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Processing quality traits of different potato (*Solanum tuberosum* L.) genotypes in India

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Abstract
Potato is an important vegetable and has potential for use in the processing industry in India. Six potato genotypes *viz.* 'Kufri Chipsona-1', 'Kufri Chipsona-4', 'Kufri Frysona', 'FC-3', 'Kufri Garima' and 'Lady Rosetta' were evaluated to find out their suitability for processing into fresh fried potato chips. Significant differences in physico-chemical parameters were observed among the genotypes. 'FC-3', 'K.Frysona' and 'Lady Rosette' contained the highest amount of dry matter content and lowest amount of reducing sugars. While genotypes, 'K.Garima' and 'K.Chipsona-4' were found inferior for processing due to poor quality traits. Based on sensory characteristics, 'FC-3', 'K.Frysona' and 'Lady Rosette' were best for processing into fresh fried potato chips. Chips prepared from these cultivars had lower moisture content, oil uptake and higher yield than from other genotypes.

Keywords: Potato, sugar content, processing, chips

1. Introduction
Potato is an important vegetable crop item throughout the world because of its high production, high calorific value, low cost and easy to cook methods [1]. Potato is a nutritious vegetable containing 16% carbohydrates, 2% proteins, 1% minerals, 0.6% dietary fibre and negligible amount of fat [2]. Besides being a rich source of carbohydrates, potato also contain some health promoting compounds such as phenolic acids, ascorbic acid and carotenoids [3]. Potato is widely used in many cuisines. Besides culinary consumption, the use of potato has progressively increased as a raw material by the processing industry [4].
The quality requirements for potato vary for different products and suitability of particular cultivars for specific product assumes great importance. 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 [5, 6].
The main potato crop in Indian plains is grown during winter and the bulk of crop produced is harvested before the 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. In case of processing varieties also all the produce cannot be utilized by the processing industries at the time of harvest, and hence the potatoes have to be stored and used periodically [7]. Potatoes reportedly undergo many physiological and biochemical changes during storage such as severe weight loss and sharp increase in reducing sugar content [8].
Potato production has significantly increased in recent years in India, making it to the position of second largest potato producing country in the world [9]. Moreover, number of processing industries and potato products are increasing with the demand of specific varieties. Despite the increasing demand of processing quality potato, the availability of suitable raw material for processing industry is scanty. Therefore, it is important to identify potato genotypes that possess traits to meet the challenges of frequently changing market, production circumstances and improving their economic condition [4]. The screening of potato genotypes with improved processing characteristics and a wide adaptability is important to all segments of potato industry. The objective of the present study was to evaluate and screen potato genotypes for processing traits for growers, food industrialists and the potato product consumers in India.

2. Materials and methods
Healthy, fully cured, uniform size tubers of six potato genotypes, 'Kufri Chipsona-1', 'Kufri

Chipsona-4', 'Kufri Frysona', 'FC-3', 'Kufri Garima' and 'Lady Rosetta' were procured from the department of Vegetable Science of Punjab Agricultural University, Ludhiana. Analysis of the fresh cultivars and preparation of potato chips were carried out in the food science and technology laboratories at Punjab Agricultural University, Ludhiana.

2.1 Preparation of potato chips
Raw potato tubers from each variety were washed, peeled, and cut into 1.4 mm thick slices with a rotary hand slicer. The cut potato slices were immersed in water to prevent enzymatic darkening. After washing and removing surface moisture with a muslin cloth, slices were fried at 180^0C for <2 min until the oil ceased bubbling [6]. Frying was in a batch type, deep fat fryer containing about 5L of oil maintained at 180^0C.

2.2 Quality analyses of fresh potato tubers and prepared potato chips
2.2.1 Physico-chemical analysis
The specific gravity of fresh potato tubers was determined by the standard water displacement method [10]. The moisture and dry matter content were determined by drying 5g of fresh tissue in hot air oven at 60±2ºC till constant weight and was calculated on fresh weight basis % [11]. Reducing sugars of raw tubers were determined by the Nelson Somogyi method [12] and total sugars by the Phenol Sulphuric acid method [13]. Starch content was analyzed by the method of Clegg [14]. Total nitrogen was estimated by the Micro-Kjeldahl method [11] and protein content was calculated using a nitrogen factor of 6.25.
Freshly prepared fried potato chips were analyzed for moisture content [11]. Oil uptake was measured using the Soxhlet extraction method [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 [16].

2.3 Statistical analysis
All the experiments were carried out in triplicate. One-way analysis of variance was performed using the SPSS version 20.0 (Statistical Package for Social Sciences). Significant differences (p<0.05) were determined by Tukey's.

3. Results and discussion
3.1 Physico-chemical analysis of raw tubers
Potato genotypes varied with respect to specific gravity, which ranged from 1.055 to 1.095 (Table 1). It was observed that 'FC-3' had the highest specific gravity (1.095) followed by 'K. Frysona'(1.090) and Lady Rosetta (1.073) while minimum value for specific gravity was noted for genotype 'K.Garima'(1.055). These differences might be related to genetic variations among different cultivars. Similar observations were reported earlier for different cultivars of potatoes [17, 18]. Dry matter content among various genotypes ranged from 16.0 to 24.0% (Table 1) with maximum dry matter content in 'FC-3' (24.0%), followed by 'K. Frysona'(23.12%) while 'K.Garima' displayed the minimum value (16.0%). As explained by Kaur and Aggarwal [19], tuber dry matter content is a strongly genetic based characteristic and differs significantly among cultivars. It was observed that genotypes with high specific gravity showed higher percentage of dry matter content. This might be due to positive correlation of dry matter content with specific gravity (r=0.988) observed in this study. A significant relationship between dry matter and specific gravity has been reported earlier [8, 20].
Starch content which is considered to be the main constituent of potato was found to be maximum in 'FC-3' (15.20%) and 'K. Frysona' (15.0%) and minimum in 'K.Garima' (12.25%). This may be due to higher dry matter content in these cultivars, as starch and dry matter contents of potato are directly related to each other [21].
The total and reducing sugars of potato genotypes ranged 0.09-2.20% and 0.02-0.54%, respectively (Table 1) and showed significant (p<0.05) difference. Potato tuber sugar content is a heritable character and may be affected by cultivar, maturity, season, production site and storage conditions [20]. For processing, low reducing (<0.1%) and total (<2.0% on fresh wt basis) sugars are desirable to avoid dark color and bitter taste in processed potato products [21]. In the present study, sugar content was within the acceptable limits in all genotypes but exceeded the limits in 'K.Garima'.

Table 1: Physico-chemical analysis of raw tubers

Genotype	Specific gravity	Dry matter (%)	Reducing sugars (%)	Total sugars (%)	Starch (%)
K. Chipsona-1	1.070±0.004^d	19.0±0.12^d	0.03±0.00^d	0.10±0.06^d	13.41±0.08^c
K. Chipsona-4	1.068±0.003^e	18.5±0.12^e	0.10±0.007^b	0.21±0.01^b	13.22±0.10^c
K. Frysona	1.090±0.004^a	23.12±0.22^a	0.05±0.003^c	0.11±0.02^c	15.20±0.20^a
FC-3	1.095±0.002^b	24.0±0.15^b	0.06±0.002^c	0.12±0.02^c	15.00±0.20^a
K. Garima	1.055±0.001^f	16.0±0.12^f	0.54±0.06^a	2.20±0.10^a	12.25±0.18^d
Lady Rosetta	1.075±0.004^c	20.0±0.11^c	0.02±0.002^d	0.09±0.02^d	14.00±0.05^b

Values are mean± standard deviation, n=3

3.2 Physico-chemical analysis of potato chips
3.2.1 Yield
The yield of fresh fried potato chips ranged 26.80-32.90% (Table 2). The yield was found to be positively correlated with the dry matter content of genotypes (Table 2). Genotypes which had higher fresh tissue dry matter (>20%), produced high yield of chips (31.8-32.9%) in comparison to lower dry matter content genotypes (26.8-29.8%) (Table 2). 'FC-3' and 'K. Frysona' produced maximum average chip yield among genotypes followed by 'Lady Rosette' and 'Kufri Chipsona-1'. The results are in conformity with published reports of Raj *et al.* [22] and Kaur *et al.* [5]. The quality of potato chips has been reported to be influenced by variety and inherent attributes such as dry matter content and specific gravity [23].

3.2.1 Oil uptake
Oil uptake is the utmost important factor determining the quality and cost of potato chips. Oil uptake in the freshly fried potato chips ranged between 32.40% to 41.80% (Table 2), with minimum in 'FC-3' and 'K. Frysona', followed by 'Lady Rosette' and maximum in 'K.Garima'. For processing purpose, the recommended oil uptake in chips is 38.0%. It may be inferred that 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 [21], 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.

Table 2: Physico-chemical analysis of fresh fried potato chips

Genotype	Moisture content (%)	Oil Uptake (%)	Yield (%)
K. Chipsona-1	1.8±0.02^{b}	33.4±0.15^{c}	29.8±0.10^{c}
K. Chipsona-4	1.9±0.01^{b}	36.8±0.20^{b}	28.9±0.18^{d}
K. Frysona	1.6±0.11^{c}	32.9±0.16^{e}	32.3±0.11^{a}
FC-3	1.7±0.05^{c}	32.4±0.15^{e}	32.9±0.13^{a}
K. Garima	3.3±0.05^{a}	41.8±0.11^{a}	26.8±0.11^{e}
Lady Rosetta	1.7±0.06^{c}	33.9±0.10^{d}	31.8±0.13^{b}

Values are mean± standard deviation, *n*=3

3.3 Sensory quality

Processing quality is largely determined by the color of the potato. Fried Potato chips prepared from 'FC-3'and 'K. Frysona' were of desirable light brown color while 'K.Garima' and 'K. Chipsona-4' produced dark colored chips (Fig. 1). The lowest rating for color in these genotypes (Table 3) conformed of high reducing sugars. The color of chips is largely determined by the reducing sugar content of the potato tubers. During high temperature frying of potatoes, the non-enzymatic Maillard reaction causes amino acids to react with carbonyl groups of reducing sugars resulting in darkening of potato chips [24].

For texture, higher score was given to chips prepared from 'FC-3', 'K. Frysona' and 'Lady Rosetta' closely followed by 'K.Chiposona-1' (Table 3). The texture of prepared product was found to be directly related to dry matter content of potato. Texture score was lowest for genotype 'K.Garima' (Table 3). A slight bitter taste occurred in chips prepared from 'K.Garima' which could be due to high level of reducing sugars in this cultivar. The results of overall acceptability indicated higher preference for chips prepared from 'FC-3', closely followed by 'K.Frysona' and 'Lady Rosetta' (Table 3).

Fig 1: Fresh fried potato chips (a): 'K. Chipsona-4' (b) 'k.Chipsona-1' (c) 'K. Garima' (d) 'FC-3' (e) 'K.Frysona'

Table 3: Organoleptic quality of fresh fried potato chips

Genotype	Appearance	Texture	Flavor	Overall acceptability
K. Chipsona-1	7.8±0.05	8.2±0.01	8.2±0.02	8.0±0.02
K. Chipsona-4	7.7±0.03	7.4±0.05	7.6±0.03	7.7±0.03
K. Frysona	8.2±0.02	8.3±0.03	8.1±0.05	8.2±0.05
FC-3	8.5±0.01	8.3±0.07	8.3±0.02	8.3±0.07
K. Garima	5.2±0.05	7.3±0.05	7.2±0.02	6.5±0.05
Lady Rosetta	8.0±0.06	8.3±0.05	8.3±0.05	8.15±0.08

Values are mean± standard deviation, *n*=3

4. Conclusion

The present study concluded that genotypes 'FC-3', 'K.Frysona' and 'Lady Rosette' were most suitable for processing into fresh fried potato chips because of higher dry matter content, lower levels of reducing and total sugars whereas genotypes, 'K. Garima' and 'K.Chipsona-1' possessed poor quality traits, such as lower dry matter and higher sugar content and were not suitable for processing.

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