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NUTRITIONAL AND PHARMACOLOGICAL POTENTIAL OF POTATO PEELS: A VALUABLE MULTI-FUNCTIONAL WASTE OF FOOD INDUSTRY

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Abstract

Potatoes are good source of dietary antioxidants *i.e.* polyphenols, with major portion present in skin than its cortex and pith. A large fraction of this crop is consumed as processed food such as French fries, chips and purees etc. producing tones of pulp and peel as waste.Phytochemical exploration of peels produced by potato processing industry could help in effective commercial utilization of this industrial by product. This study focuses on biochemical characterization, nutritional and antioxidant potential of potato peels of FT-1533 and Lady Rosetta variety used in potato chips producing industry. The in vitro antioxidant studies indicated the ethanol extracts of studied potato peels are competent in scavenging different stable and generated radical. The correlation analysis also statistically supported the contents in the extracts could act against various radicals. A highly positive correlation was found between phyto-chemical constituent and radical scavenging activity. The results acquired from this analysis revealed that this agro-industrial waste could be recommended as dietary supplements or as nutraceuticals.

***Key words*:** Antioxidants, Phytochemical, Polyphenols, Nutraceuticals and Radical scavenging.

Introduction

Potato is the fourth major and only tuber crop in the world following rice, wheat and maize with an annual production of 180 million tonnes (FAO, 2009). Dated back this crop has been considered as the keystone in human nutrition with established and documented nutritional quality. Potatoes are good source of dietary fibre, carbohydrates, minerals and phenolic substances with a high value protein and enriched with number of micronutrients *i.e.* vitamins B_1, B_3 and B_6 and minerals such as potassium, phosphorus and magnesium (Burlingame *et al*., 2009; Singh *et al*., 2011).These are also good source of dietary antioxidants i.e. polyphenols having free radical scavenging effects with major fraction localised in skin of the tuber than cortex and pith and thus help in reducing the risks of chronic diseases (Arapoglou *et al*., 2010).

Potatoes are usually peeled off during processing hence producing tones of peels as waste. It's a zero-value waste accounting to 15-40% depending on peeling method *i.e.* steam, abrasion or lye peeling. However, these peels are being utilized as feed for livestock; by-products still outpace this limited utilization. Moreover, potato peels are rich source of number of bioactive compounds (starch, proteins, phenolic compounds, polysaccharides) having functional properties. These compounds have potential antioxidant, antimicrobial, antibacterial activity. Therefore, these nutrient enriched peels can be effectively utilized in foods and non-foods applications commercially at industrial scale**.**Recovery of these natural antioxidants can be an effective and cheaper alternative of synthetic antioxidants (Al-Weshahy and Rao, 2012; Jeddou *et al*., 2016; Sepelev and Galoburda, 2015). The peels are used as a source of antioxidants and preservatives for meat and meat products (Farvin *et al*., 2012; Kannat *et al*., 2015). It has also been reported that glycoalkaloids present in potato have anticarcinogenic effects against series of human cells (Friedman, 2006). PP extract act as a strong antioxidant by protecting human erythrocyte membrane proteins from oxidative damage (Singh and Rajini, 2008).

Phytochemicals, the non-nutrient bioactive compounds found in plant foods such as fruits and vegetables, grains etc. have been profoundly associated with the decline in the risk of major chronic diseases such as cancer and cardiovascular disease. Thus, these phytochemicals of high medicinal values to humans and animals, some of which are alkaloids, tannins, flavonoids, saponins and phenolic compounds have the potential of being used as food supplements such as nutraceuticals or can be incorporated into food or pharmaceuticals (Dillard and German, 2000; Phan *et al*., 2018). The present study was undertaken to evaluate and explore the nutritional and antioxidant potential of potato peels being discarded as waste from chips industry.

Materials and Methods

Collection and preparation of plant materials

Potato peels (*Solanum tuberosum* cv. Lady Rosetta (red skin) and FT-1533 (brown skin) obtained from local potato chip manufacturing industry in New Delhi, India on 28 November, 2018. The peels were collected in plastic zip lock bags and brought to the laboratory which thereafter washed thrice with tap water to remove any debris and then rinsed with distilled water. Washed peels were weighed and freeze-dried for 2 days until constant weight was obtained. After complete dryness, they were ground to a powder and sieved using a standard 50 mesh size sieve to ensure symmetry of particle size. Freeze-dried powder samples were weighed and kept in dark glass color bottles, tightly closed, at -20°C until the day of analysis.

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Chemicals, solvents and reagents

The analytical grade chemicals, solvents and reagents used were purchased from Hi-media Laboratories, Mumbai, India; Sisco Research Laboratories, Mumbai, India and Sigma Aldrich, Bengaluru, India. The assays were carried out using Milli-Q water (Merck Millipore; Billerica, USA).

Preparation of Potato peel extracts

Solvent Extraction: 10 g of ground peels were extracted with 100 ml of ethanol by keeping overnight in shaker at 37°C. The extract was filtered using a Whatman No.1 filter paper and the residue was re-extracted thrice under the same conditions. The filtrates were combined and were evaporated in a rotary evaporator below 40°C. The dried extracts obtained were weighed and collected in storage containers for further analysis.

Proximate analysis: The proximate composition of the potato peels was analysed in accordance with the standard protocols of Association of Official Analytical Chemicals (AOAC, 2006). The estimation of the total protein was carried out by the Kjeldahl method. The amount of carbohydrates was calculated using following formula: Carbohydrate = 100-(moisture + ash + fat + protein)

The energy content was analysed by multiplying the Atwater factor to the fat, protein and carbohydrate contents (9 for fat and 4for protein and carbohydrate contents).

Determination of total polyphenol content (TP): The total phenolic content of PP ethanolic extracts was determined based on the method of Amado *et al*. (2014)**,** slightly modified using the Folin–Ciocalteu Reagent (FCR) with gallic acid as a standard. 0.1 mL of sample or blank was mixed with100 µL of diluted (1:10; FCR: Water) FCR and, after 5 min, 1 mL of a Na_2CO_3 solution (7%) was added. After incubation for 1 h at room temperature, the absorbance was read at 760 nm (Perkin Elmer Lambda 25 UV/Vis spectrophotometer, Perkin Elmer Inc., Massachusetts, USA) in 1 cm cuvettes. Readings were compared with a standard curve ofgallic acid and the total phenolic content was expressed as mg ofgallic acid equivalent per g of freeze dried solid (mg GAE/g).

Determination of total flavonoid content (Fv): The total flavonoid content was measured by the method described by Beltran *et al*. (2017) with modifications. Thereaction mixture contained 100 µL of the PP extract and 430 µL of 5% $NaNO_2$, which was incubated for 5 min. After incubation, 30 µL of $AlCl_3$ (10%) and 440 µL of NaOH (1 mol/l) were added to thereaction. The absorbance was read at 496 nm with Perkin Elmer Lambda 25 UV/Vis spectrophotometer, in 1 cm cuvettes. The results were expressed as mg of quercetin equivalents (QE) per gram (mgQE/g).

Determination of antioxidant (properties of extracts) activity

Radical scavenging activity (RSA %) assay: Free radical scavenging activity (RSA) of the samplewas measured using the method described by Rowayshed *et al*. (2015), with modifications**.** Analiquot of the sample solution (40 µL) was mixed with 2.9 ml of 0.1 mM DPPH (2, 2-diphenyl-1,1-picrahydrazyl) in ethanol solution,incubated for 30 min at 25°C in dark; the decrease inthe absorbance at 517 nm was measured. Ethanol was used as blank. Antioxidant activity was expressedas percentage inhibition of the DPPH radical and wasdetermined by the following equation:

Scavenging activity (%) = 1-(As/Ao) × 100

Where: As is the Absorbance of the sample and Aoisthe Absorbance of the control.

Control: 40 µL of ethanol mixed with 2.9 ml of DPPH methanol solution.

The ferric reducing antioxidant power (FRAP) measurement: Antioxidant activity was measured using the ferricreducing antioxidant power (FRAP) assay Rowayshed *et al*. (2015)**,** with modifications**.** The FRAP assay of compound materials in reducing ferricion (Fe+3) to ferrous ion (Fe+2). (Fe+2/TPTZ) forms ablue complex color which increases the absorption at 593 nm. The FRAP reagent contained 2.5 ml of a 10 mmol/L TPTZ (2,4,6-tripyridyl-s-triazine) solution in 40mmol/l HCL plus 2.5 mL of 20 m mol/l $FeCl3.6H_2O$and 25 ml of 0.3 mol/l acetate buffer (pH 3.6) and wasfreshly prepared and warmed at 37°C prior to usage. Aliquots of 0.1 ml sample solution was mixed with 3 ml FRAP reagent and the absorbance of reactionmixture at 593 nm was measured spectrophotometrically after incubation at 37°C for 10 min. Calibration was against a standard curve (0.02-0.1 mg/ml) using freshly prepared Trolox.

HPLC analysis of peel extract for identification of compounds in the extract: Potato peels: The supernatant (20 µL) obtained from the above extraction was directly injected into a Cosmosil C18-MS-II column (5 µm, 4.6 mm i.d. × 250 mm) HPLC column. The mobile phase consisted of the following linear gradient: acetonitrile (A) and 0.5% formic acid (B): (A) =5% (0–5 min), 18% (5.1–30 min), 53% (30.1–70 min), 90% (70.1–80 min), and 5% (80.1–100 min). The flow rate was 1.0 mL/min at 35 °C, peaks were monitored at 320 nm, and UV/Vis spectra were recorded. Chromatographic comparison with analytical standards, absorbance spectra, and mass spectra, were used to identify compounds (Friedman *et al*., 2017).

Statistical analysis

Results are expressed as means±S.D of triplicate readings. Statistical analyses are performed using one-way ANOVA for mean comparisons and Post-hoc Tukey HSD test at a 95.0% confidence level to establish the significant difference among the means using STATA software. Correlation analyses were performed using a Pearson correlation test in Excel, 2010.

Results and Discussions

Composition of the Potato Peels Waste

The chemical composition of the potato peels waste is summarised in (Table 1). Composition analysis of peels showed moisture ranged between (11.6-12.02%), (8.5-10.65%) of crude protein, (1.30-1.33%) of fat, (5.01-6.69%) of ash, (18.12-20.06%) of dietary fiber and (74.11-72.26%) of carbohydrates by difference (Fig 1). These results of dried peels of FT-1533 and Lady Rosetta cultivar of potato were broadly close to and some were within the range of previously reported values for potato peels (Amado *et al*., 2014[a]; Kumari *et al*., 2017[b]) except for the protein content, where these authors have observed slightly higher levels (16.72-18.55%)[a] and (11.17-12.44%)[b] with respect to our data, *i.e.* 8.5-10.65 % protein. These variations in composition may be attributed to various factors including varietal differences, method of peeling, agronomic and other environmental factors *(*Burlingame *et al*., 2009). This indicates that this by-product could be used as a source of carbohydrate, protein and fat.

Phytochemical analysis

As shown in Table 2, levels of total phenolic content (4.71–12.53 mg GAE/gdb) are within the range of those

reported previously by Beltran *et al*. (2017) for Acidified ethanol extract and water extract of potato peels.The LR variety extract showed higher levels of total phenolics(12.53 ± 0.30 mg GAE/g) than the brown skin FT-1533 variety (4.71 ± 0.17 mgGAE/g). Additionally, the LR extract showed high levels of totalflavonoids with 11.64 ± 0.11 mg QE/g. The FT-1533 extract showed alower level with a value of 8.85± 0.08 mg QE/g (Fig 2). The PP extracts (LR and FT-1533) were able to neutralize the FRAP and DPPH (% Radical scavenging activity) assay radicals (Table 2). The values obtained for the LR extract (62.32 ± 0.38% and13.66 ± 2.02TE/gdb, respectively) and for FT-1533extract (29.95 ± 1.32% and 11.71 ± 1.37 TE/gdb, respectively) indicated that the LR extract was more effective inneutralizing the FRAP and DPPH radicals. The higherantioxidant capacity of the LR extract could be associated withits high content of phenolic compounds. A higher level of phenolics in LRpeels is probably due to its pigmented skin as studieshave shown that coloured potatoes have higher phenoliccontents compared to white or brown-skinned potatoes (Al-Weshahy & Venket Rao, 2009; Lachman *et al*., 2008). The high antioxidant activity from LRpeels is supported by the fact that total phenolic content(TPC) and antioxidant activity (DPPH andFRAP) exhibited significantly high correlation forboth the activities ($r > 0.73$ and 0.59 respectively, $P < 0.05$). Significant difference ($P< 0.05$) was found between pair of means in terms of DPPH, FRAP, TPC and TFv among the potato peel extracts of two varieties.

Phytochemicals identification by HPLC

Therefore identification of the phenolic compounds for Lady Rosetta variety was performed using HPLC with photodiode array detection. Fig. 1 shows the chromatogram of the phenolic compounds in the PP. Table 3 shows the retention times and name of the compounds identified. Apart from phenolics and flavonoids identified, there are other essential amino acids and preservatives identified in the extract contributing to antioxidant and pharmacological potential of potato peels. Therefore, peels of Lady Rosetta variety of potato used for chips manufacturing which are primarily discarded as inedible waste can be considered as potential candidate for range of innovative functional foods and drug development.

Discussion

Among the peel extracts of two different potato varieties, LR potato peel extracts had higher phenolic content (12.53 mg GAE/gdb) and higher antioxidant activity (DPPH; %RSA: 62.32% and FRAP: 13.66 mg TE/gdb) compared to FT-1533 peel and therefore would be a preferred choice of natural antioxidants for food preservation and/or functional food ingredient applications.Based on these results and with the view of utilizing by- products from agro-industrial waste, potato peels are used as sources of nutrients and other health promoting ingredients in the formulation of functional foods. Future studies are being undertaken to evaluate their storage and process stability. Food models are being developed incorporating potato peel by-products and testing them for their bioavailability and antioxidant properties using animal and human models.

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Table 1: Chemical composition of potato peels

Parameters	Lady Rosetta peels	FT-1533 peels
Moisture %	10.75 ± 0.57	9.3 ± 0.23
Protein %	10.65 ± 0.02	8.5± 0.15
Energy (K cal/100 gm)	343.61 ± 0.53	342.14 ± 0.78
Total Ash %	5.01 ± 0.04	6.79 ± 0.17
Total Fat %	1.33 ± 0.11	1.3 ± 0.28
Total Carbohydrates %	72.26 ± 0.07	74.11 ± 0.35

The data are the mean ± SD of three replicates.

Table 2: Antioxidant activity, Total phenolic and flavonoid content of peel extracts

Potato peel	Radical Scavenging Activity (% RSA)	Frap Value (mg TE/gdb)	TPC (mg GAE/gdb)	TFV (mg QE/gdb)
Lady Rosetta	62.32 ± 0.38	13.66 ± 2.02	12.53 ± 0.30	11.64 ± 0.11
FT 1533	29.95 ± 1.32	11.71 ± 1.37	4.71 ± 0.17	8.85± 0.08

The data are the mean ± SD of three replicates

Table 3: Compounds identified in potato peel extracts

Retention time	Lady Rosetta peel extract	Properties of the compounds identified
0.591	Solanidine	Glycoalkaloid
1.083	Valine	Phenolic aldehyde
0.59	Quercetin	Flavonoid
1.461	Rutin	Flavonoid
4.326	(E)-Ferulic acid	Phenolic acid
9.66	Aniline	Derivatives such as phenylenediamines & diphenylamine are antioxidants
9.083	Propanoic Acid	Preservative
11.02	Azulene	Role as a plant metabolite
12.56	Vanillin	Phenolic Aldehyde
17.246	Salicylic Acid (2-Hydroxy Benzoic Acid)	Phenolic Acid
19.812	9 Octadecenoic Acid (Oleic Acid)	Omega-9 Fatty Acid

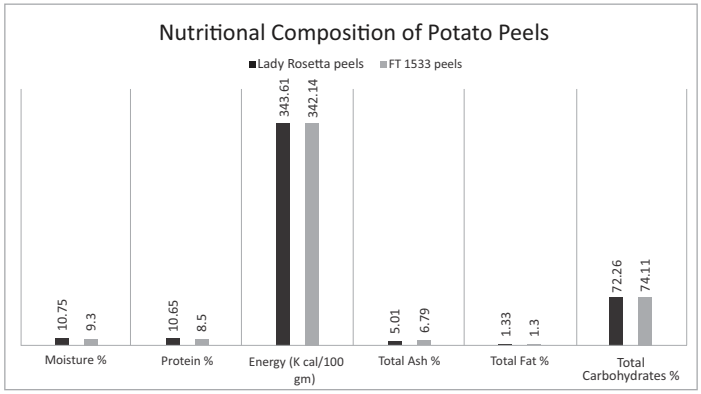

Fig 1: Nutritional composition of potato peels

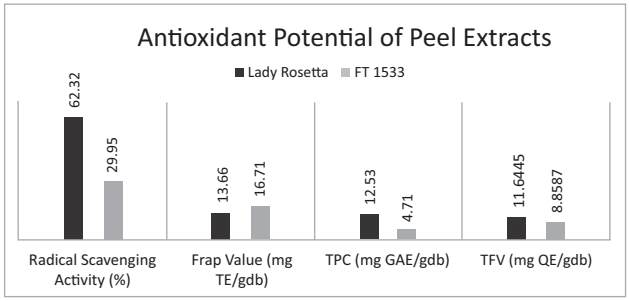

Fig. 2: Antioxidant Potential of Potato Peels

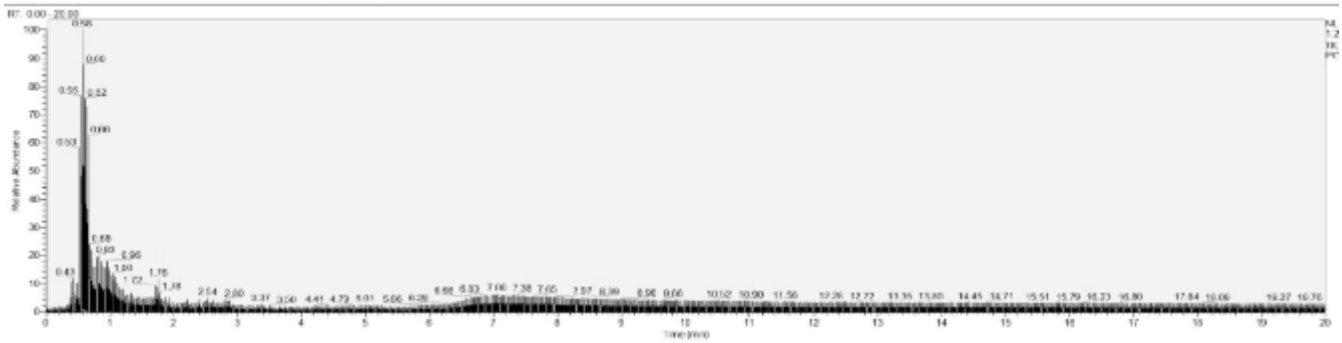

Fig 3: Chromatogram of the phenolic compounds in the PP