electric grinder and then powdered in a cyclotec mill.

Preparation of chaklis

Formulation
Chaklis were formulated by incorporating potato in different proportions. Proportions of ingredients which were liked best sensorily were selected for the development of final product. Chaklis were prepared by the ‘traditional chakli’ recipe as described by Lakshmi and Prakash, (2000) with slight modification. Potato (boiled and dehydrated) of each variety was incorporated in the traditional recipe at levels of 10, 15, 30, 45 and 60 per cent in preparation of chaklis. Based on preliminary sensory trials, substitution of up to 45% of potato produced significant desirable changes in the sensory characteristics of chaklis. So, this level was used for the preparation of the final product.

Processing method
Standardized recipe of chakli had the ingredients, boiled potato mash 80g, rice flour 80g, bengal gram flour 15g, cumin powder 0.5g, coriander powder 1.6g, red chilli powder 1.0g, carom seeds 0.4g, salt 2g, water 10mL and oil 24mL. Chaklis were prepared from soft dough obtained by mixing standardized quantities of above described ingredients. The dough was rounded-off between palms of the hands, smeared with oil and fed to a hand operated extruder. The dough (approximately 120g) was extruded directly into 1 L refined soybean oil (175 ± 5°C) in a circular manner in a thick strand with a diameter of 10 mm. After 3 min of frying, when the products turned golden brown, they were removed and drained. The control (without potato) chakli samples were used for physico-chemical, phytochemical and sensorial comparisons.

Analysis

Physicochemical analysis
The moisture, protein and ash contents of the raw materials and powdered chakli samples were determined by official methods (AOAC, 2005). Reducing sugars of raw ingredients were determined by the Nelson Somogyi method (Pearson, 1976). Oil uptake of fried chakli samples was measured using soxhlet extraction method (Ranganna, 2004). Free fatty acids (as oleic acid) and Peroxide value was determined according to Standard AOAC,(2005) methods.

Phytochemical analysis
In the raw material and prepared chaklis, the ascorbic acid content, total phenolic content and antioxidant activity as DPPH radical scavenging activity was also determined. The ascorbic acid content was determined by visual titration method using 2, 4-Dichlorophenol-Indophenol dye method (Ranganna, 2004). The results were expressed as milligram of ascorbic acid/100 g dw.

Phenolic compounds were extracted from raw ingredients and chaklis (5 g fresh tissue; 1 g dry ingredient) according to Velioglu et al., (1998) with 50 ml of 80% (v/v) aqueous methanol for 3 h at 40°C with refluxing. The content of total phenolic compounds in extract was determined using the Folin-Ciocalteu’s colorimetric method (Velioglu et al., 1998). The absorbance at 765 nm was measured after 30 min and the results were expressed as gallic acid equivalents (mg GAE/100 g dw).

The antioxidant activity of aqueous extracts of raw materials and chaklis was determined using 1, 1-diphenyl-2-picrylhydrazyl (DPPH) radical. The ability of the prepared extracts to scavenge the stable free radical was estimated using the method of Yamaguchi et al., (1998). Methanolic extract of sample was taken for antioxidant activity and calculated according to the following formula. BHT was taken as a standard at a fixed concentration of 5 mg/mL.

\[
\text{Radical scavenging activity (\%)} = \frac{\text{Absorbance of control (0 minute)} - \text{Absorbance of sample (30 minute)}}{\text{Absorbance of control (0 minute)}} \times 100
\]
Texture Analysis of chaklis

Hardness of both control chaklis and potato supplemented chaklis was determined by the texture analyzer (LOYD texture instrument LR 5K, England) with an aluminium circular probe of 70 mm of diameter and a test speed of 1 mm/s. The thresholds of force and distance were 1 g and 1 mm, respectively. Ten measurements from each chakli samples were taken. Chaklis were placed on the crisp fracture support rig (code TA-101) and the circular probe was allowed to penetrate the snacks. Hardness (g) was recorded as the maximum force required for breaking the chaklis into two pieces.

Sensory quality evaluation of fresh chaklis

Fresh chakli samples enriched with both boiled potato mash and dehydrated potato flour were evaluated by a panel of 10 judges using 9-point Hedonic scale for their sensory characteristics like appearance, flavor, texture and overall acceptability. The scores were assigned from extremely liked (9) to disliked extremely (1).

Storage studies

Chaklis were packed in 200 gauge polythene bags and sealed in tight air containers. The packed chaklis were exposed to room temperature (26-38°C/RH 35-87%) for a period of 3 months. Storage stability of the product was assessed by determining the changes in moisture, bioactive composition, antioxidant activity and perishability parameters including free fatty acid content and peroxide value. Sensory analysis of the stored chaklis was done by a semi trained panel of 10 judges using 9-point Hedonic scale.

Statistical Analysis

All the experiments were carried out in triplicate. One-way analysis of variance was performed using the SPSS version 20.0 (Statistical Package for Social Sciences). Significant differences (p<0.05) were determined by Tukey’s.

RESULTS AND DISCUSSION

Quality characteristics of fresh chaklis

Physicochemical attributes

The physicochemical characteristics of control and potato incorporated chaklis are shown in Table 2. The moisture content of control chaklis was 2.48% and that of supplemented ones in the range of 2.46-2.66%. Between the cultivars studied, moisture content of K.Pukhraj supplemented chaklis were significantly (p<0.05) higher than chaklis enriched with K.Chipsona-1 and K.Chandramukhi (Table 2). The ash content of control chaklis was 3.20% and it ranged from 3.17% to 3.42% in potato supplemented chaklis (Table 2). In control chaklis, protein content was 9.20% that was found to be significantly (p<0.05) higher than that of potato supplemented chaklis (7.27-7.62%) (Table 2). These differences might be due to variation in the composition of raw material used (Table 1).

There was a wide variation in the oil absorption of fried chaklis. Oil uptake of potato incorporated chaklis (27.67-30.70%) was found to be significantly (p<0.05) higher than that of control chaklis (20.57%) (Table 2). Between the cultivars studied, chaklis supplemented with K.Pukhraj showed higher absorption of oil compared to K.Chipsona-1 and K.Chandramukhi supplemented chaklis. This might be due to differences in their dry matter content. The dry matter content in fresh tubers of cultivars K.Chipsona-1, K.Chandramukhi and K.Pukhraj was 24.31, 24.30 and 15.31 per cent, respectively. The higher oil uptake in K.Pukhrajchakli may be due to its lower dry matter content which might have resulted in loss of moisture content during frying. Tubers dry matter content is known to be negatively correlated with oil uptake in fried potato products (Kaur et al., 2012). Lakhsmi and Prakash, (2000) reported 17-20% oil content in chaklis prepared from rice and different legume flours. In a study conducted by Sebastian et al., (2005), the authors evaluated fat content of ragi incorporated chaklis. Fat absorbed by the control was 19.0%. The authors observed that ragi flour incorporation (5%) increased fat content to 24.0% in the prepared product. There was no significant (p<0.05) difference in the free fatty acid content and peroxide value of control and potato added chaklis. However, Sebastian et al., (2005) reported an increase in the free fatty acid content of chaklis incorporated with ragi flours at different proportions in comparison to control chaklis.

Phytochemical characteristics

Phytochemical attributes i.e. ascorbic acid and total phenolic content and antioxidant activities of fresh chakli samples significantly (p<0.05) increased on supplementation with potato as compared to control chakli (Table 2). It might be due to differences in the amount of phytochemical content and antioxidant capacity in raw ingredients (Table 1). Between the cultivars studied, chaklis supplemented with K.Pukhraj had the highest bioactive content while lowest was observed in K.Chipsona-1 chaklis (Table 2). Also, the antioxidant activity measured as DPPH radical scavenging activity was highest in

Table 1: Physicochemical and phytochemical traits of raw ingredients used in development of chaklis

<table>
<thead>
<tr>
<th>Raw ingredients</th>
<th>Treatments</th>
<th>Moisture (%)</th>
<th>Reducing sugars (%)</th>
<th>Protein (%)</th>
<th>Ash (%)</th>
<th>Ascorbic acid (mg/100g)</th>
<th>Total phenols (mg GAE/100g)</th>
<th>Scavenging activity* (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K.Chipsona-1</td>
<td>Boiled mash</td>
<td>75.69±0.10</td>
<td>0.08±0.05</td>
<td>21.40±0.62</td>
<td>4.03±0.15</td>
<td>75.76±0.30</td>
<td>165.4±0.21</td>
<td>38.10±0.23</td>
</tr>
<tr>
<td>Dehydrated flour</td>
<td>6.02±0.09</td>
<td>0.05±0.01</td>
<td>20.98±0.54</td>
<td>3.86±0.08</td>
<td>62.84±0.21</td>
<td>133.2±0.20</td>
<td>20.90±0.28</td>
<td>52.81±0.12</td>
</tr>
<tr>
<td>K.Chipsona-1</td>
<td>Boiled mash</td>
<td>75.70±0.06</td>
<td>0.18±0.05</td>
<td>18.75±0.55</td>
<td>4.92±0.12</td>
<td>80.92±0.30</td>
<td>224.2±0.60</td>
<td>53.20±0.50</td>
</tr>
<tr>
<td>Dehydrated flour</td>
<td>6.05±0.20</td>
<td>0.10±0.01</td>
<td>18.04±0.40</td>
<td>4.62±0.09</td>
<td>67.54±0.22</td>
<td>167.8±0.31</td>
<td>25.86±0.50</td>
<td>63.50±0.30</td>
</tr>
<tr>
<td>K.Pukhraj</td>
<td>Boiled mash</td>
<td>84.69±0.51</td>
<td>0.30±0.03</td>
<td>23.05±0.60</td>
<td>6.85±0.18</td>
<td>107.83±0.55</td>
<td>419.9±0.65</td>
<td>63.50±0.30</td>
</tr>
<tr>
<td>Dehydrated flour</td>
<td>6.15±0.12</td>
<td>0.15±0.02</td>
<td>22.86±0.52</td>
<td>6.92±0.20</td>
<td>80.86±0.21</td>
<td>318.6±0.42</td>
<td>20.90±0.25</td>
<td>52.81±0.12</td>
</tr>
<tr>
<td>Bengal gram flour</td>
<td>Fresh</td>
<td>9.22±0.28</td>
<td>nd</td>
<td>25.77±0.30</td>
<td>3.28±0.14</td>
<td>11.20±0.15</td>
<td>246.3±1.20</td>
<td>31.00±0.21</td>
</tr>
<tr>
<td>Rice flour</td>
<td>Fresh</td>
<td>9.10±0.18</td>
<td>nd</td>
<td>7.93±0.22</td>
<td>3.41±0.20</td>
<td>10.56±0.15</td>
<td>52.81±0.12</td>
<td>28.10±0.20</td>
</tr>
<tr>
<td>Spice mix</td>
<td>Fresh</td>
<td>3.10±0.11</td>
<td>nd</td>
<td>0.11±0.04</td>
<td>3.31±0.18</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
</tr>
</tbody>
</table>

*g/100g wet basis, nd = not detected; Values within a column with different letters are significantly (p< 0.05) different; Mean values ± SD (n=3)
<table>
<thead>
<tr>
<th>Products</th>
<th>Physicochemical properties</th>
<th>Phytochemical properties</th>
<th>Antioxidant properties</th>
<th>Textural properties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Moisture (%)</td>
<td>Ash (%)</td>
<td>Protein (%)</td>
<td>Oil uptake (%)</td>
</tr>
<tr>
<td>Control (without potato)</td>
<td>2.48±0.08</td>
<td>3.20±0.18</td>
<td>9.20±0.25</td>
<td>20.57±0.21</td>
</tr>
<tr>
<td>K.Chipsona-1</td>
<td>2.48±0.09</td>
<td>3.20±0.15</td>
<td>7.38±0.22</td>
<td>27.67±0.20</td>
</tr>
<tr>
<td>K. Chandramukhi</td>
<td>2.56±0.09</td>
<td>3.42±0.14</td>
<td>7.62±0.22</td>
<td>28.41±0.11</td>
</tr>
<tr>
<td>K.Pukhraj</td>
<td>2.66±0.05</td>
<td>3.26±0.18</td>
<td>7.47±0.22</td>
<td>30.70±0.25</td>
</tr>
<tr>
<td>Chaklis supplemented with boiled potato mash</td>
<td>2.46±0.09</td>
<td>3.17±0.11</td>
<td>7.27±0.31</td>
<td>27.76±0.15</td>
</tr>
<tr>
<td>K. Chipsona-1</td>
<td>2.54±0.08</td>
<td>3.34±0.10</td>
<td>7.59±0.20</td>
<td>27.79±0.11</td>
</tr>
<tr>
<td>K. Chandramukhi</td>
<td>2.64±0.10</td>
<td>3.24±0.19</td>
<td>7.46±0.20</td>
<td>30.64±0.20</td>
</tr>
<tr>
<td>K. Pukhraj</td>
<td>2.67±0.05</td>
<td>3.26±0.18</td>
<td>7.67±0.22</td>
<td>30.77±0.25</td>
</tr>
<tr>
<td>Chaklis supplemented with dehydrated potato flour</td>
<td>2.46±0.09</td>
<td>3.17±0.11</td>
<td>7.27±0.31</td>
<td>27.76±0.15</td>
</tr>
<tr>
<td>K. Chandramukhi</td>
<td>2.64±0.10</td>
<td>3.24±0.19</td>
<td>7.46±0.20</td>
<td>30.64±0.20</td>
</tr>
</tbody>
</table>

*Results expressed on dry weight basis. Values within a column with different letters are significantly (p<0.05) different. Mean values ± SD (n=3). T-test was used to determine the significance of difference in properties among products. All products were produced and stored as described in Table 1.

It is clear from Table 3 that there was no significant difference (p>0.05) in sensory quality of chaklis between products, which might have been due to differences in texture. The highest acceptability score was found for K.Pukhraj (Table 3). Compared to K.Chipsona-1 and K.Chandramukhi, K.Pukhraj showed a significant difference (p<0.05) in the moisture content of the prepared product. This might be due to differences in composition of chaklis. In composed chaklis, the moisture content of K.Pukhraj was lower than that of K.Chipsona-1 and K.Chandramukhi, which might have contributed towards its soft texture.

Storage studies can be successfully prepared from both boiled potato mash and boiled potato flour. When fresh potatoes are not available, chaklis can be prepared by using off-season color, flavor, texture and overall acceptability scores for both boiled potato mash and boiled potato flour. Similarly, these results indicate that chaklis stored at room temperature (22-35ºC) for 60 days (Kulkarni et al., 1994).
stored for some days and then consumed, it was worthwhile to study the keeping quality of prepared products in terms of rancidity parameters. Rancidity is a major cause of food deterioration in fried foods. The most common tests recommended for assessing the quality of deep-fried snacks are free fatty acids and peroxide values of extracted fat (Jonnalagadda et al., 2001).

Free fatty acid (FFA) and Peroxide values (PV)

There were no differences in FFA content and PV between chaklis prepared with either boiled potato mash or dehydrated flour (Fig. 3a). However, storage duration significantly (p < 0.05) affected the levels of FFA and PV in fried chaklis. The initial mean FFA content of chaklis was 0.110% which increased significantly (p < 0.05) to 0.240% after 3 months of storage, regardless of treatment (Fig. 3a). The increase in FFA content might be due to hydrolytic rancidity at elevated temperatures.
temperatures. PV increased from mean initial value of 0.446 to 2.66 meq O\textsubscript{2}/kg fat after 3 months of storage (Fig. 3b). This increase in PV might be due to the auto-oxidation of the oil absorbed during deep-fat-frying of chaklis. Similar increases in FFA content and PV were reported in stored bhujia prepared from different cereal legume mixtures (Kulkarni et al., 1994, fried sev and boondi (Waghray and Gulla, 2010) as well as deep-fried potato snacks (Berry et al., 1986). In the present study, all the chakli samples had their FFA and PV below the critical value of 1.0% and 10 meq O\textsubscript{2}/kg fat, respectively as specified in BIS standards for fried potato chips (BIS 1989a, 1989b).

Phytochemical content and antioxidant properties

The plant foods are known for their phytochemical content and antioxidant characteristics; therefore, it is essential to investigate the influence of storage and processing on these bioactive food components.

Ascorbic acid and Total phenolic content

During storage, the mean ascorbic acid content of chaklis was found to be decreased from original value, regardless of the treatments (i.e. fresh potato mash and potato flour) (Fig. 4a). The initial mean ascorbic acid content of chaklis was 12.66 mg/100 g dw, which decreased (p < 0.05) consistently to 10.60 mg/100 g dw, after 3 months of storage. This might be due to oxidation of the thermolabile ascorbic acid into dehydroascorbic acid upon storage. The ascorbic acid loss accounted to 16.27% after 3 months of storage period. Abong et al., (2011) observed similar losses in ascorbic acid content during storage of potato crisps.

During storage, a significant (p < 0.05) decrease in total phenolic content was observed in all the chakli samples, irrespective of the treatments (Fig. 4b). The mean content of total phenolics of chaklis was estimated to be 53.35 mg GAE/100g initially and this was found to decrease significantly (p < 0.05) to 43.86 mg GAE/100g after 3 months of storage at room temperature (28-35°C) (Fig. 4b). This might be due to the sensitivity of phenolic components to oxidation at above stored conditions. The change in mean total phenolics content of chaklis during the entire storage period from the initial values was 17.78%. Selvamuthukumaran and Khanum, (2014) reported 36% losses in total phenolics of buckwheat jam stored at 37°C for 8 months. According to Lachman et al., (2008), the level of phenols present in fruits and vegetables can be influenced by growing conditions, harvest conditions, species, processing methods and storage conditions.

As to the treatments, higher mean ascorbic acid and total phenolics were observed for chaklis supplemented with boiled potato mash in comparison to potato flour chaklis (Fig. 4a, b). This might be due to presence of higher amount of phytochemicals in the fresh boiled potato mash compared to dehydrated potato flour (Table 1) as a result of losses caused by leaching into water and degradation from the effect of heat during processing. Bioactive compounds are soluble in water but susceptible to thermal processes. They are lost by washing out of potato and undergoing thermal degradation (Nems et al., 2015).

DPPH radical scavenging activity

There was slight but significant (p < 0.05) decrease in the mean radical scavenging activities of chaklis regardless of treatments (Fig. 4c). The mean radical scavenging activities of chaklis extracts was estimated to be 63.66% initially and this was found to decline significantly to 44.86% after 3 months of storage (Fig. 4c). The decrease in the total antioxidant activity may be linked to decrease in the content of phytonutrients such as total phenolics and ascorbic acid. The correlation between bioactive concentration and antioxidant activity of plant foods is well established (Ah-Hen et al., 2012, Kaur and Kapoor, 2002). Kapoor and Aggarwal, (2014) reported significant losses (43.40%) of total antioxidant activity in carrot juice stored at room temperature for 6 months. In our study,
the loss in total antioxidant capacity as radical scavenging activity accounted for 29.77% after 3 months of storage.

Regarding treatments, extracts of chaklis supplemented with boiled potato mash showed a significantly \( (p<0.05) \) higher content of radical scavenging capacity compared to potato flour chaklis extracts (Fig. 4c). This might be due to differences in the profiles of antioxidants contained in boiled potato mash and in the dehydrated flour (Table 1). According to Nems et al. (2015), thermal stages of food processing are one of most important factors affecting the changes in the bioactive components naturally present in raw material and therefore change the antioxidant capacity of the processed food. Singla et al., (2010) compared the total antioxidant activities of extracts obtained from osmotically dehydrated and spiced mushroom snack food with raw unprocessed mushrooms; they reported 76 and 72% scavenging activity of free extracts of raw and dry snack mushrooms, respectively on DPPH radical.

Sensory quality

The effect of storage on the overall acceptability of chaklis stored at room temperature (26-38°C/RH 35-87%) is represented in Table 4. Potato supplemented chaklis had better acceptability scores as compared to control (without potato) chaklis. Potato incorporated chaklis from all the three cultivars were found to be highly desirable up to 3 months of storage. Also, chaklis supplemented with K. Pukhraj, an unmarketable cultivar, displayed excellent keeping quality during the entire storage period (Table 4). Incorporation of such potato cultivars into low-cost value added products such as chaklis could serve as an excellent vehicle for enhancing the utilization of this resourceful food crop.

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