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CHIPPING AND NUTRITIONAL QUALITY OF POTATO CULTIVARS GROWN IN NORTH INDIAN PLAINS

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ABSTRACT : Ten potato cultivars, commonly grown in North Indian plains were evaluated for processing and nutritional quality. Within the cultivars studied, Kufri Chipsona-1, Atlantic and Lady Rosetta were rated as the best varieties for processing into potato chips, since these contained the highest amount of dry matter content, lowest amount of reducing and total sugars and produced chips of desirable colour, texture and flavour. While Kufri Pukhraj, a table variety, which was found unfit for processing was considered highly suitable for direct consumption since it contained the highest amount of bioactive compounds including ascorbic acid, total phenolics and total antioxidant activity.

Keywords : *Potato, sugar content, processing, chips.*

Potatoes are one of the important crops which ranks fourth among the food crops in the world after wheat, rice and maize in total production (Misra and Kulshrestha, 10). Potato contains carbohydrates (16%), proteins (2%), minerals (1%) dietary fibre (0.6%) and negligible amount of fat. Besides being rich in carbohydrates, potato contains some health beneficial compounds such as phenolic acids, ascorbic acid and carotenoids (Kaur *et al*., 8; Ezekiel *et al.,* 5).

India is amongst the five major potato producing countries in the world with a production of 38.01 million MT (FAO, 6). Leading Indian states in potato production are Uttar Pradesh, West Bengal, Bihar and Punjab. Punjab is the fourth largest producer of potato in the country comprising 5% of India's total production.

Numerous potato cultivars are grown in different parts of the country. However, all the cultivars are not suitable for processing. Potato must meet certain requirements concerning chemical composition and quality for processing. Potatoes designed for chipping must have certain quality attributes viz. round to oval tubers, preferably 74mm length, shallow eyes, >20% dry matter and low reducing sugars (<0.1% on fresh weight basis) so as to yield chips of excellent quality (Kaur *et al.,* 8).

In the northern plains, the crop is grown during winter under sub tropical conditions from November to January. The bulk of the potatoes produced is harvested before the onset of the hot and dry summer which is followed by the hot and humid rainy season. Such ambient conditions necessitate cold storage of potatoes (Gahlawat and Sehgal, 7). From April onwards, industries utilize potatoes stored at intermediate temperatures (10-12°C) with a sprout suppressant, CIPC (Isopropyl N-(3-Chlorophenyl Carbamate).

However, after July, stored potato varieties also start accumulating higher amounts of reducing sugars and the potatoes become unsuitable for processing (Pandey *et al.,* 11). During this period, processing industries located in the north have to procure potatoes from central parts of India involving significant expenditure on transportation and, therefore, increased cost of production.

Keeping above facts in view, the present study was designed to determine the suitability of ten potato cultivars grown in the northern Indian plains for processing and nutritional quality. The present study would be beneficial for both growers and consumers. Cultivation of suitable processing varieties would save the wastage of this resourceful crop and will bring remunerative returns to the farmers as the processing potatoes fetch premium price. Also nutritional information would help in increasing awareness among consumers regarding the content of health beneficial phytochemicals present in this nutritious vegetable.

MATERIALS AND METHODS

Selection of potatoes

Healthy fully matured uniform sized tubers of ten potato cultivars viz; Kufri Jyoti, Kufri Badshah, Kufri Chandramukhi, Kufri Pukhraj, Kufri Lauvkar, Frito Lay 1533, Atlantic, Kufri Chipsona-1, Kufri Chipsona-3 and Lady Rosetta, were procured from the department of Vegetable Science of Punjab Agricultural University, Ludhiana. Analysis of the fresh cultivars and

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preparation of potato chips were carried out in the food science and technology laboratories at Punjab Agricultural University, Ludhiana.

Preparation of potato chips

Eight tubers from each variety were washed, peeled, and cut into 1.4 mm thick slices with a rotary hand slicer. After washing and removing surface moisture with a muslin cloth, slices were fried in cotton seed oil at 180°C for <2 min until the oil ceased bubbling (Kaur *et al.,* 8). Frying was in a batch type, deep fat fryer containing about 5L of oil maintained at 180°C

Physicochemical and Organoleptic studies of fresh potato tubers and fried potato slices

Fresh potatoes were analyzed for dry matter content (AOAC, 1). Reducing sugars were determined by the Nelson – Somogyi Method (Pearson, 12). Starch content was estimated by the method of Clegg (4). Ascorbic acid content was determined using the dichlorphenol indophenol titration method of Ranganna (15). Total phenols were estimated by the Folin-Ciocalteu's colorimetric method (Velioglu *et al.,* 22). Total antioxidant activity of the raw tubers was estimated by DPPH (1, 1- diphenyl- 2-picrylhydrazyl) as described by Shimada *et al*. (19) with some modifications. Methanolic extract of 5g 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.

$$\text{Radical scavenging activity (\%)} = \frac{\text{Absorbance of control (0 minute)} - \text{Absorbance of sample (30 minute)}}{\text{Absorbance of control (0 minute)}} \times 100$$

Freshly prepared fried potato chips were analyzed for moisture content (AOAC 1). Oil uptake was measured using the Soxhlet extraction method (Ranganna, 15). Yield was calculated after frying the chips. Coded samples were presented to 10 panelists and score for color, texture, flavor and overall acceptability was determined on a 9-point hedonic scale (Amerine *et al.,* 3).

Results were analyzed statistically using completely randomized design experiment as discussed by Singh *et al.* (20).

RESULTS AND DISCUSSION

Physicochemical and bioactive analysis of fresh potato tubers

Physicochemical analysis

The data on the physico-chemical parameters of different potato cultivars (Table 1) reared that dry matter content ranged between 17.30% to 24.0% among different cultivars. Dry matter content has a strong influence on chip quality and high dry matter (>20%) is required for higher yield and lesser oil absorption in the finished products. Between the cultivars studied, Kufri Chipsona-1, Kufri Chipsona-2, Kufri Chandramukhi, Atlantic, Lady Rosetta showed higher dry matter content (21.1-24.0%) while Kufri Jyoti, Kufri Pukhraj and Kufri Badshah showed lower dry matter content (Table 1). These values are comparable to the data reported by Singh *et al.* (21). The range of specific gravity among different potato cultivars was 1.062-1.095 (Table 1). There is a linear relationship between specific gravity and dry matter content. Cultivars having higher dry matter content were found to have higher specific gravity.

Table 1: Physicochemical analysis of potato cultivars

Cultivar	Specific gravity	Dry matter (%)	Reducing sugars (%)	Total sugars (%)	Starch (%)	Ash (%)	Protein (%)
Kufri Chipsona-1	1.085±0.004	21.9±0.09	0.02±0.03	0.09±0.003	14.9±0.05	0.73±0.02	2.01±0.09
Kufri Chipsona-3	1.087±0.004	22.3±0.06	0.02±0.02	0.11±0.006	15.2±0.20	0.70±0.02	2.80±0.05
Kufri Pukhraj	1.062±0.003	17.3±0.09	0.18±0.05	0.32±0.02	12.9±0.18	0.89±0.05	1.90±0.08
Kufri Chandramukhi	1.080±0.002	21.1±0.03	0.05±0.002	0.11±0.01	14.1±0.13	0.93±0.07	1.89±0.07
Kufri Badshah	1.066±0.003	18.3±0.16	0.30±0.02	2.20±0.08	13.2±0.12	0.98±0.10	1.40±0.04
Frito Lay 1533	1.082±0.004	21.2±0.25	0.03±0.003	0.08±0.002	13.9±0.08	1.01±0.10	2.85±0.11
Atlantic	1.094±0.005	23.9±0.03	0.02±0.001	0.06±0.002	15.9±0.09	1.12±0.08	2.90±0.13
Lady Rosette	1.095±0.005	24.0±0.12	0.02±0.001	0.05±0.002	16.5±0.16	0.70±0.05	1.81±0.09
Kufri Lauvkar	1.080±0.004	21.1±0.11	0.06±0.002	0.11±0.03	14.2±0.10	0.98±0.05	2.00±0.15
Kufri Jyoti	1.066±0.003	18.2±0.06	0.19±0.06	0.30±0.01	12.8±0.13	0.95±0.02	1.82±0.09
CD (P = 0.05)	0.002	0.15	0.02	0.03	0.17	0.07	0.10

The total and reducing sugars which play an important role in the non- enzymatic Millard browning reaction, ranged 0.02 – 0.30% and 0.05 – 2.20%, respectively (Table 1) among different cultivars. Low reducing (<0.1% on fresh wt basis) and total (<2.0% on fresh wt basis) sugars is desirable for making light colored finished potato products. In this study, cultivars with lower amount of reducing sugars produced light colored potato chips, while Kufri Jyoti, Kufri Pukhraj and Kufri Badshah with high levels of reducing sugars produced dark chips (Plate 1) and were, therefore considered unfit for chipping.

Starch content which is considered to be the main constituent of potato was found to be maximum in Lady Rosetta (16.5%), followed by Atlantic (15.9%) and minimum in Kufri Jyoti (12.8%) (Table 1). This might be due to higher dry matter content in these cultivars, as starch and dry matter contents of potato are directly related to each other. Similar observations were reported earlier for different cultivars of potatoes (Raj *et al.,* 13).

The protein and ash content of different cultivars ranged between 1.40 to 2.90% and 0.70 to 1.12% respectively (Table 1). These differences might be related to botanical origin and genetic variations among the different cultivars. Data for protein and ash content is in line with those reported by Sandhu and Parhawk (17) for different potato cultivars.

Bioactive analysis

Potatoes are considered as significant source of bioactive compounds such as ascorbic acid and total phenolics that help reduce the risk of chronic diseases (Ezekiel *et al,* 5). Fig.1 illustrates the ascorbic acid content among different potato cultivars. The values for ascorbic acid content of potato cultivars ranged between 11.30% and 16.40%. Maximum ascorbic acid was found in Kufri Pukhraj (16.40 mg/100g), followed by Kufri Jyoti (15.50 mg/100g) and minimum in Frito Lay 1533 (11.30 mg/100g). Ascorbic acid is an important health promoting compound as well as a potent antioxidant which accounts up to 13% of the total antioxidant capacity in potato. Its antioxidant activity has been associated with its ability to act as free radical acceptor.

Another important bioactive component in potatoes is phenolics compounds. Phenolic compounds are secondary plant metabolites (phyto chemicals) which are known for their health beneficial properties. The most presented polyphenolic compounds in potato tubers are tyrosine, caffeic acid,

Plate 1 : Potato chips prepared from different cultivars.

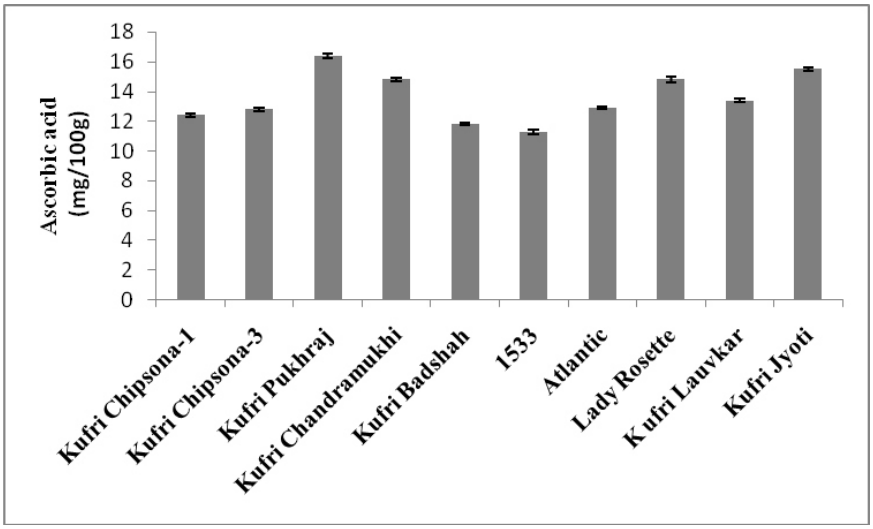

Fig. 1 : Ascorbic acid content of different cultivars. Values are mean ± SD, n=3. *Error bars represents SD of the means.*

ferulic acid and chlorogenic acid (Ezekiel *et al*, 5). Total phenolic content of different potato cultivars is shown in Fig. 2. Kufri Pukhraj displayed the highest phenolic content (63.50 mg GAE / 100g), followed by Kufri Badshah (63.40 mg GAE / 100g) and Kufri Jyoti (61.20 mg GAE / 100 g). In contrast, processing varieties such as Kufri Chipsona-1, Kufri Chipsona-2, Atlantic and Lady Rosette showed lower values for phenolic content. Similar results for total phenols were documented earlier by Marwaha *et al.* (9). Earlier phenolics were considered undesirable due to their contribution in enzymatic browning. Enzymatic discoloration occurs due to the oxidation of these compounds by polyphenol oxidase. But recent studies have proven their health promoting properties. The scavenging properties of phenolics are mainly due to their redox properties which allow them to act as reducing agents, hydrogen donors and singlet oxygen quenches. Thus potatoes have potential for use as "functional food" for improving human health.

Total antioxidant activities of fresh potato cultivars as determined by DPPH radical scavenging method, are presented in Fig. 3. DPPH is a free radical generating compound, deep purple in color which is reduced by the presence of antioxidants, decolorizing the solution. The loss in color leads to decrease in the absorbance intensity thus providing a basis for measurement of antioxidant activities in the extract. Radical scavenging activity of methanolic extracts of various potato cultivars was in the range of 26.8-63.5% (Fig. 3). It can be observed from Fig. 4 that radical scavenging activity in fresh potato cultivars decreased continuously with increase in retention time and maximum activity was shown at 30 minutes and became stable thereafter. Within the cultivars studies, methanolic extracts of Kufri Pukhraj displayed highest

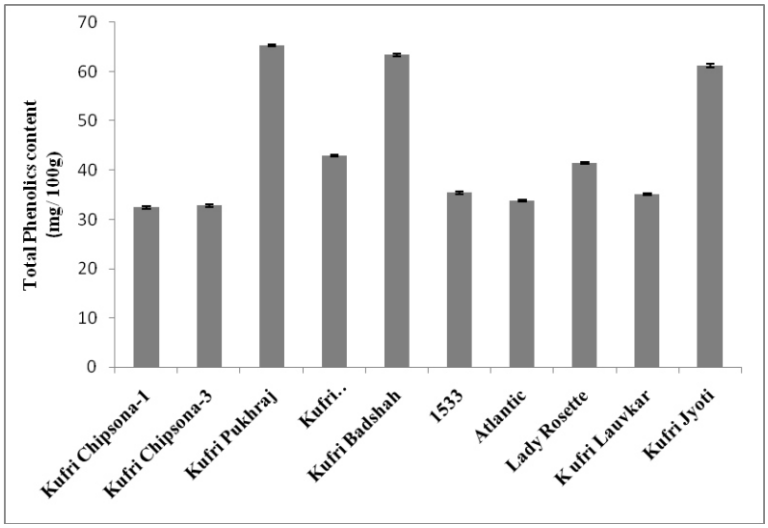

Fig. 2 : Total phenolic content of different cultivars. Values are mean ± SD, n= 3.

radical scavenging activity (63.5%), closely followed by Lady Rosette (62.8%), Kufri Jyoti (58.1%) and Kufri Badshah (55.8%) while Kufri Chipsona-1 showed lowest scavenging activity (26.8%). The increase in antioxidant activity in these cultivars may be due to presence of higher levels of bioactive compounds such as ascorbic acid and phenolic compounds. Reyes *et al.* (16) observed high positive correlation between of potatoes and conducted that these compounds are mainly responsible for the antioxidant activity. Al Saikhan *et al.* (2) determined total antioxidant capacity in different genotypes of potato cultivars and found that total antioxidant capacity (per cent inhibition relative to control) ranged 65.2-88.1% and 68.6-89.2% in white and yellow flesh cultivars, respectively. In the present study, cultivars such as Kufri Pukhraj, Kufri Jyoti and Kufri Badshah which showed poor processing attributes, may be regarded superior for direct consumption owing to their higher total antioxidant capacities.

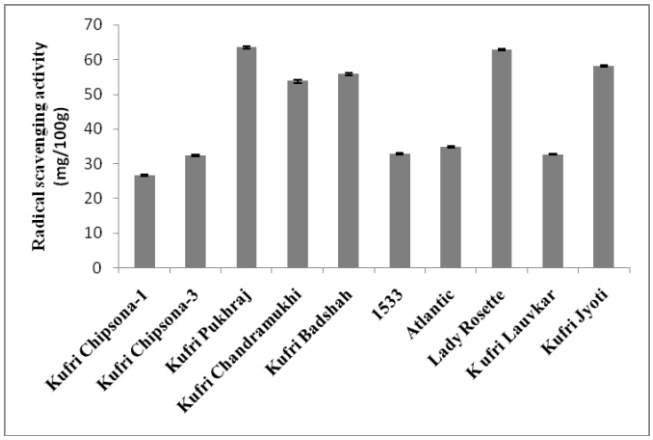

Fig. 4. Total antioxidant activities of different cultivars. Values are mean ± SD, n = 3. Error bars represents SD of the means.

Physicochemical analysis of fresh potato chips prepared from different cultivars

Physico-chemical characteristics of fresh potato chips prepared from different cultivars are depicted in Table 2. The yield of potato chips was positively correlated with the dry matter content of cultivars. Cultivars which had higher fresh tissue dry matter (>21%), produced high yield of chips (29.4-32.9%) in comparison to lower dry matter content cultivars (26.5-28.1%) (Table 2). Lady Rosetta produced maximum average chip yield among cultivars followed by Kufri Chipsona-1, Kufri Chipsona-3 and Atlantic. The results are in conformity with published reports of Raj *et al.* (16) and Marwaha *et al.* (9).

Oil uptake is the most important factors determining the quality and cost of potato chips. Oil uptake in the fried chips ranged between 32.0% to 41.8% (Table 2), with minimum in Lady Rosetta, closely followed by Atlantic and Kufri Chipsona-1 and maximum in Kufri Pukhraj. For processing purpose, the recommended oil uptake in chips is 38.0%. Cultivars with higher dry matter content, produced chips of acceptable oil uptake whereas cultivars with lower dry matter, produced unacceptable chips with high oil uptake. As explained by Ramezani and Aminlari (14) higher dry matter contents of raw tubers allow lesser oil uptake, desirable flavor, texture and increased yield of chips. High oil absorption in processed products is undesirable for health conscious consumers as well as the industry because it increases production cost. The higher oil uptake in Kufri Pukhraj may have been due to loss of moisture content during frying.

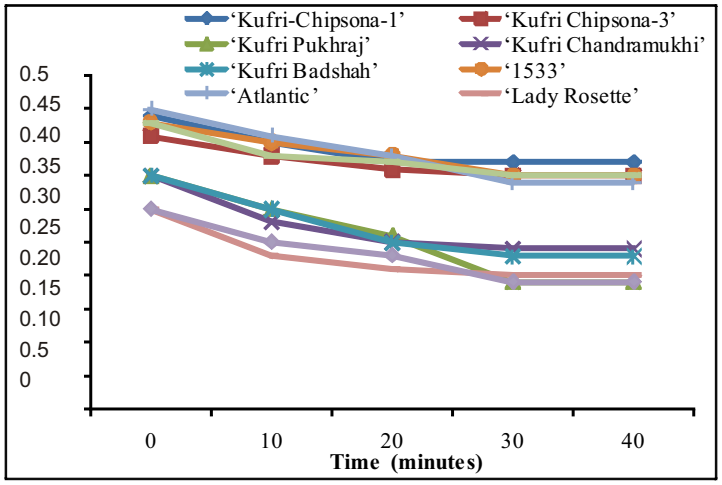

Fig. 4. Radical scavenging activities of different potato cultivars.

Table 2: Physicochemical analysis of fresh fried potato chips

Cultivar	Moisture content (%)	Oil uptake (%)	Chip yield (%)
Kufri Chipsona-1	1.8±0.01	33.4±0.15	29.8±0.10
Kufri Chipsona-3	1.9±0.01	33.9±0.18	30.2±0.11
Kufri Pukhraj	3.2±0.05	41.8±0.11	26.8±0.11
Kufri Chandramukhi	1.7±0.06	34.2±0.11	28.9±0.18
Kufri Badshah	2.8±0.05	40.4±0.11	26.5±0.18
Frito Lay 1533	1.7±0.02	34.0±0.15	30.0±0.11
Atlantic	1.6±0.10	32.8±0.16	31.6±0.11
Lady Rosette	1.7±0.11	32.9±0.10	32.9±0.13
Kufri Lauvkar	1.6±0.05	33.0±0.10	29.4±0.12
Kufri Jyoti	2.7±0.05	40.1±0.20	26.9±0.13
CD (P = 0.05)	0.08	0.15	0.08

Table 3 : Organoleptic quality of fresh fried potato chips

Cultivar	Appearance	Texture	Flavour	Overall acceptability
K. Chipsona-1	8.0±0.05	8.3±0.05	8.1±0.01	8.2±0.02
K. Chipsona-3	7.8±0.05	8.2±0.06	8.2±0.02	8.0±0.03
K. Pukhraj	5.4±0.01	6.9±0.06	6.6±0.01	6.3±0.05
K. Chandramukhi	5.7±0.04	7.4±0.06	6.6±0.03	6.6±0.02
K. Badshah	5.2±0.05	7.3±0.05	7.2±0.05	6.5±0.02
Frito Lay 1533	7.7±0.01	7.4±0.04	7.6±0.05	7.7±0.03
Atlantic	8.7±0.04	8.4±0.04	8.2±0.05	8.4±0.02
Lady Rosette	8.5±0.04	8.3±0.03	8.3±0.07	8.3±0.02
K. Lauvkar	6.4±0.05	7.0±0.05	6.2±0.05	6.5±0.03
K. Jyoti	6.5±0.05	7.3±0.01	7.2±0.05	7.0±0.02

Values are mean ±SD, n = 3

Organoleptic quality of fresh fried potato chips

Potato chips prepared from Kufri Chipsona-1, Lady Rosetta and Kufri Chandramukhi were of desirable light brown color while Kufri Pukhraj, Kufri Jyoti and Kufri Badshah produced dark coloured chips (Plate 1). The lowest rating for color in these cultivars (Table 3) confirmed of high reducing sugars. High reducing sugars disqualifies potato tuber as raw material for fried potato products (Marwaha *et al.,* 9; Ramezani and Aminlari, 14).

Kufri Chipsona-1, Atlantic and Lady Rosetta produced potato chips which were crisp in texture and were liked very much with mean texture score of 8.3 (Table 3). This might be due to higher dry matter content in these cultivars. The relationship of texture of chips with dry matter content of raw tubes is well established (Santerre *et al.,* 18). A slight bitter taste occurred in chips prepared from Kufri Badshah which could be due to high level of reducing sugars in this cultivar. The results of overall acceptability indicated higher preference for Kufri Chipsona-1 (8.3 on a 9 - point scale) closely followed by Lady Rosetta and Atlantic (8.2 on a 9-point scale).

CONCLUSION

The results clearly demonstrated that tubers of Kufri Chipsona-1, Atlantic and Lady Rosetta had high dry matter content, produced high yield of chips of excellent color, flavor and texture quality and contained low levels of reducing sugars. So these cultivars were considered the best for chip industry. On the other hand, Kufri Pukhraj, Kufri Badshah and Kufri Jyoti with low dry matter content and high reducing sugars were found inferior for processing. These varieties are suitable for table consumption due to higher levels of health promoting compounds such as ascorbic acid, total phenols and total antioxidant activity.

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