Research Article

Determination of processing quality of local potato germplasms for industrial use

Ajmal Khan[1], Faisal Nouroz[1,2*], Shazia Erum[3]

[1]Department of Botany, Hazara University Mansehra, Pakistan
[2]Department of Bioinformatics, Hazara University Mansehra, Pakistan
[3]Plant Genetic Resource Institute, NARC, Islamabad, Pakistan

***Corresponding author's email:** faisalnouroz@gmail.com

Abstract

Potato (*Solanum tuberosum* L.) of the family Solanaceae is ranked globally as the fourth most important crop after rice, maize, and wheat. More than 7,500 different varieties of potato are found around the globe. In Pakistan the total area under potatoes cultivation is 134300 ha with production of about 2.5 million tons/annum. The availability of fresh and nutritive potatoes for human utilization is very essential. The present study was conducted to screen thirty-six potato genotypes for processing quality characteristics including specific gravity, dry matter and ash contents to determine their suitability for industrial use in compliance with food safety standards. The purpose of this study was to identify the new and best processing varieties considered suitable for industrial use and to recommend such varieties to the farmers for further growth. Among the thirty-six potato genotypes, 393594-72 (1.080 g/cm^3), Kuroda (1.083 g/cm^3), Potato-III (1.085 g/cm^3) and Romeo (1.095 g/cm^3) has the highest specific gravity, whereas Sarpomira (20.13%), 393574-72 (20.21%), Kuroda (21.1%), Potato-III (21.25%), and Romeo (23.38%) was found superior for their dry matter. The maximum ash contents were recorded in Sturna (6.65%) followed by Zia-III (5.55%). Most of the potatoes cultivars at any location produced tubers with a dry matter content greater than 18.0% and a specific gravity of 1.070 g/cm^3, which are within the acceptable range for processing. The study was helpful in evaluation of best potato genotypes for industrial purposes and their cultivation by the farmers.

Keywords: Quality attributes, Genotypes, Potato, Germplasm, Romeo, Industrial use.

Article History: **Received:** 14 Nov 2024, **Revised:** 29 Nov 2024, **Accepted**: 5 Dec 2024, **Published:** 16 Dec 2024.

Introduction

Potato (*Solanum tuberosum* L.) ranks the fourth most consumption crop in the world after rice, maize, and wheat [1]. Potato, a member of family Solanaceae originated from the high Andes of South America and was initially cultivated in the Lake Titicaca near the border of Peru and Bolivia. In 1858, it was introduced to Ethiopia by the German botanist, Shimper. During sixteen century Spanish explorers introduced it to European countries and then it became an important food crop all over the world. It is believed that it is introduced in India by the Portuguese traders or by British missionaries in the beginning of seventeenth century. The British apparently introduced potato to the Sudan in the early 20th century. Now a days, more than 7,500 different potato varieties are found around the globe [2, 3, 4]. In Pakistan several potato genotypes are grown for various purposes and 35 potato genotypes were tested in a study for best trait selection and screening [5]. The availability of fresh potatoes for human utilization is essential in developed and developing countries, which represent more than 80% of total national output with a total production of 359 million tons in 2020 [6]. Potato is usually grown in tropical as well as subtropical regions of the world during cool and dry seasons. It is an annual cold season crop, where the optimum temperature required to produce best quality tubers range from 16 to 20ºC. Potato vigorously grows under cooler climate when day temperature is not above 35ºC and night temperature is below 20ºC. Most potato cultivars do not produce tubers when the night temperature is above 23ºC [7, 8].

Nature has gifted Pakistan with excellent edaphic and favorable environmental conditions. Therefore, in Pakistan fresh potato tubers are available throughout the year by growing two crops each year in the plain area and one in the hilly regions. In Pakistan, the total area under potato cultivation is 134300 ha with the production of 2.5 million metric tons [9]. Among the major potato growing nations of the world, China is at top, followed by Russia, Ukraine, Poland and India. Every hectare of land usually produced around sixteen to nineteen tones of potato, while European and American countries are producing around 30-40 tons per hectare [10]. Outrageously, the production of potato in Pakistan is much lower as compared to other potato growing countries on account of the low yield of new adapted varieties. In Pakistan, low yield is predominantly due to diseases, as fugal and viral infections are the most critical and causes great economic losses [11].

The consumption of potato is continuously increasing due to its nutritional value and great adaptability. The fresh potatoes requirement for human consumption is essential in developed and developing countries. Potato is grown around the globe, where the consumption is about 75 to 95 kg/ capita/ year. In the USA the utilization of potato per capita is much more than the other vegetables [12]. Other than culinary consumption, the utilization of potato has progressively increased as a raw material for processing in industries. Of over thirty million tons of potato annual production, ten million is utilized by the industries to produce variable items such as French fries, and potato chips while the rest are consumed as fresh. Beside it is a staple food in European countries but their utilization both in fresh and processed form is increasing significantly in Asian countries [13]. The continuous increase of popularity for the potatoes is mainly due to the population explosion, urbanization, tourism, as well as export of processed products. However, the potato processing industries sets high quality standards for industrial use. The first one is the portion of certain size grades, and the second one is the high dry matter contents of the tubers. In industrial scale the preparation of French fries from potatoes demands tubers graded >50 mm and 40-65 mm for crisps preparation. Besides tubers size and shape the specific gravity is also the most important quality parameter for processing. Particularly the specific gravity is highly correlated with dry matter components, and the tuber with lower specific gravity may result in cheap processing quality [14]. Therefore, the composition of potato must be checked for some variables, for example, dry matter, carbohydrates contents and reducing sugar contents before determining its right use, handling, and processing. For processing purposes, it is necessary for potato to fulfill certain quality traits such as low reducing sugars and high dry matter contents. Because during frying the reducing sugar contents induced a non-enzymatic Millard browning reaction with free amino acids during which resulting in desirable color and flavor of fried potato products [15]. High dry matter contents improve chip quality, crispness and reduce oil absorption in field products [16]. Dry matter content of raw potato is an important parameter to be considered especially if the tubers are meant for processing. Potato tubers with a dry matter content of 20 to 24% are ideal for making French fries while those with a dry matter content of up to 24% are ideal for preparing crisps [17, 18].

The present study was conducted to screen potato genotypes for processing quality traits including specific gravity, dry matter and ash contents to determine their suitability for industrial use in compliance with food safety standards. The major purpose was the identification of new and best trait varieties, considered best for industrial use, and to recommend these varieties to the farmers for further growing and propagation.

Material and Methods

Collection of tubers

The research materials (potato tubers) were collected from Potato Program, National Agriculture Research Centre (NARC), Islamabad, Pakistan and were carefully transported to the experimental site for further analysis.

Sample preparation

The potato tubers were washed with abundant tap water, rinse in deionized distilled water and were dried with towel paper. The tubers were exposed to the air for 10 to 15 minutes for drying. With the help of a stainless-steel slicer, slices of each tuber were obtained until a 50 g weighed sample was obtained, the samples in a glass petri dish were kept in oven for drying at 60 ºC (Fig. 1a-f). The samples after drying were weighed, milled in a stainless-steel mill, placed in polyethylene zip loc bags, sealed and stored in cupboard until required.

Figure 1: Sample Preparation from the tubers of selected potato germplasms. A) Washing of potato tubes, B) Cutting of potato tubers, C) Slice storage, D) Oven drying at 60 ºC, E) Grinding of samples, F) Determination of total ash contents.

Determination of specific gravity (SG)

The specific gravity of potato tubers was determined with the help of potato hydrometer developed by Snack Food Association (SFA) Virginia as per described standard procedure.

Determination of dry matter (DM)

Dry matter (DM) was determined for the prepared potato tubers powders using hot oven drying method as described by association of official analysis chemistry [19]. To determine the total dry matter contents of potato germplasm a known weight (W1) of potato tubers sample was taken in a tarred crucible. Moisture contents of samples were determined by drying the samples in oven at 60°C until a constant weight (W2) was obtained. The dry matter of the sample was calculated according to the following formula: Dry Matter %= W2/(W1) X 100

Determination of total ash (TA)

The standard procedure [19] was adopted for total ash determination. Three grams (W1) dried and ground sample was taken into a tarred crucible. The crucible was ignited on the oxidizing flame of burner to remove the smoke fumes. Then the crucible was kept into muffle furnace maintained at about 600°C temperature. The temperature was maintained until white/ gray color was obtained. After complete ignition the crucible was brought out from furnace and placed in desiccators cooled and weight (W2) of ash was record. The percentage of ash was calculated by the following formula: Total Ash (%) = W2/W1x 100.

Statistical analysis

Statistical data were analyzed by using Statistix 8.1 and Excel software. Analysis of Variance was applied for comparison among different potato genotypes to confirm whether the values are significantly different taking $P<0.05$ as significant level.

Results

The aim of the current study was to determine the processing traits of thirty-six different potato germplasms for industrial use based on selected parameters such as specific gravity (SG), dry matter (DM) and total ash (TA) contents. As these traits are highly significant to produce potato products at industrial level.

Specific gravity

Results showed that tubers of different potato genotypes varied from each other with respect to specific gravity (SG). The SG results of the simple ANOVA between the tubers of thirty-six different genotypes were found highly significant ($P < 0.01$). It was obvious from the results that the SG of potato genotypes occurred between 1.053 and 1.095 g/cm^3 (Fig. 2). Among the thirty six potato genotypes, Romeo (1.095 g/cm^3), Potato-III (1.085 g/cm^3), Kuroda (1.083 g/cm^3), and 393594-72 (1.080 g/cm^3) has shown the highest specific gravity followed by Astrix (1.076 g/cm^3), while the lowest specific gravity was noted for 2005-4, Zia-I, FD-70-1, CIVI-95-CIMECA, HZD 02-1499, AGB-Red and Sturna with the values of 1.053 g/cm^3 (Table 1). Tubers having high specific gravity are preferred for processing and Romeo, Potato-III, Kuroda, and 393594-72 were found as outstanding genotypes for these characteristics. Potato tubers should have a SG value of more than 1.080 and tubers having SG value less than 1.070 are generally unacceptable for processing. So, the varieties 2005-4, Zia-I, FD-70-1, CIVI-95-CIMECA, HZD 02-1499, AGB-Red and Sturna with the values of 1.053 g/cm^3 are not good for industrial processing.

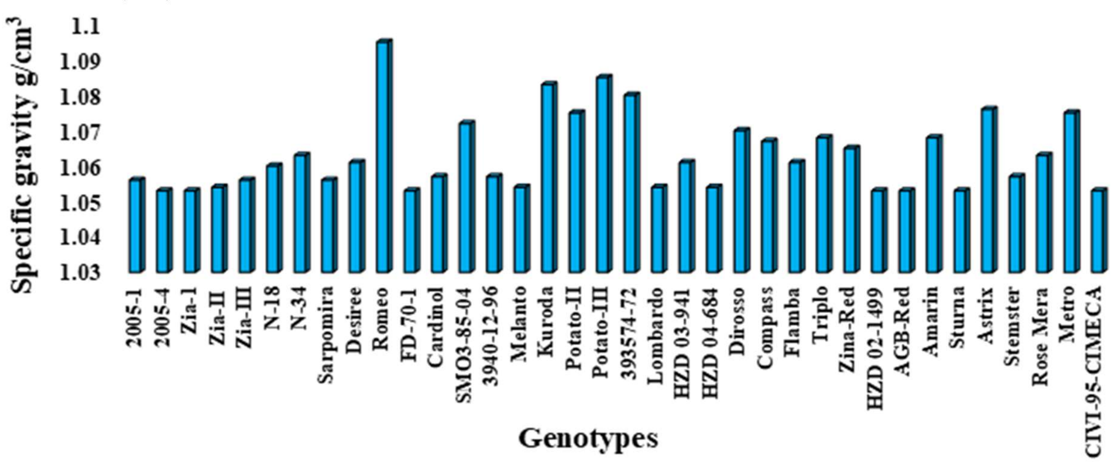

Figure 2: Variation in the specific gravity of selected potato germplasms.

Table 1: Quality parameters of selected potato genotypes. The specific gravity, dry matter and total ash contents of thirty-six selected potato germplasm are presented.

No.	Genotypes	Specific gravity g/cm^4	Dry Matter (%)	Total Ash (%)
1	2005-1	1.056 ^{lm}	15.44 ^{l}	5.27 $^{f-h}$
2	2005-4	1.053 ^{n}	14.17 ^{p}	5.06 $^{g-j}$
3	Zia-1	1.053 ^{n}	14.69 ^{n}	5.55 $^{d-f}$
4	Zia-II	1.054 ^{n}	14.17 ^{p}	6.25 ^{bc}
5	Zia-III	1.056 ^{l}	15.21 ^{lm}	6.55 ^{ab}
6	N-18	1.060 ^{k}	16.11 ^{k}	5.02 $^{h-k}$
7	N-34	1.063 j	16.19 ^{k}	4.91 $^{i-l}$
8	Sarpomira	1.056 ^{l}	20.13 ^{c}	4.70 $^{k-o}$
9	Desiree	1.061 ^{h}	17.59 ^{hi}	4.62 $^{l-p}$
10	Romeo	1.095 ^{a}	23.38 ^{a}	4.45 $^{o-q}$
11	FD-70-1	1.053 ^{n}	13.58 ^{q}	5.59 $^{d-f}$
12	Cardinol	1.057 ^{l}	15.06 ^{m}	4.91 $^{i-l}$
13	SMO3-85-04	1.072 ^{f}	18.85 ^{f}	4.42 $^{n-q}$
14	3940-12-96	1.057 ^{l}	15.33 ^{lm}	4.97 $^{h-k}$
15	Melanto	1.054 ^{n}	13.21 ^{r}	4.57 $^{l-q}$
16	Kuroda	1.083 ^{c}	21.10 ^{b}	4.06 ^{rs}
17	Potato-II	1.075 ^{e}	19.38 ^{de}	4.34 $^{p-r}$
18	Potato-III	1.085 ^{b}	21.25 ^{b}	4.23 ^{qr}
19	393574-72	1.080 ^{d}	20.21 ^{c}	4.47 $^{m-q}$
20	Lombardo	1.054 ^{mn}	14.72 ^{n}	4.06 ^{rs}
21	HZD 03-941	1.061 ^{k}	16.34 ^{k}	4.82 $^{j-l}$
22	HZD 04-684	1.054 ^{mn}	14.56 ^{no}	4.76 $^{j-n}$
23	Dirosso	1.070 ^{g}	18.37 ^{g}	3.42 ^{u}
24	Compass	1.067 ^{h}	17.50 $^{h-j}$	5.70 ^{de}
25	Flamba	1.061 ^{k}	16.24 ^{k}	4.23 ^{qr}
26	Triplo	1.068 ^{h}	17.18 ^{j}	4.83 $^{j-l}$
27	Zina-Red	1.065 ^{i}	17.28 ^{ij}	4.90 $^{i-l}$
28	HZD 02-1499	1.053 ^{n}	14.41 $^{n-p}$	5.80 ^{d}
29	AGB-Red	1.053 ^{n}	14.56 ^{no}	4.79 $^{j-m}$
30	Amarin	1.068 ^{h}	17.71 ^{h}	5.39 $^{e-g}$
31	Sturna	1.053 ^{n}	14.31 ^{op}	6.65 ^{a}
32	Astrix	1.076 ^{e}	19.61 ^{d}	3.88 st
33	Stemster	1.057 ^{l}	15.32 ^{lm}	6.20 ^{c}
34	Rose Mera	1.063 ^{j}	16.37 ^{k}	5.18 $^{g-i}$
35	Metro	1.075 ^{e}	19.21 ^{e}	3.66 ^{tu}
36	CIVI-95-CIMECA	1.053 ^{n}	14.55 ^{no}	4.33 $^{p-r}$
	CV value	1.98	0.93	3.46
	LSD value	0.09	0.31	0.34

LSD 5%: Means followed by the same letters do not differ significantly at $p < 0.05$.

Dry matter

Dry matter (DM) was determined by oven drying method at 60°C till constant weight was achieved. The dry matter parameter showed variation among selected potato genotypes (Table 1). The variation in dry matter (DM) contents among each selected potato germplasm is highly significant at percent level (Table 2). Result showed that DM content of potato tubers ranged from 13-23%. Among thirty-six potato genotypes (Fig. 3), Romeo has the highest dry matter contents of (23.38%) followed by Kuroda and Potato-III, with the value of (21.1%) and (21.25%), respectively. The lowest DM for Zia-II was 14.1%, followed by FD-70-1 (13.58%) and Melanto (13.21%). The varieties Zia-1, Zia-II and Zia-III show DM content of 14.69%, 14.17% and 15.21% respectively. DM content of raw potato is an important parameter to be considered especially if the tubers are meant for processing. DM contents also affect the starch contents of potato tubers. Studies revealed a negative correlation between the DM and Fat contents especially when deep oil frying is involved.

Total ash

The total ash contents of thirty-six different potato germplasm were also calculated according to the standard procedure [19]. The results regarding total ash contents of the different potato varieties are presented in Table 1. Analysis of variance for total ash (TA) contents revealed highly significant difference among selected potato cultivars. Total ash contents of tested potatoes germplasms were found between 3.42-6.65%. The maximum ash contents (Fig. 4) were recorded in Sturna (6.65%) followed by Zia-III (6.55%) and Zia-II (6.25%), while the minimum ash contents were seen in Dirosso (3.42%), followed by Metro (3.66%), and Astrix (3.88%). The varieties Potato-II and Potato-III have shown total ash contents of 4.34% and 4.23% respectively, whereas total ash contents seen in HZD 03-941 and HZD 04-684 were 4.82% and 4.76% respectively.

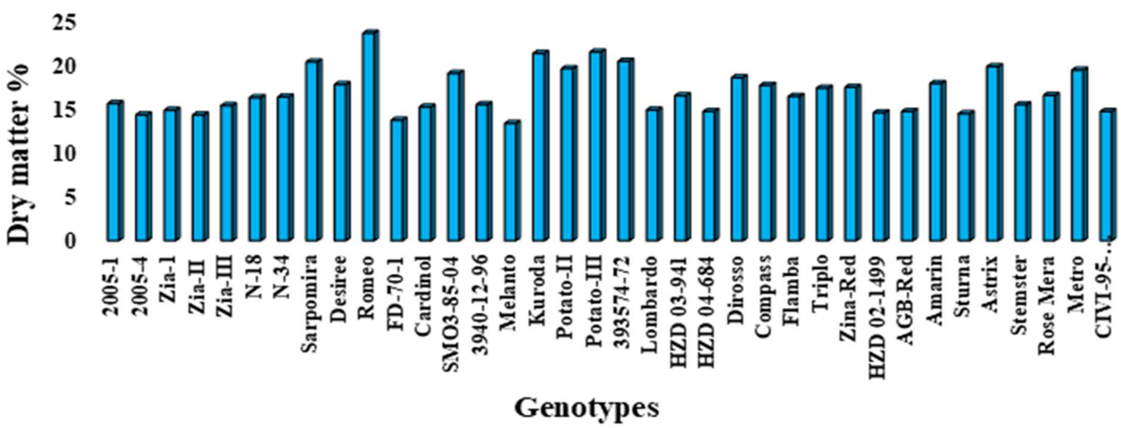

Figure 3: Variation in the dry matter of selected potato germplasms.

Table 2: Mean values of specific gravity, dry matter and total ash contents of selected potato germplasm.

Source of Variation	Degree of freedom	Specific gravity	Dry matter	Total ash
Genotypes	35	2.380**	16.0922**	1.18795 **
Error	36	9.583	0.0236	0.02878
Total	71			

* = Significant (P < 0.05); ** = Highly significant (P < 0.01).

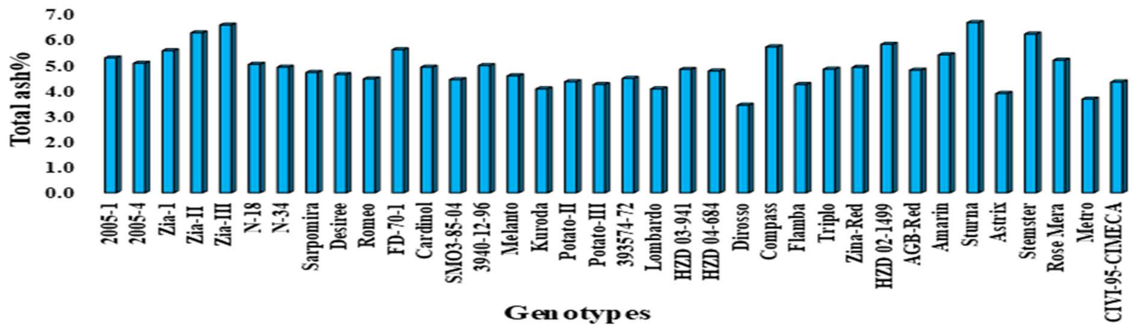

Figure 4: Variation in total ash contents of selected potato germplasms.

Discussion

Potato varieties varied based on specific gravity reported in the present study generally matched with preceding research reports. Previous investigations of six different genotypes of potato showed that the specific gravity ranged from 1.121 to 1.141 [20]. Recent investigation showed that SG mostly lies in the range of 1.064 - 1.094 and 1.078 – 1.10, respectively [21, 22]. Likewise, eight varieties of potato were investigated, where SG value ranged from 1.343 and 1.144. The maximum SG was calculated in NARC 1-2006/1 (1.14) followed by NARC 2002-1 (1.13), while the minimum value for specific gravity was found in NARC 1-2006/2 (1.03) [23]. The small variation found among these results from present studies presumably emanated from temperature changes over time, soil condition, as well as rainfall recorded at different locations and varying conditions in different years at the same location. The specific gravity of potatoes is also affected by variety, maturity time and cultural practices such as irrigation, fertilization etc. [15].

Results of the present study revealed that the dry matter (DM) contents ranged from 14 to 23%. Romeo has the highest DM contents, while Zia-II has the lowest DM contents. Earlier investigations reported that DM contents of potato tubers ranged from 15% to 20.1% in Kufri Ashoka and Kufri Jawahar respectively [24]. The highest dry matter contents for La Molina (24-26%) variety were investigated in another study [17]. The dry matter of thirty-two different potato varieties were estimated, where the results revealed that maximum dry matter was found in NARC 1-2006/1 (25.65%), while NARC 1-2006/2 had minimum dry matter of 14.86%. These six commercial potato varieties were also tested for their chemical composition. Their results on dry weight basis revealed that Lady Rosetta variety produced tubers with maximum dry matter (25.85%) amongst all the tested varieties, while the lowest dry matter (22.95%) was observed in Agria [25]. The dry matter content at Adet, Merawi and Debretabor ranged from 13.96 to 23.45%, 15.24 to 25.84% and 18.88 to 29.25%, respectively [26].

In the present investigation the total ash contents of tested potatoes germplasm lied between 3.42% and 6.65%. The maximum ash contents were recorded in Sturna (6.65%) followed by Zia-III (6.55%), while the minimum ash contents were observed in Dirosso with the value of 3.42%. Results of the present observation supported that the ash contents varied from 1.0 to 2.0% in Diament, Cardinal, Lale-e-Faisal and Desiree cultivars [27]. The total ash contents of different potato varieties grown in district Okara ranged from 3.30 to 1.89% in Agria and Atlantic respectively [28]. Another study demonstrated that the ash contents varied significantly among the tested potato genotypes and ranged from 1.46% to 1.66%. The maximum ash content was observed in SH-5 (1.66%), while the minimum content was observed in FD 19-2 (1.46%) genotype. The highest differences in total ash contents between different potato genotypes may be due to the genotypes difference. The ash contents in different potato cultivars are influenced by some non-genetic factors such as soil condition, climatic condition and environmental condition as well as using different fertilizers etc. [28, 29, 30].

Conclusions

A total of 36 potato varieties were tested for their traits such as specific gravity, dry contents and total ash contents. The specific gravity of these varieties ranged from 1.053 g/cm^3 to1.095 g/cm^3, dry matter content ranged from 13.21%-23.38% and total ash contents of tested potatoes germplasms were found between 3.42-6.65%. The high specific gravity and dry matter contents were observed in varieties Romeo, Potato-III and Kuroda, while the maximum ash contents were recorded in Sturna (6.65%) followed by Zia-III (6.55%) and Zia-II (6.25%). Overall, most of the potato cultivars produced tubers with a dry matter content greater than 18.0% and a specific gravity of 1.070 g/cm^3, which are within the acceptable range for processing.

References

1. Qamar M, Ahmad S, Mirza B, Din M, Hussain I. In-vitro response of true potato seeds (TPS) parents for micro propagation. Sarhad Journal of Agriculture (Pakistan). 2010;26(2). 245-249.
2. Ríos D, Ghislain M, Rodríguez F, Spooner DM. What is the origin of the European potato? Evidence from Canary Island landraces. Crop Science. 2007 May;47(3):1271-1280.
3. Akkale C, Yıldırım Z, Yıldırım MB, Kaya C, Ozturk G, Tanyolaç B. Assessing genetic diversity of some potato (Solanum tuberosum L.) genotypes grown in Turkey using the AFLP marker technique. Turkish Journal of Field Crops. 2010 Jan 1;15(1):73-78.
4. Bedini G, Chakravartula SN, Nardella M, Bandiera A, Massantini R, Moscetti R. Prediction of potato dry matter content by FT-NIR spectroscopy: Impact of tuber tissue on model performance. Future Foods. 2023 Dec 1; 8:100241.
5. Khan FA, Irum S, Erum S, Muhammad A, Nouroz F, Kanwal S. In vivo propagation of potato (Solanum tuberosum l.) cultivars. Asian Journal of Agriculture and Rural Development. 2016;6(11):210-220.
6. FAOSTAT F. Food and agriculture organization of the United Nations. Statistical database. 2013 Jul 20.
7. Mathur A. Studies on phosphorylation status of starch in potato tubers (*Solanum tuberosum* L.) MSc. Thesis, Department of Biotechnology and Environmental Sciences, Thapar Institute of Engineering and Technology, Patiala. 2003;10-14.
8. Kwambai TK, Struik PC, Gorman M. Understanding genotype × environment interactions in potato production to guide variety adoption and future breeding strategies. Potato Research. 2024; 67:663-694.
9. FAOSTAT. Food and Agriculture Organization of the United Nations. http://www.FAO.org. Volume 2009.
10. Thamburaj S, Singh. Textbook of vegetables, tuber crops and spices, Indian Council of Agriculture Research, New Delhi. 2001.
11. Farooq K, Mahmood MM, Sher R, Aman D. Khan AR. Evaluation of CIP potato germplasm for Late blight resistance during summer season in Sharn, Kaghan Valley. Asian Journal of. Plant Sciences. 2002; 1(2):195-196.
12. Lin BH, Yen ST. US potato consumption: Looking ahead to 2020. Journal of Food Products Marketing. 2004 Sep 14;10(2):49-65.
13. Brown CR. Antioxidants in potato. American Journal of Potato Research.

2005; 82:163-175.
14. Hogy P. Fangmeier A. Atmospheric CO enrichment affects potatoes: 2. Tuber quality traits. European Journal of Agronomy. 2009; 30:85-94.
15. Kaur S, Sandhu KS, Aggarwal P. Chlorpropham affects processing quality of potato during storage. International Journal of Vegetable Science. 2012; 18(4):328-345.
16. Freita STD, Pereira EIP, Gomez ACS, Brackmann A, Nicoloso F, Bisognin D. Processing quality of potato tubers produced during autumn and spring and stored at different temperatures. Horticultura Brasileira 2012; 30:91-98.
17. Kabira JN, Lemaga B. Potato processing: Quality evaluation procedures for research and food industry applications in East and Central Africa. Kenya. Agriculture Research Institute, Nairobi, Kenya. 2003:20.
18. Rachappanavar V, Kumar M, Kumar V, Patil VU, Sharma V. Evaluation of processing quality attributes of potato (Solanum spp.) genotypes grown in Mid-Hills of Himachal Pradesh. Potato Research 2023; 67:901-929.
19. Cunniff P. AOAC international. Official methods of analysis of AOAC International. 16th ed. Arlington, VA, USA: AOAC International. 1995.
20. Amoros W, Espinoza, J, Bonierbale M. Assessment of variability for processing potential in advanced potato populations. CIP Program Report. 2000;185-195.
21. Asmamaw Y, Tsegaw T, Seyoum T. Specific gravity, dry matter concentration, pH, and crisp-making potential of Ethiopian potato (*Solanum tuberosum* L.) cultivars as influenced by growing environment and length of storage under ambient conditions. Potato Research. 2010; 53:95-109.
22. Elfnesh F, Tekalign T, Solomon W. Processing quality of improved potato (*Solanum tuberosum* L.) cultivars as influenced by growing environment and blanching. African Journal of Food Science. 2011; 5(6):324-332.
23. Ekin Z. Some analytical quality characteristics for evaluating the utilization and consumption of potato (*Solanum tuberosum* L.) tubers. African Journal of Biotechnology. 2011; 10(32):6001–6010.
24. Uppal DS. 1999. Quality traits and chipping performance of newly released potato varieties. Journal of the Indian Potato Association. 1999; 26:139-142.
25. Abbas G, Farooq K, Hafiz IA, Hussain A, Abassi NA, Shabbir G. Assessment of processing and nutritional quality of potato genotypes of Pakistan. Pakistan Journal of Agriculture Science. 2011; 48(3):169-175.
26. Abebe T, Shermarl W, Thunya T. Evaluation of specific gravity of Potato varieties in Ethiopia as a criterion for determining processing quality. Kasetsart Journal - Natural Science. 2013; 47:30-41.
27. Javed MA, Sarwar M, Ahmad MM, Abbas SMN. Varietal suitability of potatoes for dehydration. Pakistan Journal of Agriculture Science. 1995; 32(1-2):135-139.
28. Abbasi KS, Tariq M, Muhammad G, Sartaj A, Muhammad I. Physico-chemical, functional and processing attributes of some potato varieties grown in Pakistan. African Journal of Biotechnology. 2011; 10(84):19570-19579.
29. Aziz A, Yasin M, Randhawa MA, Yasmin A, Jahangir MA, Sohail M. Nutritional and antioxidant profile of some selected Pakistani potato cultivars. Pakistan Journal of Food Sciences. 2013; 23(2):78-93.
30. Tessema GL, Mohammed AW, Abebe DT. Genetic variability studies for tuber yield and yield attributes in Ethiopian released potato (*Solanum tuberosum* L.) varieties. Peer Journal. 2022; 10: e12860.