ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)
Food Science and Technology

DOI: https://doi.org/10.1590/fst.26217

Analysis of selective potato varieties and their functional assessment

Kashif Sarfraz ABBASI[1], Abdul QAYYUM[2*], Ayaz MEHMOOD[3], Talat MAHMOOD[4], Sami Ullah KHAN[2], Muhammad LIAQUAT[5], Asma SOHAIL[1], Asif AHMAD[1]

Abstract

The number of attributes, related to the selection of potato varieties, was evaluated with reference to their potential in chip processing. Five commercial varieties of potato were analyzed regarding their physico-chemical, functional, and processing aspects. In general, Lady Rosetta subsequently, Chipsona were the most noticeable potato varieties considering their physical attributes. A significant correlation (R = 0.925) was estimated amongst geometric mean diameter and surface area. Maximum dry matter and starch contents were observed in Lady Rosetta followed by Chipsona. Desiree showed higher fat, sugar and mineral contents than all other selected potato cultivars. Promising correlation (R= 0.952) was estimated among total minerals and ash contents. Functional traits were recorded maximum in Desiree followed by Lady Rosetta. A significant correlation (R = 0.907) was described between total phenolic contents and radical scavenging activity. Lady Rosetta proved to be the most preferred potato variety considering post processing parameters followed by Chipsona.

Keywords: potato; post processing; functional characteristics; characterization.

Practical Application: Physiochemical and functional attributes of potato varieties.

1 Introduction

Potato (*Solanum tuberosum* L.), is one of the major staple and world's fourth largest food crop primarily of Latin American continent and yielded more dry matter per hectare than the major cereal crops. World over, it is ranked fourth amongst the other food crops like; wheat, rice and maize (Mahgoub et al., 2015). It is a delicious, nutritive and highly palatable vegetable with 75% water contents. One hundred grams of cooked potato provides 86 kilocalories energy containing 20 g carbohydrate, 1.7 g protein, 1.8 g fibres, 17 mg vitamin C, 11 mg riboflavin 1.2 mg niacin 13 mg calcium and traces of different other minerals and fibre (Fabbri & Crosby, 2016). It is low cholesterol and high potassium food containing important antioxidants thus capable of protecting human beings against cardiovascular diseases and cancer (Andre et al., 2009). In addition to its table and cookery use, number of processed potato products viz. potato crisp, potato patties, dehydrated potato granules, alcoholic beverages and flakes are being prepared. Commonly prepared dishes of potato include: Fried potatoes (French fries), boiled/steamed potatoes, baked potatoes and mashed potatoes mixed with yogurt or milk and butter (Tierno et al., 2016). However the most important one being the potato chips which gained terrific economic value in processed food industry.

Potato is also contained with multiple types of phenolic compounds including flavonols, anthocyanidins and different phenolic acids. These highly valued compounds play an important role to protect cell from degenerative disorders and potential trauma due to oxidative stress (Akyol et al., 2016). Exploitation of those naturally occurring antioxidants found in potatoes as a functional ingredient would be very beneficial in specialty food product development.

The potato crop is however also associated with the presence of preprocessing toxin i.e glycoalkaloids in tubers (Nema et al., 2008) and post processing toxins i.e acrylamide in processed food preparations (Stadler et al., 2004) which are of the grave food safety concern and related with their genetic precursor. In addition greening on light exposure (Sengul et al., 2004) and cold sweetening under low temperature storage (Blenkinsop et al., 2002) also impart significant economic loss to the crop.

At larger scale of potato processing, the quality of finished product is directly proportional to the physico-chemical and functional attributes of raw potato tubers. In Pakistan, different potato cultivars are being cultivated due to the agro-ecological diversity. Raw tubers of those multivariate potato varieties have significant potato processing traits. However, there is still need of doing such detailed physico-chemical characterization so that the functional potential of potato varieties under local climatic conditions may properly be exploited. The paper explains important quality attributes of five commercial potato varieties to reveal their differential characteristics. Correlations between

Received 09 Aug., 2017
Accepted 29 Sept., 2018
[1] *Department of Food Technology, Pir Mehr Ali Shah, Arid Agriculture University, Rawalpindi, Pakistan*
[2] *Department of Agronomy, The University of Haripur, Pakistan*
[3] *Department of Soil Science, The University of Haripur, Pakistan*
[4] *Food and Nutrition Division, Nuclear Institute for Food and Agriculture, Peshawar, Pakistan*
[5] *Department of Food Science & Technology, The University of Haripur, Pakistan*
*Corresponding author: aqayyum@uoh.edu.pk

different quality parameters will predict consumer preferences and their specific economic use.

2 Materials and methods

2.1 Materials

Five commercial potato varieties harvested from Okara District, (Punjab, Pakistan) and were directly brought to the Food Technology Department, PMAS-Arid Agriculture University, Rawalpindi (Pakistan) where the experiments were conducted. These potato cultivars were selected as per their widespread adaptation ability under indigenous growing environments. Chipsona (CHI) and Satellite (SAT), were Yellow-white skinned while Cardinal (CRD), Desiree (DESR) and Lady Rosetta (LR) were among the red skinned varieties. The tubers were washed, graded (> 50 mm length), sorted and were placed for curing between 15-20 °C temperatures for the period of one week.

2.2 Physical analysis of potato varieties

The size of the potato in terms of linear dimensions i.e. length was measured by a digital vernier caliper (0-150 mm, China) with an accuracy of 0.01 mm. The Geometric Mean Diameter (D_g) was calculated by applying the following Equation (1) as described by Abbasi et al. (2011).

$$D_g = (LWT)^{0.333} \quad (1)$$

Where L is length, W is width and T is thickness of the fruit.

Tuber Sphericity was calculated by the following Formula (2) as described by Ahmadi et al. (2008):

$$\phi = (D_g / L) \times 100 \quad (2)$$

Surface area (S) was determined according to Baryeh (2001) by using the following Formula (3):

$$S = \pi D_g^2 \quad (3)$$

Where, D_g is the Geometric mean diameter of the potato. Tuber counts (TC) per 25 kg packaging were manually calculated for each tested variety. Firmness of the tubers was measured by Wagner Fruit Firmness Tester (Model FT-327 with plunger size of 11 mm) and the resulted readings were then converted into kilopascals (Kpa). Specific gravity of each selected cultivar was determined by taking the both weights of the potato tuber in air as well as in water according to Association of Official Analytical Chemists (1990) method no. 936.13 (Equation 4).

$$Specific\ Gravity = Weight\ in\ air / (Weight\ in\ air - Weight\ in\ water) \quad (4)$$

Total Soluble Solids (TSS as ºBrix) were determined in the pulp of each sample using a digital refractometer PAL-3 (ATAGO, Japan) at 29 ± 1 °C and temperature correction was made accordingly as described by Association of Official Analytical Chemists (1990) method no. 932.12. The pH values were noted by using a pH-meter (Inolab, WTW Series, Germany) as described in Association of Official Analytical Chemists (1990) method no. 981.12. Sprouting (SPRT) was also determined as the percentage of sprouted eyes as explained by Ranganna et al. (1998) (Equation 5).

$$\%\ Eyes\ Sprouted = No.\ of\ eyes\ sprouted / Total\ no.\ of\ eyes \times 100 \quad (5)$$

2.3 Proximate and chemical analysis

The analysis for proximate composition of selected potato varieties was carried out using different analytical methods and the comparison amongst different cultivars was also done on the basis of results obtained from those analysis.

Dry matter (DM) was determined by oven drying method at 102 °C till constant weight is achieved as described in Association of Official Analytical Chemists (1990) method No. 934.06. Starch estimation was carried out by making the tuber sugar free by the repeated extraction with 80% iso-propanol. Tubers were dried at 70 °C and then starch was hydrolyzed by 60% perchloric acid. The glucose was estimated spectrophotometerically by using anthrone reagent as described by Kumar et al. (2005). Crude protein estimation was carried out by multiplying the total nitrogen contents with conversion factor 6.25 using the Kjeldhal apparatus as described by Association of Official Analytical Chemists (1990) method no. 920.10. Crude fat was determined according to the Association of Official Analytical Chemists (1990) method no. 983.23. Reducing sugar, non-reducing sugar (NRS) and total sugars contents were also determined by Lane and Eynon titration using Fehling's solution as described in Association of Official Analytical Chemists (1990) method no. 925.35. Crude fibre was estimated by AOAC method no. 920.86 and ash content was determined by Association of Official Analytical Chemists (1990) method no. 940.26.

2.4 Determination of Functional properties

Ascorbic acid (AA) was determined by titrimetric method using 2, 6 dichlorophenol indophenol dye as described by Association of Official Analytical Chemists (1990) method no. 967.21.

The total glycoalkaloids (TGA) determination was carried out by the method described by Grunenfelder et al. (2006). Ground lyophilized potato tissue (500 mg) was extracted in 10 ml of 80% ethanol at 85-90 °C for 25 min. The extract were filtered and reduced to 3-5 ml on rotary evaporator at 50 °C. Each extract was rinsed twice with 3 ml of 10% (v/v) acetic acid and then centrifuged at 10,000 g for 30 min at 10 °C. The pH of the supernatants was adjusted at 9 with NH_4OH. The extract was refluxed 70 °C for 25 min and stored overnight at 4 °C temperature. The extract were similarly centrifuged as earlier, after discarding the supernatants the resulting pellets were dissolved in 0.5 ml of 7% (v/v) phosphoric acid and stored at -20 °C. The total glycoalkaloids were estimated by adding 200 µl of extract in 1 ml of 0.03% (w/v) in concentrated phosphoric acid. The contents were allowed to settle for 20 min and absorbance was measured at 600 nm. TGA concentrations were quantified based on α-solanine (Sigma-Aldrich) standard curve using a CE-2021, spectrophotometer (CECIL Instruments Cambridge, England).

Chlorophyll (CHL) extraction was carried out by acetone and quantification was carried out by spectrophotometer as described in Association of Official Analytical Chemists (1990) method no. 942.04.

Total phenolic contents (TPC) in terms of gallic acid equivalent (GAE) were determined by folin-ciocalteu (FC) assay as described by Lachman et al. (2008) with some modifications. Tubers randomly selected from each variety were freeze dried and then extracted with 80% ethanol. 2 gm extract was quantitatively converted into 100 ml volumetric flask and adjusted with 80% ethanol. In 5 ml of the sample slightly diluted with distilled water, 2.5 ml of FC and 7.5 ml of 20% sodium carbonate solution was added. The contents were allowed to settle for 2 hours and absorbance was measured at 765 nm using a CE-2021, spectrophotometer (CECIL Instruments Cambridge, England). Total phenolics were estimated by standard calibration curve obtained from measuring the absorbance of known gallic acid concentration (10-100 ppm). The results were expressed as mg gallic acid equivalents (GAE) per 100 g of dry matter.

Antioxidant activity (AOX) was measured as radical scavenging activity using method described by Singh & Rajini (2004) that involves the use of the free radical 1,1-diphenyl-2-picrylhydrazyl (DPPH). 5 mg of lyophilized potato extract was incubated with 1.5 ml of DPPH solution (0.1 mM in 95% ethanol). The reaction mixture was properly shaken and allowed to stand for 20 min under room temperature. The absorbance of the resulting mixture was determined at 517 nm against blank. The antioxidant activity was determined as decrease in the absorbance of DPPH using the following Equation (6).

$$Scavenging\ effect\ (\%) = 1 - (A_{sample\ 517\ nm} - A_{Control\ 517nm}) \times 100 \quad (6)$$

2.5 Mineral analysis

The mineral contents in potato tubers were determined as described in Association of Official Analytical Chemists (1990) method no. 923-07. Briefly 5 g of sample was digested with 10 ml of nitric acid: perchloric acid (7:3) mixtures at temperature up to 180-200 °C till transparent contents were obtained. The contents were diluted to volume of 100 ml with bidistilled water. The mineral contents i.e Fe, Ca, Mg of tubers were determined in an atomic absorption spectrophotometer (GBC-932 Australlia) whereas Na and K by flame photometer (Model PFP 7 Jenway, England) and phosphorus by using a spectrophotometer (CE-2021, 2000 series CECIL Instruments Cambridge, England).

2.6 Potato chips evaluation

The potato tubers of selected varieties were processed into potato chips. Peeled tubers were sliced (1.2-1.5 mm thick) and blanched in 1.5% NaCl solution at 85 °C for 2 min. After pre drying the chips were fried in electric fryer at 180-185 °C temperatures for 3 min using palm oil. The fried chip were cooled and placed in dry oven at 105 °C till constant weight for moisture contents (MC) estimation. The fat absorption (FAB) in different chip samples were determined by soxhlet extraction apparatus as described by Association of Official Analytical Chemists (1990) method no. 983.23. The estimation of glycoalkaloids as solanine (SOL) in potato chips was carried out by the same method as described above. A panel of twenty five learned people including the faculty members of Food Technology Department who were the habitual consumers of the potato chips selected as judge for the sensory evaluation. The judges were requested to record their degree of preferences for Crispiness (CRP), Flavor (FLV) and Taste (TAS) according to the five point hedonic scale as described by Kita (2002). The Color (COL) of the chips was correlated with British Potato Council (BPC) frying color chart and the values were expressed as approximate L-values.

2.7 Statistical analysis

Results were subjected to statistical analysis by considering the varieties as variation source, using one-way analysis of variance (ANOVA). Statistical differences with P-values under 0.05 were considered significant and means were compared by Duncan Multiple Range test according to Steel et al. (1997).

3 Results and discussion

The mean values acquired from physical analysis of each selected potato variety like size, geometric mean diameter (GMD), sphericity, surface area, tuber counts/25 kg, firmness, specific gravity, TSS, pH and sprouting potential are given in Table 1a. The Analysis of Variance for (ANOVA) to compare the mean results for all under investigating varieties are also included. Table 1b showed that all the tested varieties were significantly different from each when comparing their physical parameters like size, GMD and surface area expressed positive correlation. Desiree had maximum tuber size (85.4 mm) followed by Cardinal (83.3 mm) and Lady Rosetta (75.5 mm) and is inversely related to the tuber counts/25 kg packaging (R = -0.991). Lady Rosetta exhibited maximum surface area (15924.3 mm^2) followed by Desiree (16067.8 mm^2). Lady Rosetta experienced maximum sphericity (94.3%) followed by Chipsona (85.8%). The parameters

Table 1a. Physical analysis of potato varieties.

Variety	Size (mm)	GMD (mm)	Sphericity (%)	Surface area (mm^2)	TC/25 kg	Firmness (Kpa)	Specific Gravity	TSS (°Brix)	pH	Sprouting (%)
CAR	83.3 ± 2.31 b	66.5 ± 1.16 c	79.8 ± 3.19 d	13903 ± 7.03 d	155.0 ± 1.16 c	775 ± 4.04 h	1.07 ± 0.03 d	5.73 ± 1.17 c	6.15 ± 1.29 e	59.3 ± 1.54 b
CHI	68.5 ± 2.96 d	58.8 ± 1.48 d	85.8 ± 1.64 b	14029 ± 10.54 c	166.0 ± 0.78 b	883 ± 3.65 g	1.09 ± 0.11 b	5.63 ± 1.36 d	6.17 ± 1.17 d	50.0 ± 1.99 d
DES	85.4 ± 2.38 a	68.3 ± 1.12 b	80.0 ± 2.18 d	14666 ± 9.49 b	150.3 ± 0.89 d	760 ± 5.20 i	1.07 ± 0.08 e	5.93 ± 1.15 a	6.27 ± 1.36 b	63.0 ± 2.45 a
LR	75.5 ± 2.88 c	71.2 ± 2.23 a	94.3 ± 3.38 a	15924 ± 9.43 a	165.7 ± 0.33 b	948 ± 6.93 a	1.10 ± 0.02 a	5.56 ± 1.49 e	6.18 ± 1.09 c	46.0 ± 1.38 e
SAT	64.7 ± 1.81 e	54.5 ± 2.58 e	84.3 ± 2.47 c	9336 ± 3.57 e	185.3 ± 0.88 a	862± 4.62 d	1.08 ± 0.09 bc	5.84 ± 1.20 b	6.28 ± 1.12 ab	56.7 ± 1.66 c

CAR (Cardinal), CHI (Chipsona), DES (Desiree), LR (Lady Rosetta), SAT (Satellite), GMD (Geometric mean diameter), TC (Tuber counts), TSS (Total soluble solid); Means with different letters indicate significant difference at 5% probability level ($p < 0.05$).

explained are critical in determining the economic value of the crop as per the recommendations in British Quality Chip Charter by British Potato Council (BPC). The tubers were sorted on the basis of size (>50 mm) to minimize the sugar contents in the processed products. The high sugar contents in small sized tuber have also been reported by Kumar & Ezekiel (2006). Maximum specific gravity (1.10) was recorded in the tubers of Lady Rosetta followed by Chipsona variety and were seen to be highly correlated with their Firmness (R = 0.979) (Table 1b). Cardinal and Desiree were amongst the varieties with low specific gravity values. Varietal differentiation on the basis of specific gravity and its association with other quality parameters has also been reported by Lefort et al. (2003). While considering the pH values (6.15-6.28); a significant difference amongst tested varieties was observed however non-significant difference were recorded between Satellite and Desiree. Maximum TSS was determined in Desiree (5.93 °Brix) followed by Satellite. Abbasi et al. (2011) has also explained the change in pH and TSS of selective potato varieties.

At ambient temperature (25 ± 1 °C) storage for 50 days, Desiree showed maximum sprouting percentage (63%) followed by Cardinal (59.3%) and Satellite (56.7%), however longer dormancy and lowest sprouting was seen in Lady Rosetta (Table 1a). The results manifested in (Table 2a) showed that the maximum dry matter (26%) and starch contents (77.7%) were observed in Lady Rosetta as compared to all the varieties under study on dry weight basis while Desiree had minimum dry matter (21.2%) and starch contents (72.1%) followed by Cardinal and Satellite. Highly Significant correlation (R = 0.976) was seen between these two parameters in tested varieties (Table 2b) which supported the previous outcomes described by Casañas et al. (2002). A narrow

Table 1b. Correlation among physical parameters of potato.

	Size	GMD	Sphericity	Surface area	TC/25	Firmness	Specific gravity	TSS	pH
GMD	0.831								
Sphericity	-0.669	-0.146							
Surface area	0.784	0.925	-0.168						
TC/25	-0.991	-0.855	0.623	-0.831					
Firmness	-0.350	0.074	0.745	-0.041	0.332				
Specific gravity	-0.288	0.145	0.718	0.051	0.270	0.979			
TSS (°brix)	0.309	-0.035	-0.594	0.004	-0.285	-0.103	-0.082		
pH	-0.223	0.224	0.678	0.156	0.232	0.745	0.802	-0.196	
Sprouting	0.187	-0.097	-0.441	-0.032	-0.209	-0.170	-0.160	0.720	-0.481

GMD (Geometric mean diameter), TC (Tuber counts), TSS (Total soluble solid).

Table 2a. Proximate composition of potato varieties.

Variety	Dry Matter (%)	Starch (g/100 g)	Protein (g/100 g)	Fat (g/100 g)	Total Sugar (%)	Reducing Sugar (%)	Non reducing Sugar (%)	Fibre (g/100 g)	Ash (%)
CAR	22.4 ± 0.95 d	73.6 ± 2.03 d	11.4 ± 2.07 c	0.97 ± 0.017 d	1.94 ± 0.023 c	0.45 ± 0.058 c	1.29 ± 0.012 c	7.67 ± 0.402 b	3.25 ± 0.179 b
CHI	24.5 ± 2.95 b	75.7 ± 1.95 b	11.0 ± 2.93 d	1.02 ± 0.011 c	1.39 ± 0.058 d	0.43 ± 0.058 c	0.96 ± 0.029 d	7.72 ± 0.559 a	2.89 ± 0.239 c
DES	21.3 ± 3.81 e	72.1 ± 2.32 e	13.3 ± 2.91 a	1.28 ± 0.046 a	2.40 ± 0.058 a	0.57 ± 0.040 b	1.82 ± 0.040 a	6.75 ± 0.144 e	3.58 ± 0.115 a
LR	26.0 ± 4.82 a	77.7 ± 1.32 a	10.5 ± 1.20 e	0.80 ± 0.026 e	0.94 ± 0.023 e	0.22 ± 0.012 d	0.71 ± 0.023e	7.19 ± 0.581 c	2.56 ± 0.351d
SAT	22.8 ± 1.23 c	74.2 ± 1.92 c	12.0 ± 1.39 b	1.25 ± 0.015 b	2.25 ± 0.115 b	0.70 ± 0.029 a	1.55 ± 0.029b	6.94 ± 0.115 d	2.99 ± 0.186 c

CAR (Cardinal), CHI (Chipsona), DES (Desiree), LR (Lady Rosetta), SAT (Satellite); Means with different letters indicate significant difference at 5% probability level ($p < 0.05$).

Table 2b. Correlation among proximate parameters of potato.

	Dry Matter	Starch	Protein	Fat	Total Sugar	Reducing Sugar	Non reducing sugar	Fibre	Ash
Starch	0.976								
Protein	-0.564	-0.542							
Fat	-0.648	-0.621	0.307						
Total Sugar	-0.566	-0.502	0.207	0.864					
Reducing sugar	-0.359	-0.277	0.025	0.727	0.937				
Non reducing sugar	-0.634	-0.563	0.352	0.857	0.983	0.877			
Fibre	-0.272	-0.329	-0.541	0.191	0.059	0.035	-0.031		
Ash	-0.169	-0.265	-0.027	-0.470	-0.485	-0.583	-0.445	0.214	
Total minerals	-0.214	-0.283	0.073	-0.380	-0.354	-0.485	-0.293	0.054	0.952

range (0.80% to 1.28%) was projected in terms of fat contents of all the selected potato cultivars with highest contents in Desiree. From the proximate analysis it was proven that the mean protein contents were significantly different in each variety as also been mentioned by Casañas et al. (2009). Maximum protein contents (13.3%) were yielded by Desiree while Lady Rosetta attained the lowest (9.9%). Assessment of total Sugars revealed that the minimum sugar contents (0.94%) were attained by Lady Rosetta variety followed by Chipsona. The low protein and sugar contents in Lady Rosetta may be taken as quality parameters and have been considered vital in producing smaller amounts of post processing toxin i.e. acrylamide. The occurrence of acrylamide in potato chips during its processing (Friedman, 2003) is directly associated with Maillard reaction (Kita et al., 2004). Therefore, to avoid the formation of acrylamides, it may be suggested to choose such potato cultivars those have lower sugar and protein contents. Table 2a also shown non-starch polysaccharides (as fibres) contents found in different potato varieties. It was revealed that maximum fibre contents (7.72%) were found in Chipsona while minimum fibre contents (6.75%) were recorded in Desiree. A significant difference among different potato varieties in terms of their chemical composition was also observed by Sato et al. (2017). The mean values for Ash contents given in Table 3 manifested that maximum ash contents (3.58%) were shown by Desiree with non-significant difference was noted between satellite and Chipsona. While taking in account of mineral contents (Table 3), the potato varieties like Desiree (574 mg/100 g) and Cardinal (570 mg/100 g) might be the ideal varieties as compared to others and Cv. Satellite may be the least favorites with (527 mg/100g) mineral contents. Table 4a expressed the results on dry matter basis about functional characteristics in different potato varieties. Desiree followed by Lady Rosetta furnished maximum ascorbic acid contents (109.4 mg/100 g). The ascorbic acid contents being an important antioxidant were significantly correlated (Table 4b) with other functional parameters like glycoalkaloids as solanine contents (R = 0.839), polyphenol contents (R = 0.739) and antioxidant activity (R=0.699).

Hejtmánková et al. (2009) also showed the similar results. Glycoalkaloids contents projected as α-solanine were maximum in Desiree (19.66 mg/100 g) and minimum in Chipsona (11.21 mg/100 g). Maximum chlorophyll contents were stored in Satellite i.e 1.397 mg/100 g followed by Chipsona (Table 4a). Glycoalkaloids plays an important role in the creation of natural resistance in tubers against biological invaders like viruses, fungi, insects, and herbivores. While it has also been recognized as one of the toxins concerning to the human diet with maximum safe limit of 20 mg/100 g on Fresh Weight basis (Nema et al., 2008). The current study revealed that the tested five varieties of potato showed the initial glycoalkaloids contents lower than the tolerable limit thus considered safe for human consumption. Significant correlation (R = 0.907) has been noted between total phenolic contents and radical scavenging activity as supported by Lachman et al. (2008). Amongst evaluated varieties, maximum total phenolic contents and radical scavenging activity were attained by Desiree (Table 4a).

Quality parameters of potato chips are stated in Table 5a. Chips were evaluated for the moisture contents, fat absorption and sensory evaluation after the processing of different potato cultivars. Mean moisture contents ranged between 1.70-1.20% with maximum contents (1.70%) in Desiree and the minimum (1.20%) in Lady Rosetta. However non-significant difference ($p \leq 0.05$) was observed in Cardinal and Satellite. The study presented that the fat absorption (%) in chips was directly proportional to their moisture contents having significant correlation (R = 0.849). These results were supported by Kita (2002). Glycoalkaloids can considerably be reduced (81.95% in Lady Rosetta – 77.87% in Chipsona) by preparatory operations like peeling, cutting, slicing, washing and frying during potato chip processing. These results are also in line with the findings documented by Peksa et al. (2006).

In general highly positive correlation was detected between all the sensory attributes documented by the judges (Table 5b). The response of judges regarding the chip color was interrelated with British Potato Council (BPC) chip chart to calculate the approximate L-values. The best chip color was displayed by Lady Rosetta (L-64.80) followed by Chipsona (L-62.85). Owing to the low sugar and protein contents found in Lady Rosetta attributed overriding color scores which were also in accordance with the findings of Kyriacou et al. (2009). Crispiness is a key textural feature in chips, mostly characterized by high dry matter and starch contents. Potato varieties having higher specific gravity contained with considerable starch contents along with higher molecular weight non starch polysaccharides thus giving stable, solid and thin arrangement as also reported by Kita (2002). Maximum crispiness scores (4.75) was obtained by Lady Rosetta followed by Chipsona (4.25). Similar trend was seen in the taste and flavor scores as presented by the panel of judges (Table 5a). Lady Rosetta continued its supremacy over the other tested varieties with maximum flavor (4.85) and taste (4.80) scores followed by Chipsona.

Table 3. Mineral contents in potato varieties.

Variety	Sodium (mg/100 g)	Potassium (mg/100 g)	Iron (mg/100 g)	Calcium (mg/100 g)	Phosphorous (mg/100 g)	Magnesium (mg/100 g)	Total minerals (mg/100 g)
CAR	7.38 ± 0.15 c	461.3 ± 6.45 b	1.68 ± 0.10 d	17.75 ± 1.44a	55.17 ± 3.20b	27.67 ± 1.72 a	570 ± 12.06 a
CHI	8.33 ± 0.14 b	382.0 ± 4.73 e	2.14 ± 0.27 b	12.80 ± 0.58d	42.33 ± 2.41d	27.73 ± 1.12 a	541 ± 9.25 c
DES	7.15 ± 0.29 c	482.0 ± 8.07 a	2.19 ± 0.36 a	13.20 ± 0.98c	45.67 ± 3.14c	24.33 ± 1.06 cb	574 ± 13.92 a
LR	9.27 ± 0.15 a	430.0 ± 11.52 d	1.84 ± 0.18 c	15.93 ± 1.45b	71.33 ± 5.14a	23.47 ± 2.14 c	551 ± 18.58 b
SAT	6.70 ± 0.55 d	451.7 ± 7.66 c	1.71 ± 0.29 d	12.75 ± 1.15 d	36.17 ± 1.14e	18.47 ± 1.14 d	527 ± 10.93 d

CAR (Cardinal), CHI (Chipsona), DES (Desiree), LR (Lady Rosetta), SAT (Satellite); Means with different letters indicate significant difference at 5% probability level ($p< 0.05$).

Table 4a. Functional attributes of tested potato varieties.

Variety	AA (mg/100g)	TGA (mg/100g)	CHL (mg/100g)	TPC (mg GAE/100g)	RSA (%)
CAR	81.9 ± 2.05 c	12.5 ± 4.05 c	0.89 ± 0.87 c	115.6 ± 10.00 e	35.5 ± 0.17 e
CHI	76.5 ± 1.15 e	11.2 ± 1.05 d	1.01 ± 0.23 b	125.9 ± 8.86 d	42.9 ± 0.29 d
DES	109.4 ± 3.47 a	19.7 ± 3.19 a	0.81 ± 0.29 d	192.7 ± 6.06 a	59.3 ± 0.15 a
LR	89.0 ± 2.73 b	17.4 ± 5.03 b	0.90 ± 0.23 c	165.6 ± 6.32 b	55.7 ± 0.16 b
SAT	78.5 ± 2.30 d	12.5 ± 3.11 c	1.40 ± 0.58 a	132.8 ± 13.01 c	44.7 ± 0.81 c

CAR (Cardinal), CHI (Chipsona), DES (Desiree), LR (Lady Rosetta), SAT (Satellite), AA (Ascorbic acid), TGA (Total glycoalkaloids), CHL (Chlorophyll), TPC (Total phenolic content), RSA (Radical scavenging activity); Means with different letters indicate significant difference at 5% probability level ($p< 0.05$).

Table 4b. Correlation among functional parameters of potato.

	AA (mg/100g)	TGA (mg/100g)	CHL (mg/100g)	TPC (mg GAE/100g)
TGA	0.839			
CHL	-0.008	0.288		
TPC	0.739	0.801	0.035	
RSA	0.699	0.837	0.176	0.907

AA (Ascorbic acid), TGA (Total glycoalkaloids), CHL (Chlorophyll), TPC (Total phenolic content), RSA (Radical scavenging activity).

Table 5a. Assessment of potato chips.

Variety	MC (%)	FAB (%)	TGA (mg/100g)	COL (L-value)	CRP (Scores)	FLV (Scores)	TAS (Scores)
CAR	1.46 ± 0.33 b	37.45 ± 2.71 b	2.60 ± 0.19 c	61.10 ± 2.81 d	3.80 ± 0.67 d	4.03 ± 0.33 c	4.07 ± 0.33 c
CHI	1.30 ± 0.32 c	32.85 ± 2.92 d	2.48 ± 0.15 d	62.85 ± 1.86 b	4.25 ± 0.60 b	4.22 ± 0.44 b	4.39 ± 0.47 b
DES	1.70 ± 0.39 a	40.61 ± 5.71 a	3.99 ± 0.29 a	60.40 ± 2.87 e	3.65 ± 0.59 e	3.10 ± 0.58 e	3.10 ± 0.58 e
LR	1.20 ± 0.19 d	27.77 ± 1.80 e	3.15 ± 0.24 b	64.80 ± 0.91 a	4.75 ± 0.28 a	4.85 ± 0.12 a	4.80 ± 0.19 a
SAT	1.47 ± 0.45 b	34.19 ± 1.66 c	2.45 ± 0.21 d	61.80 ± 0.88 c	4.00 ± 0.33 c	3.57 ± 0.33 d	3.87 ± 0.88 d

CAR (Cardinal), CHI (Chipsona), DES (Desiree), LR (Lady Rosetta), SAT (Satellite), MC (Moisture content), FAB (Fat absorption), TGA (Total glycoalkaloids), COL (Color), CRP (Crispiness), FLV (Flavor), TAS (Taste); Means with different letters indicate significant difference at 5% probability level ($p< 0.05$).

Table 5b. Correlation among different parameters of potato chips.

	MC (%)	FAB (%)	TGA (mg/100g)	COL (L-value)	CRP (scores)	FLV (scores)
FAB	0.849					
TGA	-0.034	0.131				
COL	-0.908	-0.768	0.230			
CRP	-0.707	-0.585	0.300	0.673		
FLV	-0.911	-0.812	0.059	0.849	0.757	
TAS	-0.893	-0.791	-0.059	0.759	0.841	0.912

MC (Moisture content), FAB (Fat absorption), TGA (Total glycoalkaloids), COL (Color), CRP (Crispiness), FLV (Flavor), TAS (Taste).

4 Conclusion

Amongst the five tested potato cultivars, Lady Rosetta variety showed best performance due to its appropriate size and sphericity, low sprout (%), high dry matter, low fats and reducing sugars, mineral contents, significant functional potential and above all the outstanding processing characteristics. Chipsona was at second highest due to its better dry matter contents, prolonged dormancy period and exalting processing indicators. Domineering functional potential has been studied in Desiree variety but it proved inferior to Lady Rosetta in physical and chemical as well as in overall processing potentials. The significant correlation among different quality attributes may be helpful in further research for economic significance of potato varieties.

References

Abbasi, K. S., Masud, T., Gulfraz, M., Ali, S., & Imran, M. (2011). Physico-chemical, functional and processing attributes of some potato varieties grown in Pakistan. *African Journal of Biotechnology*, 10(84), 19570-19579.

Ahmadi, H., Fathollahzadeh, H., & Mobli, H. (2008). Some physical and mechanical properties of Apricot fruits, Pits and Kernels (cv. Tabarzeh). *American-Eurasian Journal of Agriculture and Environmental Sciences*, 3(5), 703-707.

Akyol, H., Riciputi, Y., Capanoglu, E., Caboni, M. F., & Verardo, V. (2016). Phenolic compounds in the potato and its byproducts: an overview. *International Journal of Molecular Sciences*, 17(6), 835. http://dx.doi.org/10.3390/ijms17060835. PMid:27240356.

Andre, C. M., Schafleitner, R., Legay, S., Lefèvre, I., Aliaga, C., Nomberto, G., Hoffmann, L., Hausman, J., Larondelle, Y., & Evers, D. (2009). Gene expression changes related to the production of phenolic compounds in potato tubers grown under drought stress. *Phytochemistry*, 70(9), 1107-1116. http://dx.doi.org/10.1016/j.phytochem.2009.07.008. PMid:19664789.

Association of Official Analytical Chemists – AOAC. (1990). *Official methods of analysis of the Association of Official Analytical Chemists* (15th ed.). Virginia: USA.

Baryeh, E. A. (2001). Physical properties of Bambara groundnuts. *Journal of Food Engineering*, 47(4), 321-326. http://dx.doi.org/10.1016/S0260-8774(00)00136-9.

Blenkinsop, R. W., Copp, L. J., Yada, R. Y., & Marangoni, A. G. (2002). Changes in compositional parameters of tubers of potato (*Solanum tuberosum*) during low temperature storage and their relationship to chip processing quality. *Journal of Agricultural and Food Chemistry*, 50(16), 4545-4553. http://dx.doi.org/10.1021/jf0255984. PMid:12137474.

Casañas, R., González, M., Rodríguez, E., Marrero, A., & Díaz, C. (2002). Chemometric studies of chemical compounds in five cultivars of potatoes from Tenerife. *Journal of Agricultural and Food Chemistry*, 50(7), 2076-2082. http://dx.doi.org/10.1021/jf011074c. PMid:11902959.

Casañas, R., Hernández, P. L. S., Rodríguez, E. M., & Romero, C. D. (2009). Chemical composition of eight cultivars of potatoes. Application of multivariant analysis. *Acta Alimentaria*, 38(4), 405-414. http://dx.doi.org/10.1556/AAlim.38.2009.4.1.

Fabbri, A. D. T., & Crosby, G. A. (2016). A review of the impact of preparation and cooking on the nutritional quality of vegetables and legumes. *International Journal of Gastronomy and Food Science*, 3, 2-11. http://dx.doi.org/10.1016/j.ijgfs.2015.11.001.

Friedman, M. (2003). Chemistry, biochemistry, and safety of acrylamide: a review. *Journal of Agricultural and Food Chemistry*, 51(16), 4504-4526. http://dx.doi.org/10.1021/jf030204+. PMid:14705871.

Grunenfelder, L. A., Knowles, L. O., Hiller, L. K., & Knowles, N. R. (2006). Glycoalkaloid development during greening of fresh market potatoes (*Solanum tuberosum* L.). *Journal of Agricultural and Food Chemistry*, 54(16), 5847-5854. http://dx.doi.org/10.1021/jf0607359. PMid:16881686.

Hejtmánková, K., Pivec, V., Trnková, E., Hamouz, K., & Lachman, J. (2009). Quality of coloured varieties of potatoes. *Czech Journal of Food Sciences*, 27(Special Issue 1), 310-313. http://dx.doi.org/10.17221/605-CJFS.

Kita, A. (2002). The influence of potato chemical composition on crisp texture. *Food Chemistry*, 76(2), 173-179. http://dx.doi.org/10.1016/S0308-8146(01)00260-6.

Kita, A., Brathen, E., Knutsen, S., & Wicklund, T. (2004). Effective way of decreasing acrylamide content in potato crisps during processing. *Journal of Agricultural and Food Chemistry*, 52(23), 7011-7016. http://dx.doi.org/10.1021/jf049269i. PMid:15537311.

Kumar, D., & Ezekiel, R. (2006). Effect of physiological and biochemical attributes of potato cultivars Kufri Lauvkar and Atlantic on their chipping quality. *Potato Journal*, 33, 50-55.

Kumar, D., Ezekiel, R., Singh, B., & Ahmed, I. (2005). Conversion table for specific gravity, dry matter and starch content from under water weight of potatoes grown in North Indian plains. *Potato Journal*, 32(1-2), 79-84.

Kyriacou, M. C., Ioannides, I. M., Gerasopoulos, D., & Siomos, A. S. (2009). Storage profile and processing potential of four potato (*Solanum tuberosum* L.) cultivars under these storage temperature regimes. *Journal of Food Agriculture and Environment*, 7(1), 31-37.

Lachman, J., Hamouz, K., Orsák, M., Pivec, V., & Dvořák, P. (2008). The influence of flesh colour and growing locality on polyphenolic content and antioxidant activity in potatoes. *Scientia Horticulturae*, 117(2), 109-114. http://dx.doi.org/10.1016/j.scienta.2008.03.030.

Lefort, J. F., Durance, T. D., & Upadhyaya, M. K. (2003). Effects of tuber storage and cultivar on the quality of Vacuum Microwave-Dried (VMD) potato chips. *Journal of Food Science*, 68(2), 690-696. http://dx.doi.org/10.1111/j.1365-2621.2003.tb05733.x.

Mahgoub, H., Eisa, G., & Youssef, M. (2015). Molecular, biochemical and anatomical analysis of some potato (*Solanum tuberosum* L.) cultivars growing in Egypt. *Journal of Genetic Engineering and Biotechnology*, 13(1), 39-49. http://dx.doi.org/10.1016/j.jgeb.2014.11.004.

Nema, P. K., Ramayya, N., Duncan, E., & Niranjan, K. (2008). Potato glycoalkaloids: formation and strategies for mitigation- A review. *Journal of the Science of Food and Agriculture*, 88(11), 1869-1881. http://dx.doi.org/10.1002/jsfa.3302.

Peksa, A., Golubowska, G., Aniolowski, K., Lisinska, G., & Rytel, E. (2006). Changes in glycoalkaloids and nitrate contents in potato during chip processing. *Food Chemistry*, 97(1), 151-156. http://dx.doi.org/10.1016/j.foodchem.2005.03.035.

Ranganna, B., Raghavan, G. S. V., & Kushalappa, A. C. (1998). Hot water dipping to enhance storability of potatoes. *Postharvest Biology and Technology*, 13(3), 215-223. http://dx.doi.org/10.1016/S0925-5214(98)00015-5.

Sato, H., Koizumi, R., Nakazawa, Y., Yamazaki, M., Itoyama, R., Ichisawa, M., Negichi, J., Sakuma, R., Furusho, T., Sagane, Y., & Takano, K. (2017). Data on the weights, specific gravities and chemical compositions of potato (*Solanum tuberosum*) tubers for food processing from different areas of Hokkaido, Japan. *Data in Brief*, 11, 601-605. http://dx.doi.org/10.1016/j.dib.2017.03.009. PMid:28349110.

Sengul, M., Keles, F., & Keles, M. S. (2004). The effect of storage conditions (temperature, light, time) and variety on the glycoalkaloids content of potato tubers and sprouts. *Food Control*, 15(4), 281-286. http://dx.doi.org/10.1016/S0956-7135(03)00077-X.

Singh, N., & Rajini, P. S. (2004). Free radical scavenging activity of an aqueous extract of potato peel. *Food Chemistry*, 85(4), 611-616. http://dx.doi.org/10.1016/j.foodchem.2003.07.003.

Stadler, R. H., Robert, F., Riediker, S., Varga, N., Davidek, T., Devaud, S., Goldmann, T., Hau, J., & Blank, I. (2004). In-depth mechanistic study on the formation of acrylamide and other vinylogous compounds by Maillard reaction. *Journal of Agricultural and Food Chemistry*, 52(17), 5550-5558. http://dx.doi.org/10.1021/jf0495486. PMid:15315399.

Steel, R. D., Torrie, J. H., & Dickey, D. (1997). *Principle and procedure of statistics. A biometrical approach* (3rd ed.). New York: McGraw-Hills Book Co. Inc.

Tierno, R., Lopez, A., Riga, P., Arazuri, S., Jaren, C., Benedicto, L., & Galarreta, J. R. (2016). Phytochemicals determination and classification in purple and red fleshed potato tubers by analytical methods and near infrared spectroscopy. *Journal of the Science of Food and Agriculture*, 96(6), 1888-1899. http://dx.doi.org/10.1002/jsfa.7294. PMid:26058597.