Quality characteristics and shelf life studies of potato (Solanum tuberosum L.) Incorporated “chakli” - an Indian traditional snack

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Abstract: Potatoes 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, and shelf life quality. The control products were without potato. Results indicated that protein content was significantly higher in control chaklis compared to potato supplemented chaklis. Oil uptake significantly increased on supplementation with potato. Sensory evaluation indicated higher overall acceptability scores for potato enriched chaklis compared to control chaklis. Storage studies showed marginal changes in the moisture content and rancidity parameters of the product. Potato incorporated chaklis from all the three cultivars were found to be highly desirable up to 3 months of storage. Potato consumption can be increased through the production of such low cost food products.

Key words: Potato, cultivars, chakli, rice, supplementation

Introduction
Potato (Solanum tuberosum L.) is the most important tuber crop of the world and most important vegetable food crop in India. Potato is a wholesome food containing 16% carbohydrates, 2% proteins, 1% minerals, 0.6% dietary fibre and negligible amount of fat (Brown 2005, Kaur et al., 2012). Besides being a rich source of carbohydrates, potato also contain some health promoting compounds such as phenolic acids, ascorbic acid and carotenoids which are commonly described as antioxidants (Ezekiel et al., 2013, Kasper et al., 2013). In world scenario, India became the second largest producer of potato with a production of 41.48 million tons in the year 2012-13 (Saxena and Mathur, 2013). Increased potato production has led to several post harvest problems especially their storage resulting in heavy post-harvest losses and wastage of this resourceful crop (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-fat fried 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.

The traditional food sector is primarily restricted to households and it is increasingly being realized to bring it out in the open for a much varied use (Lakshmi and Prakash, 2000). There are certain eminent research needs to bring the traditional foods into the commercial sector. Potato processing has considerable potential to reduce post-harvest losses and to generate income through the manufacture of value-added food products (Kulkari et al., 1997). So it is worthwhile to study the possibility of incorporating potato to a fried snack item that can be prepared commercially as well as at household levels. 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 and shelf life properties.

Materials and Methods

Raw materials: Two potato cultivars known for better quality characteristics (Kufri Chипsona-1, Kufri Chandramukhi) and one commonly cultivated variety (Kufri Pukhraj) were produced from Vegetable Crops Department of the University and were used for production of chaklis. Began gram flour, rice flour from broken kenels 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 from fresh boiled potato mash of each cultivar. 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 (2 L) for 5 min. The boiled potatoes were cooled and mashed.

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 modifications. Potato (fresh boiled mash) 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: 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...
Quality characteristics and shelf life of potato product

Fresh potato mash
Mixing with rice flour, Bengal gram flour and various spices
Kneading
Soft dough
Extrusion through a die
Frying (175±5°C/3 min)
Cooling
Packaging

Fig. 1: Flow chart for preparation of chaklis

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 physicochemical, phytochemical and sensorial comparisons. The process flow chart for the manufacturing of chakli is shown in Fig.-1.

Physicochemical analysis: The moisture, protein and ash contents of the powdered chakli samples were determined by official methods (AOAC, 2005). 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.

Texture analysis: Hardness of both control chakli and potato supplemented chakli was determined by the texture analyzer (LLOYD texture instrument LR 5K, England) with an aluminum circular probe of 70 mm of diameter and a test speed of 1 mm/s. The thresholds of force and distance were 1g and 1mm, respectively. Ten measurements from each chakli samples were taken. Chakli 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 chakli into two pieces.

Sensory quality evaluation of fresh chaklis: Fresh chakli samples (enriched with boiled potato mash) and control (without potato) samples 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: Chakli 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 and rancidity 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

The physicochemical and textural characteristics of control and potato incorporated chaklis are shown in Table-1. The moisture content of control chaklis was 2.48% and that of supplemented ones in the range of 2.48-2.66%. 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. The ash content of control chaklis was 3.20% and it ranged from 3.20% to 3.42% in potato supplemented chaklis. In control chaklin, protein content was 9.20% that was found to be significantly (p<0.05) higher than that of potato supplemented chaklis (7.38-7.62%). 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%). Between the cultivars studied, chaklis supplemented with K.Pukhraj showed higher absorption of oil compared to K.Chipsona-1 and K.Chandramukhi supplemented chaklis. There was no significant (p<0.05) difference in the free fatty acid content (FFA) and peroxide value (PV) of control and potato added chaklis. As for texture, it was found that hardness of potato supplemented chaklis was significantly (p<0.05) lower than that of control chaklis. Among the cultivars, the chaklis incorporated with K.Pukhraj showed a significant (p<0.05) lower hardness than the chaklis supplemented with K.Chipsona-1 and K.Chandramukhi.

During storage, there was a gradual increase (p<0.05) in the moisture content of chaklis, irrespective of cultivars. As seen in Fig. 2, the average moisture content of chaklis increased from 2.68% to 3.48% during 3 months of storage. Storage duration significantly (p<0.05) affected the levels of FFA 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 cultivars (Fig. 3a). There was a significant (p<0.05) increase in the levels of peroxides in all the chaklis samples, irrespective of cultivars. PV increased from mean initial value of 0.446 to 2.66 meq O₂/kg fat after 3 months of storage (Fig. 3b). Potato supplemented chaklis had better acceptability scores as compared to control (without potato) chaklis (Table 2). Within the cultivars studied, sensory characteristics i.e. color, flavor, texture and overall acceptability scores for chaklis supplemented with K.Chipsona-1 and K.Chandramukhi appeared to be higher than

### Table-1: Quality characteristics of fresh chaklis

<table>
<thead>
<tr>
<th>Products</th>
<th>Physicochemical properties</th>
<th>Textural properties</th>
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<tbody>
<tr>
<td></td>
<td>Moisture (%)</td>
<td>Ash (%)</td>
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<tr>
<td>Control (without potato)</td>
<td>2.48±0.08a</td>
<td>3.20±0.18a</td>
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<tr>
<td>Chaklis supplemented with different potato cultivars</td>
<td></td>
<td></td>
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<tr>
<td>K.Chipsona-1</td>
<td>2.48±0.09a</td>
<td>3.20.15a</td>
</tr>
<tr>
<td>K. Chandramukhi</td>
<td>2.56±0.09a</td>
<td>3.420.14a</td>
</tr>
<tr>
<td>K.Pukhraj</td>
<td>2.66±0.05a</td>
<td>3.260.18a</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)

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for K.Pukhraj. Compared to K.Chipsona-1 and K.Chandramukhi chaklis, chaklis supplemented with K.Pukhraj were darker in color (Fig. 4). 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-2).

Significant (p<0.05) differences were observed in physicochemical characteristics of fresh potato incorporated chaklis and control chaklis. These differences might be due to variation in the composition of raw material used. There was a wide variation in the oil absorption of fried chaklis. Incorporation of potato resulted in significant (p<0.05) increase in the oil uptake of chaklis compared to control (without potato) chaklis. Within the cultivars studied, chaklis enriched with K.Pukhraj showed significantly (p<0.05) higher absorption of oil compared to chaklis supplemented with other two cultivars. 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.Pukhraj chaklis may be due to its lower dry matter content which might have resulted in loss of moisture content during frying. Tuber dry matter content is known to be negatively correlated with oil uptake in fried potato products (Kaur et al. 2009, Marwaha et al. 2009). 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. Non-significant (p < 0.05) differences were observed 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.

The hardness of control chaklis was significantly (p < 0.05) higher than that of potato enriched chaklis. The higher hardness of the control chaklis might be due to differences in composition. Among the cultivars, the chaklis incorporated with K.Pukhraj showed a significant (p < 0.05) lower hardness than the chaklis supplemented
with K.Chipsona-1 and K.Chandramukhi. This might be due to higher oil absorption in K.Pukhraj chaklis which might have contributed towards its soft texture. According to Totossaum and Lourdes Perez- Chabela (2006), higher fat content increases the flavor but also imparts soft texture to the food product. During storage of chaklis at room temperature (26-38°C/RH 35-87%) for 3 months, gradual but significant (p<0.05) rise in the moisture content was noticed, regardless of cultivars. This might be due to variation in atmospheric relative humidity, which ranged from 35-85% during the storage period. Similar behaviour was also observed in rice flour and colocasia Sevian (a deep fried snack) stored at room temperature (22-35°C) for 60 days (Kulkarni et al., 1994). Rancidity is a major problem in fried foods and also a major cause of food deterioration. 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). FFA are the products of enzymatic or microbial degradation of lipids. Determination of FFA gives information about stability of fat during storage. There were no differences in FFA content between control chaklis and chaklis prepared with addition of boiled potato mash. However, storage duration significantly (p < 0.05) affected the levels of FFA in fried chaklis samples. The increase in FFA content in deep-fried chaklis might be due to the development of oxidative rancidity during storage. Sebastian et al. (2005) reported gradual increase in FFA in ragi incorporated chaklis during storage of 4 weeks at room temperature. Lakshmi and Prakash (2000) observed only a marginal rise in FFA in chaklis prepared from different legume blends. BIS (Bureau of Indian standards) specifications for maximum FFA content in fried potato chips are 1.0% (BIS, 1989a). In our study, the value for FFA content in all the fried chakli samples were below the critical limit.

The primary products of lipid oxidation are hydro peroxides (Jonnalagadda et al., 2001). Therefore, PV was used as an index to assess the level of lipid oxidation in chaklis during storage. There was a significant (p < 0.05) increase in the levels of peroxides in all the chaklis samples, irrespective of cultivars. Increase in the PV during storage period indicates formation of peroxides due to oxidation. In a study conducted by Kulkarni et al. (1994), PV ranged from 0.50 to 3.70 meq O₂/kg fat during 60 days storage of fried Sevian at room temperature. PV value of fried sevian and boondi increased from 6.6 to 32.7 meq O₂/kg fat and 8.5 to 33.2 meq O₂/kg fat, respectively during storage up to 90 days at room temperature (Waghray and Gulla 2010). In another study carried out on deep-fried potato snacks, PV ranged from 12.4 to 757 meq O₂/kg fat when stored for 180 days (Berry et al. 1986). In the present study, all the chakli samples had their PV below the critical value of 10 meq O₂/kg fat as specified in BIS standards for fried potato chips and French fries (BIS 1989a, 1989b).

As for the sensory quality, incorporation of potato resulted in higher acceptability scores compared to control (without potato) chaklis. Within the cultivars studied, chaklis supplemented with K.Pukhraj were darker in color compared to K.Chipsona-1 and K.Chandramukhi chaklis. The lowest rating for color in K.Pukhraj contributed to high reducing sugars in this cultivar (0.31%) compared to the other two cultivars, 0.06%. Color of fried potato products is the most significant visual quality criterion, which is dependent on the amount of reducing sugars in raw tubers because they induce a non enzymatic Millard reaction with free amino acids, forming unacceptable brown to black pigmented products (Ramezani and Aminlari 2004). The range of color in potato products

made from K.Chipsona-1, K.Chandramukhi and K.Pukhraj agrees with that reported by Kaur et al. (2012), Marwaha and Sandhu (2006). It can be concluded that chaklis can be prepared from both medium and high sugar potato cultivars which provide high acceptability ratings and could be stored safely up to 3 months with only marginal rise in moisture content, free fatty acids and peroxide value. 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.

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References