

Evaluation of Antioxidant Phytochemicals in Different Genotypes of Potato

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ABSTRACT

Potato (*Solanum tuberosum* L.) is considered a natural source of phytochemicals that help lower the risk of chronic diseases. Thus, ascorbic acid, total phenolic content and antioxidant activities of Indian potato genotypes were studied. 'Kufri Pukhraj' was the best genotype in terms of nutritional components, since it contained the highest amount of ascorbic acid (19.42 mg/100g), and total phenolic content (68.20 mg GAE/100g). Also 'Kufri Pukhraj' had the highest DPPH radical scavenging activity of 67.30%. On the other hand, genotype 'Kufri Chipsona-1', most commonly used cultivar for processing, displayed the lowest content of total phenolics (31.30 mg GAE/100g) and total antioxidant activity (28.80%). Correlation analysis between total phenolic content and antioxidant activity ($r=0.8502$) showed a high degree of correlation indicating that these bioactive components contributes to the total antioxidant activity in potato genotypes.

Keywords: Antioxidants, ascorbic acid, potato, phenols, phytochemicals

I. INTRODUCTION

Antioxidants are substances that reduce or inhibit oxidative processes in human body and food products [1]. Free radicals or reactive oxygen species are responsible for these degenerative reactions and are associated with many chronic diseases [2]. Fruits and vegetables are considered rich source of antioxidant phytochemicals such as polyphenols, anthocyanins, ascorbic acid etc. which are helpful in assisting the body to neutralize free radicals. Therefore, consumption of a diet high in dietary antioxidants is utmost important, in order to reduce the harmful effects of free radicals.

Potato (*Solanum tuberosum* L.) is one of the most widely consumed vegetable in India. Potato contains 16% carbohydrates, 2% protein, 1% minerals, 0.6% dietary fibre and negligible amount of fat [3]. Apart from being a significant source of starch, potatoes are considered as a potential antioxidant source in human diet. Potatoes contain several secondary metabolites (phytochemicals) with antioxidant activity, which contributes to the physiological defense against oxidative and free radical mediated reactions [4]. The major antioxidants in potato include ascorbic acid and phenolic compounds [5]. These bioactive compounds are reported to have multiple beneficial properties, including anti-inflammatory, anti-carcinogenic and cardio-protective effects [6]. Their redox properties allow them to act as reducing agents, hydrogen donors and singlet oxygen quenchers [7], thus contributing towards scavenging activity of these compounds. A large number of scientific studies suggest that their consumption can reduce the risk of many degenerative diseases, such as cancer, type 2

diabetes and heart disease [8, 9]. Bioactive composition of potato compared to other vegetables is low [4] but since potato form a substantial part of our daily diet, it is therefore, important to screen and identify those genotypes which are high in antioxidants. This information would serve as a mean for increasing awareness among consumers regarding the level of these health promoting compounds present in the nutritious vegetable.

II. MATERIALS AND METHODS

2.1 Raw material

Fourteen potato genotypes including 11 Indian genotypes ('Kufri Chipsona-1', 'Kufri Chandramukhi', 'Kufri Pukhraj', 'Kufri Chipsona-3', 'Kufri Badshah', '1533', 'Kufri Lauvkar', 'Kufri Jyoti', 'Super', 'Khyati' and 'Pushkar') and 3 exotic genotypes which are commonly cultivated in India ('FC-3', 'Atlantic' and 'Lady Rosette') were procured from the Vegetable farm of Punjab Agricultural University, Ludhiana. Phytochemical analysis of genotypes was carried out in the Food Science and Technology laboratories at Punjab Agricultural University, Ludhiana.

2.2 Phytochemical analysis

2.2.1 Ascorbic acid

The ascorbic acid content was estimated by visual titration method using 2,4-Dichloro-phenol-Indophenol dye method[10]. Results were expressed as milligrams of ascorbic acid/100 g fresh weight.

2.2.2 Total phenolic content

Total phenolic content was determined by modification of Folin-Ciocalteu's colorimetric

method [11]. 5 g tissue was refluxed with 80% aqueous methanol for 3 hours at 40°C. After filtration, the final volume was made to 100 ml with 80% methanol. For estimation of total phenols, 1 ml of this extract was mixed with 5 ml freshly prepared Folin-Ciocalteu reagent. After 3 minutes, 4 ml of saturated sodium carbonate solution was added. Absorbance of the resulting blue complex was read at 765 nm after 30 minutes. The values were reported as mg of gallic acid equivalent (GAE) per 100 gram with reference to gallic acid standard curve.

2.2.3 Antioxidant activity

The antioxidant activity was measured according to Shimada *et al* [12] with little modifications. For estimation of antioxidant activity, 1 ml of methanolic

extract prepared as above was mixed with 1 ml Tris-HCl buffer (50 mM, pH 7.4). Then 2 ml of 0.1 mM freshly prepared DPPH was added to the reaction mixture. After incubating for 30 min, absorbance was read at 517 nm against blank (80% methanol and tris buffer). The free radical scavenging activity was determined by comparing the absorbance with control solution to which distilled water was added instead of sample with 2 ml of DPPH and 1 ml of Tris buffer. DPPH (1,1-diphenyl-2-picrylhydrazyl) was used as the source of free radical. DPPH, deep purple in color, is reduced by the presence of antioxidants, decolorizing the solution. In this case, BHT was used as standard antioxidant compound at a fixed concentration of 5 mg/ml.

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

2.3 Statistical analysis

All the experiments were conducted in triplicate and the mean and standard deviation were calculated using MS Excel software. The data were subjected to one-way analysis of variance (ANOVA) using SPSS version 11.0 (Statistical Package for Social Sciences).

III. RESULTS AND DISCUSSION

3.1 Phytochemical analysis

3.1.1 Ascorbic acid content

The results revealed a considerable diversity in the ascorbic acid content among the various potato genotypes investigated in the present study. Ascorbic acid content in Indian and exotic potato genotypes ranged 11.80 to 19.42 mg/100 g fresh weight (Table 1). Maximum ascorbic acid was found in genotype 'Kufri Pukhraj' (19.42 mg/100g), followed by 'Kufri Chandramukhi' (18.41 mg/100g) and 'Super' (18.32 mg/100g) while 'Kufri Lauvkar' showed minimum ascorbic acid content (11.80 mg/100g).

In previous studies on different potato genotypes, the ascorbic acid content was reported to be in the range of 10.60 – 20.60 mg/100g [13, 14]. These differences in ascorbic acid content might be related to varietal characteristics. Ascorbic acid is a beneficial phytochemical which accounts up to 13% of the total antioxidant capacity in potato [15]. Its antioxidant activity has been linked to its ability to act as free radical acceptor.

3.1.2 Total phenolic content

Phenolic compounds are secondary plant metabolites present in fruits and vegetables. Phenolic acids and flavonoids are the two major classes of phenolic compounds which are known to possess antioxidant activity [16]. The predominant phenolic compounds in potato include chlorogenic acid, caffeic acid, ferulic acid, scopolin and

cryptochlorogenic acid [5]. Total phenolic content of various potato genotypes are shown in Fig. 1. 'Kufri Pukhraj' displayed the highest phenolic content (68.20 mg GAE/100g) followed by 'Kufri Badshah' (66.80 mg GAE/100g) and 'Kufri Jyoti' (65.40 mg GAE/100g). In contrast, processing genotypes such as 'Kufri Chipsona-1', 'FC-3', 'Atlantic' and 'Lady Rosette' showed lower values for phenolic content. Minimum total phenolic was observed in 'Kufri Chipsona-1' (31.30 mg GAE/100g) (Fig. 1). Total phenolic content differs significantly between cultivars and is a genetic based character. Harvest location has a strong influence on the accumulation of phenolic compounds by synthesizing different quantities and/or types of phenolics [17]. It has been suggested that nutritive content of potato tubers may be affected by the quantity of nutrients in fertilizer application. Application of nitrogen, potassium and phosphorus containing fertilizers decreased total phenols in potato tubers [23]. Al-Saikhan *et al* [18] reported 53-177 mg GAE/100g fresh weight of phenolics in potato, while Kaur and Kapoor [19] reported a phenolic content of 149.8 mg GAE/100g dry weight in raw potato tubers. Higher values for phenolics (270 mg/100g dw) in Indian genotypes were reported earlier by Lokendrajit *et al* [20]. The amount of phenolics in Iranian cultivars ranged 16.57-36.24 mg GAE/100g [17] and 38.61-145.4 mg GAE/100g dw [21].

Earlier phenolics were considered undesirable due to their participation in enzymatic browning which occurs due to their oxidation by polyphenol oxidase enzyme. But recent studies have documented their health boosting properties. So potato genotypes rich in these phenolic substances can act as 'delivery mechanism' for these potent antioxidants.

3.1.3 Total Antioxidant activity

Antioxidant activities of potato genotypes as determined by DPPH radical scavenging method are presented in Fig. 2. Radical scavenging activity of methanolic extracts of fresh potato samples was in the range of 28.80-67.30%. It can be seen from Fig. 3. that radical scavenging activity in fresh potato samples decreased continuously with increase in retention time and maximum activity was observed at 30 minutes and became stable thereafter.

Within the genotypes studied, methanolic extracts of 'Kufri Pukhraj' displayed highest radical scavenging activity (65.30%), closely followed by 'Super' (63.50%), 'Lady Rosette' (61.50%) and 'Kufri Jyoti' (59.80%) (Fig. 2). Commonly used processing cultivar 'Kufri Chipsona-1' showed lowest scavenging activity of 28.80%. Higher antioxidant activities in 'Kufri Pukhraj', 'Super', 'Kufri Jyoti' might be due to presence of higher levels of bioactive compounds such as ascorbic acid and phenolics in these genotypes. Reyes *et al* [22] noticed high positive correlation between antioxidant capacity and phenolic content and concluded that these compounds are mainly responsible for antioxidant activity. Al Saikhan *et al* [18] determined total antioxidant activity in different genotypes of potato cultivars and found that total antioxidant capacity (Percent inhibition relative to control) ranged 65.20-88.12%. Hesam *et al* [17] reported higher antioxidant activity of 92.89% and 94.10% in Iranian potato genotypes by DPPH radical scavenging method while moderate antioxidant activity of 80% in Canadian potato genotype 'Russet Burbank' was reported by Velioglu *et al* [11]. Kaur and Kapoor [19] determined antioxidant activity in both aqueous and alcoholic (80%) potato extracts by β -carotene bleaching method. The authors suggested moderate antioxidant activities of 62.5% and 62.3% in aqueous and alcoholic extracts, respectively. According to Ezekiel *et al* [4], although potatoes contain relatively low amount of total phenolic acids, but they have high antioxidant activity compared to other fruits and vegetables.

3.2 Correlation between Antioxidant activity, total phenolic content and ascorbic acid content

Positive significant correlation ($r=0.8502$) occurred between antioxidant activity and total phenolic content in various potato extracts (Table 2) suggesting that phenolics were the main antioxidant components. Phenolic compounds are believed to account for a major portion of the antioxidant activity in many plants. Reyes *et al* [22] reported that wounding-induced phenolic components in potatoes were significantly related to antioxidant activity. Kaur and Kapoor [19] determined antioxidant activity and total phenolic content in various Asian vegetable extracts including potato. The authors

established a positive correlation of antioxidant activity with total phenolic content ($r^2 = 0.6678$). Previous studies on various potato genotypes also demonstrated linear relationship between antioxidant activity and total phenolic content [16, 17]. The present study showed that the antioxidant activity is majorly contributed by phenolic compounds. A moderate correlation was also noticed between ascorbic acid and total antioxidant activity ($r=0.4261$) (Table 2). Thus potato genotypes rich in phenolics and ascorbic acid can serve as a source of dietary antioxidants.

IV. CONCLUSION

As shown in this study, potatoes contain enough phytochemicals to be used as functional food for improving human health. Genotypes 'Kufri Pukhraj', 'Kufri Badshah' and 'Kufri Jyoti' which are commonly used for table purposes may be regarded superior for direct consumption because of higher amounts of ascorbic acid, total phenolics and antioxidant activities. In contrast, processing genotypes such as 'Kufri Chipsona-1', 'Lady Rosetta' and 'FC-3' may be considered inferior in terms of nutritional composition. Looking at the increasing inclination of consumers towards more natural health foods, there is a need to enhance antioxidant phytochemicals level in processing potatoes by developing new genotypes from available germplasm high in these health beneficial compounds.

REFERENCES

- [1] C Tamuly, B. Saibia, M. Hazarika, J. Bora, M.J. Bordoli and O.P. Sahu, *Correlation between phenolic, flavonoid, and mineral contents with antioxidant activity of underutilized vegetables*, *International Journal of Vegetable Sciences*, 19(1), 2013, 34-44.
- [2] N Babbar, H. S. Oberoi, D.S. Uppal and R.T. Patil, *Total phenolic content and antioxidant capacity of extracts obtained from six important fruit residues*, *Food Research International*, 44, 2011, 391-396.
- [3] S. Kaur, K.S. Sandhu and P. Aggarwal, *Chlorpropham affects processing quality of potato during storage*, *International Journal of Vegetable Science*, 18, 328-345.
- [4] R Ezekiel, N. Singh, S. Sharma and A. Kaur, *Beneficial phytochemicals in potato – a review*, *Food Research International*, 50, 2013, 487-496.
- [5] J Lachman and K. Hamouz, *Red and purple colored potatoes as a significant antioxidant source in human nutrition – a review*, *Plant Soil Environment*, 51(11), 2005, 477-482.

- [6] K L Kaspar, J S Park, C R Broun, K Weller and C. F. Ross, *Sensory emulation of pigmented fresh potatoes*, *Food and Nutrition Sciences*, 4, 2013, 77-81.
- [7] S Mann, D. Gupta and R.K. Gupta, *Evaluation of nutritional and antioxidant potential of Indian Buckwheat grains*, *Indian Journal of Traditional Knowledge*, 11(1), 2012, 40-44.
- [8] M L Slattery, J. Benson, K. Curtin, K.N. Ma, D. Scheffer and J.D. Potter, *Carotenoids and colon cancer*, *American Journal of Clinical Nutrition*, 71, 2000, 675-582.
- [9] S Pal, A. Bhattacharya, A. Konar, D. Mazumdar and A.K. Das, *Chemical composition of potato at harvest and after cold storage*, *International Journal of Vegetable Science*, 14(2), 2008, 162-176.
- [10] S Ranganna, *Handbook of analysis and quality control for fruit and vegetable products* (Tata McGraw Hill Pub Col. Ltd., New Delhi, India, 1986).
- [11] Y S Velioglu, G. Mazza, L. Gho and B.D. Onmah, *Antioxidant activity and total phenolics in selected fruits and vegetables and grain products*, *Journal of Agricultural and Food Chemistry*, 46, 1998, 4113-4117.
- [12] K Shimada, K. Fujikawa, K. Yahara and T. Nakamura, *Antioxidant properties of Xanthan on the antioxidation of soybean oil in cyclodextrin emulsion*, *Journal of Agricultural and Food Chemistry*, 40, 1992, 945-948.
- [13] D Raj, V.K. Joshi and B.B. Lal, *Yield, quality and storability of potato flour of different Indian cultivars*, *International Journal of Food an Fermentation Technology*, 1(1), 2011, 111-117.
- [14] R S Marwaha, D. Kumar, S.V. Singh and S.K. Pandey, *Clipping and nutritional qualities of Indian and exotic processing varieties stored under different conditions*, *Journal of Food Science and Technology*, 46(4), 2009, 354-358.
- [15] C R Brown, *Antioxidants in potato*, *American Journal of Potato Research*, 82, 2005, 163-172.
- [16] K Ah-Hen, C. Fuenzalida, S. Hess, A. Contreras, A. Vega-Galvez and R. Lemus-Mondca, *Antioxidant capacity and total phenolic compounds of twelve selected potato landrace clones grown in Southern Chile*, *Chilean Journal of Agricultural Research*, 72(1), 2012, 3-9.
- [17] S Pal, A. Bhattacharya, A. Konar, D. Mazumdar and A.K. Das, *Chemical composition of potato at harvest and after cold storage*, *International Journal of Vegetable Science*, 14(2), 2008, 162-176.
- [18] M S Al-Saikhan, I. R. Howard and J.C. Miller, *Antioxidant activity and total phenolics in different genotypes of potato (Solanum tuberosum L.)*, *Journal of Food Science*, 60, 1995, 341-343.
- [19] C Kaur and H.C. Kapoor, *Antioxidant activity and total phenolic content of some Asian vegetables*, *International Journal of Food Science and Technology*, 37L 2002, 153-161.
- [20] N Lokendrajit, C.B. Singh, N. Swapana and M.S. Singh, *Evaluation of nutritional value of two local potato cultivars (Aberchaibi and Amubi) of Manipur, North-East India*, *The Bioscan*, 8(2), 2013, 589-593.
- [21] R Ramezani and M. Aminlari, *Comparing chemical composition of four potato varieties for processing*, *Journal of Food Science and Technology*, 41(6), 2004, 689-691.
- [22] I F Reyes, J.C. Miller and I. Cisneros-Zevallos, *Antioxidant capacity, aulhocyanins and total phenolics in purple- and red-fleshed potato (Solanum tuberosum L.) genotypes*, *American Journal of Potato Research*, 82, 2005, 271-277.
- [23] J P Singh, R.S. Marwaha and O.P. Srivastava, *Processing and nutritive qualities of potato tubers as affected by fertilizers nutrients and sulphur application*, *Journal of Indian Potato Association*, 22.

Table 1. Ascorbic acid content of different potato genotypes

S. No.	Cultivar	Ascorbic acid content (mg/100g)
1	'Kufri Chipsona-1'	16.51 ^c ± 0.10
2	'Kufri Chandramukhi'	18.41 ^b ± 0.12
3	'Kufri Pukhraj'	19.42 ^a ± 0.20
4	'Kufri Chipsona-3'	13.40 ^f ± 0.30
5	'Kufri Badshah'	12.80 ^{fg} ± 0.15
6	'1533'	14.30 ^e ± 0.20
7	'Kufri Lauvkar'	11.80 ⁱ ± 0.18
8	'Kufri Jyoti'	10.80 ^j ± 0.20
9	'Super'	18.32 ^b ± 0.12
10	'Kufri Khyati'	14.90 ^d ± 0.15
11	'Kufri Pushkar'	12.31 ^{gh} ± 0.25
12	'FC-3'	14.20 ^e ± 0.16
13	'Atlantic'	12.90 ^{fg} ± 0.20
14	'Lady Rosetta'	14.20 ^e ± 0.18

Values are mean ± standard deviation, n=3. Values with same superscript within the column do not differ significantly.

Table 2: Correlation between antioxidant activity, total phenolic content and ascorbic acid Content

Correlation	Coefficient of correlation (r)
Antioxidant activity verses total phenolics	0.8502
Antioxidant activity verses ascorbic acid	0.4261
Ascorbic acid verses total phenolics	0.2426

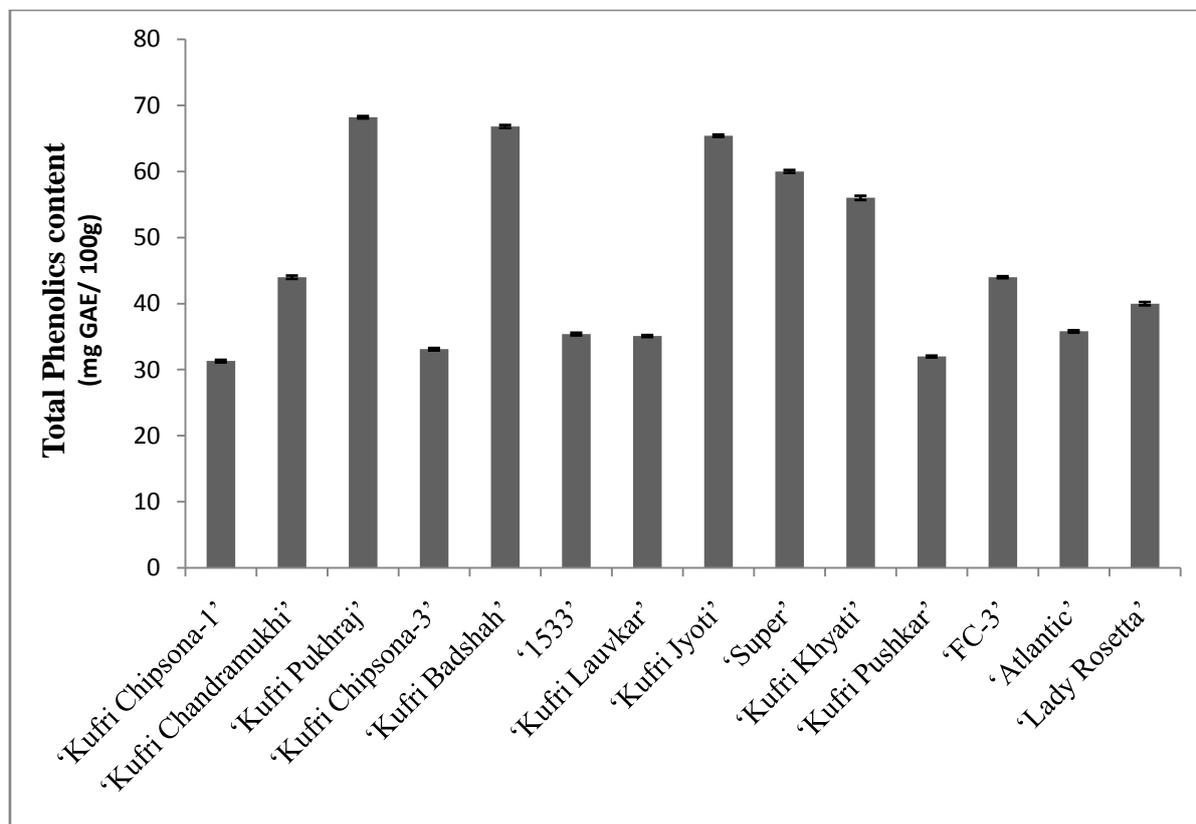


Fig. 1 Total phenolic content of different potato genotypes. Values are mean ± standard deviation, n=3. Error bars represent standard deviation of the means.

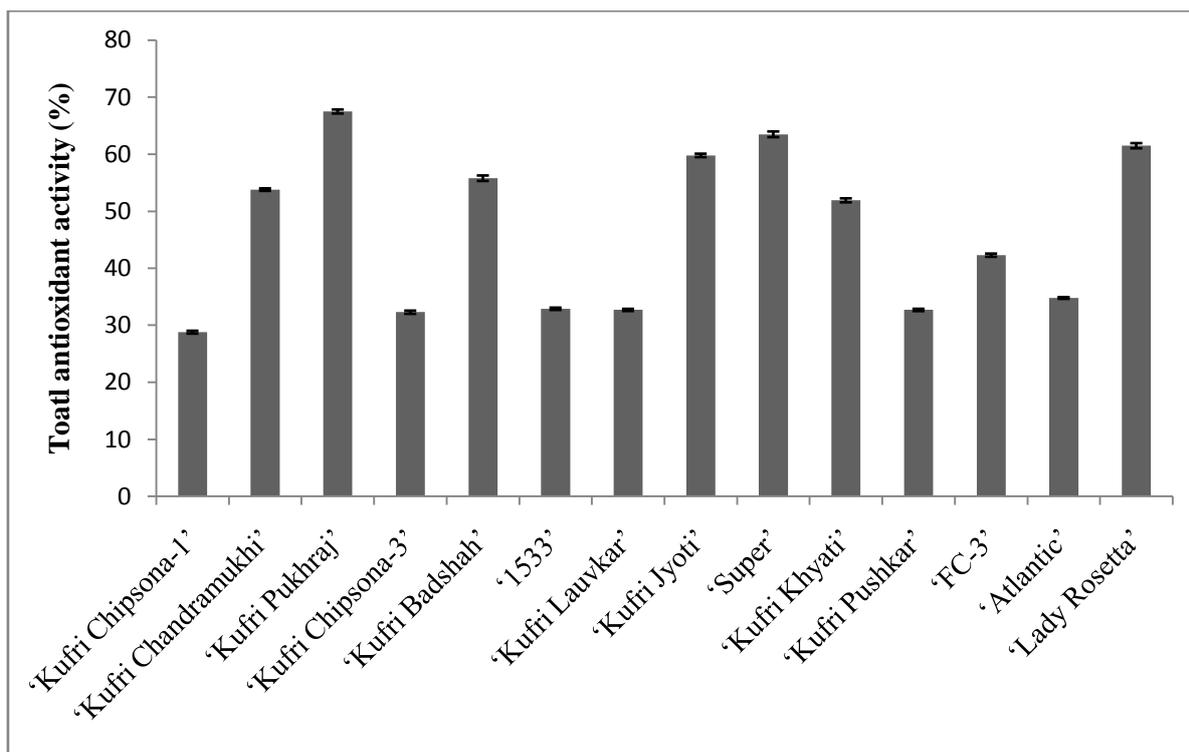


Fig. 2 Total antioxidant activity of different potato genotypes. Values are mean± standard deviation, n=3. Error bars represent standard deviation of the means.

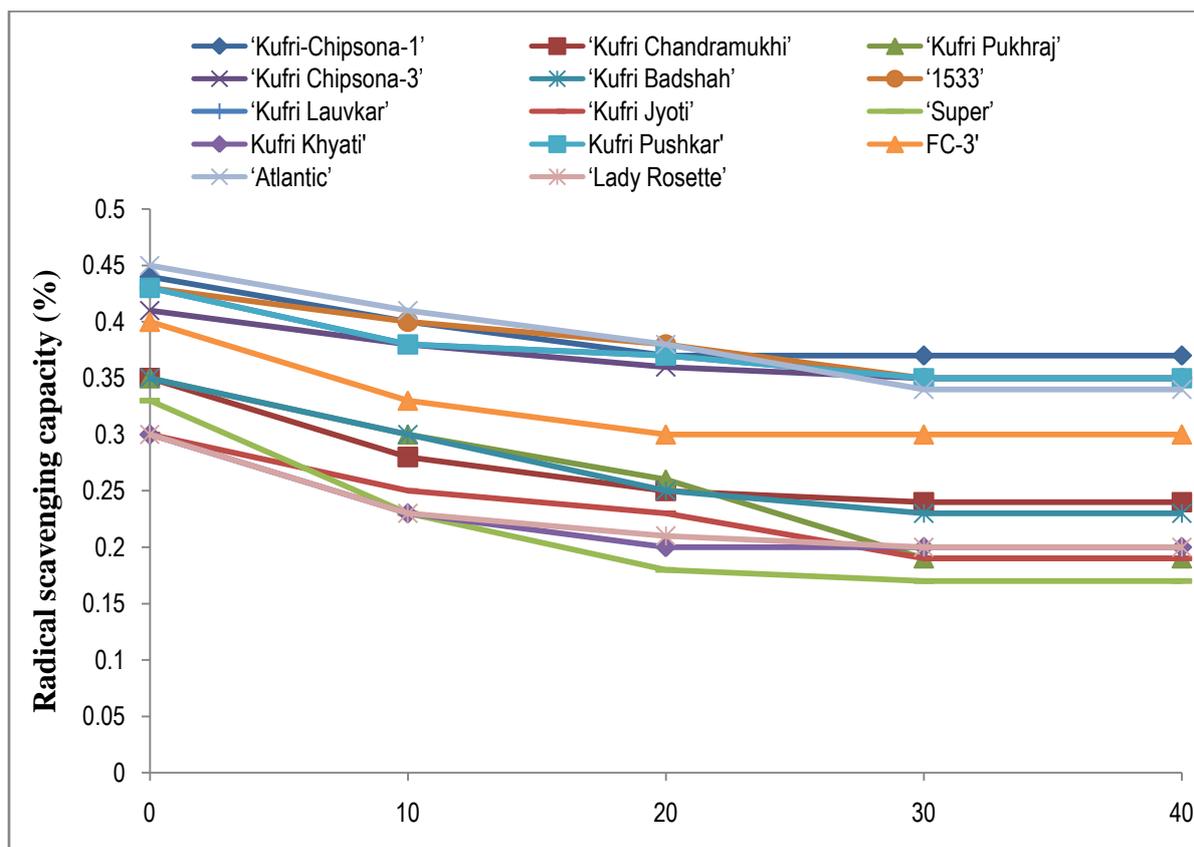


Fig.3 Radical scavenging activities of different potato genotypes.