RESEARCH ARTICLE Indian Journal of Agricultural Research, Volume 59 Issue 12: 1835-1840 (December 2025)

Estimation of Mineral Content and Physico-chemical Properties of Different Indian Cultivars of Potato

Vidushi Dhaliwal[1], Deven Verma[1], Durlabh[2], Brahmacharimayum Amana Sharma[3], Vishal Thakur[1], Yaman Kumar[1], Kunal Soga[1]

10.18805/IJARe.A-6366

ABSTRACT

Background: This research was carried out at LPU in September 2023 with an aim to identify genetic differences in mineral content, chemical and physical characteristics of fifteen different potato germplasm. This will provide the information regarding the varieties that are rich in nutrients and other essential components, making it easier to choose the right variety for the specific purpose.

Methods: An Induced Coupled Plasma Optical Emission Spectroscope (ICP-OES) was used to determine ten specific minerals (Fe, Zn, B, Ca, P, K, Mn, Mg, S, Cu) and physico-chemical properties such as starch content through anthrone-reagent method whereas, moisture content, flesh color, *etc*. were also analyzed using specific methods.

Result: Analysis revealed that Kufri Uday had the greatest Fe, Zn and Cu content. In contrast, Kufri Chandramukhi displayed greater concentrations of Ca, Mn and P. Kufri Khyati exhibited higher levels of K, while Kufri Jyoti had a higher S content than the other varieties. On the other hand, Kufri Chipsona-1, Kufri Himsona and Kufri Chandramukhi were ranked as the superior kinds for processing due to their greatest levels of dry matter content, specific gravity and starch content.

Key words: Dry matter, ICP-OES, Mineral content, Potato, Specific gravity, Starch content.

INTRODUCTION

Potatoes are believed to be the “King of Vegetables” because they are consumed by a large population throughout the world in many different ways. Additionally, it is considered as a key source of carbohydrates for human beings in various countries. Potato, which became known as the “hidden treasure” during the International Year of Potato in 2008, is a significant source of carbohydrates (such as starch), minerals (iron, calcium, magnesium, manganese), vitamins and protein with a high biological value (Raigond *et al.,* 2020; Vidushi *et al.,* 2022; Deepika *et al.,* 2024).

The potato processing industry is rapidly expanding in India. To be deemed appropriate for processing, potatoes must adhere to certain quality standards, including having low sugar and starch levels and a great amount of dry matter content. Enhancing the dry matter content enhances chips production and crispness and reduces the oil absorption in fried products.

Iron is essential for transporting oxygen in the human body and is incorporated into the heme group. Symptoms are pale complexion and heightened vulnerability to infections. Zinc is a vital component of many key enzymes. Its deficiency leads to inadequate brain development, hair loss, impaired eyesight and abnormalities in taste and smell. Copper is not just an antioxidant but also crucial for properly functioning the central nervous system. Its deficiency may lead to symptoms such as decreased appetite, swelling and joint inflammation. Manganese is an essential component of various enzymes. Manganese deficiencies result in deformities in the bones and impede the production of collagen during the process of wound healing. Potassium is an essential component required by the body for protein synthesis, glucose metabolism and cellular elongation. Moreover, it has been shown that elevated potassium intake reduces urine calcium excretion, nephrolithiasis and osteoporosis. Phosphorus contributes to the preservation of healthy cells, bones and teeth.

The correlation between the rise in agricultural productivity and decrease in the concentration of mineral elements has been established. This is because the rapid development of plants outpaces their capacity to absorb these elements, resulting in a diluting effect. The mineral concentration in plants is influenced by soil composition and genotype. Currently, there is limited data available regarding the genetic variations in the mineral content

[1]School of Agriculture, Lovely Professional University, Phagwara-144 411, Punjab, India.

[2]Government Agriculture College, Tijara, Alwar-301 411, Rajasthan, India.

[3]Hemvati Nandan Bahuguna Garhwal University, Srinagar Pauri Garhwal-246 174, Uttarakhand, India.

Corresponding Author: Deven Verma, School of Agriculture, Lovely Professional University, Phagwara-144 411, Punjab, India. Email: deven.26212@lpu.co.in

ORCID: 0000-0002-4022-8865, 0000-0002-7091-2860

How to cite this article: Dhaliwal, V., Verma, D., Durlabh, Sharma, B.A., Thakur, V., Kumar, Y. and Soga, K. (2025). Estimation of Mineral Content and Physico-chemical Properties of Different Indian Cultivars of Potato. *Indian Journal of Agricultural Research.* **59(12):** 1835-1840. doi: 10.18805/IJARe.A-6366.

Submitted: 20-01-2025 **Accepted:** 18-03-2025 **Online:** 28-04-2025

among different potato varieties in India, which also exhibit varying yield potential. The current research was aimed to analyze the variance in micronutrient content and physico-chemical properties in the flesh of tubers because there are ample of varieties in market, it is very crucial to select those which serves the purpose.

MATERIALS AND METHODS

There were fifteen different varieties of potato *viz.,* Kufri Uday, Kufri Chipsona-1, Kufri Jyoti, Kufri Pukhraj, Kufri Surya, Kufri Lalima, Kufri Lima, Kufri Khyati, Kufri Mohan, Kufri Himsona, Kufri Chandramukhi, Diamond, 5758, 302 and 3797 that are grown in North-Indian plains, were procured from the commercial cold store and were planted in grow bags of size 24 × 40 cm at Lovely Professional University, Punjab in September, 2023. The mixture of soil, vermicompost and cocopeat was prepared in the ratio of 4:3:1 (v/v) for the filling of grow bags. Three separate replications of each of the 15 varieties were carried out simultaneously using completely randomized design (CRD). Each grow-bag contained five- six tubers which were planted 20 cm apart from each other.

The soil mix was analyzed for its pH, EC and mineral content. The pH of the soil mix was neutral (7.0), electrical conductivity (0.18 mmhos/cm) and the Nitrogen (45 mg/kg), Phosphorus (34 mg/kg), Potassium (120 mg/kg), Iron (150 mg/kg), Zinc (1.68 mg/kg), Copper (5.42 mg/kg), Manganese (0.79 mg/kg), Boron (0.64 mg/kg), Sulphur (14 mg/kg), Calcium (254 mg/kg) were available in the soil.

Potato tuber mineral content

A one-gram sample of powder was taken from the dried samples and the crushed samples were then digested with nitric acid (65%) and perchloric acid (70%) mixture (4:1 v/v). After digestion, 5 mL of samples, left in the conical flask, were diluted with double-distilled water to a final volume of 100 mL. An Induced Coupled Plasma-Optical Emission Spectroscope (ICP-OES) was used to measure the mineral concentrations in the acid digest (Andre *et al.,* 2007).

Physical and chemical properties

A range of methods were used to record the physical and chemical characteristics of fifteen distinct varieties of potato tubers. Flesh colour was quantified in accordance with the DUS guidelines (Distinctness, Uniformity and Stability). The analysis of starch was done according to that of Clegg (1956). The usual water displacement technique was used to ascertain the specific gravity (Raj *et al.,* 2011). The dry matter was determined by drying the samples that were weighed in a hot air oven at a temperature of 70±2°C until they reached a constant weight (Singh *et al.,* 2020). The moisture content and ash contents of the samples were also determined and expressed as a percentage (AOAC, 2005). A hand refractometer was used to determine the TSS and the results were expressed as °Brix at a temperature of 20°C using a reference table for temperature (Ranganna, 1986).

The data analysis in the research was conducted using IBM SPSS version 25. One-way analysis of variance, DMRT were used at a significance level of p= 0.05. The results have been reported as the mean±SD.

RESULTS AND DISCUSSION

Mineral content (mg/kg on dry weight basis)

Iron

The iron content of the varieties with the greatest concentration was discovered in Kufri Uday (55.20), followed by Kufri Lalima (52.36) and the lowest in Kufri Chipsona-1 (21.73 mg/kg) on dry weight basis (Table 1). Iron levels over 40 mg/kg were determined in Kufri Surya, Kufri Mohan, Diamond and Kufri Jyoti. The predominant fluctuation was identified within the range of 20 and 56 mg/kg. Brown *et al.* (2010) also demonstrated a higher degree of variability in the iron content of the tubers. Tripathy (2024) also determined the iron content in rice so that the biofortification can be done through breeding to increase the status of the rice grain.

Zinc

The zinc content was greatest in Kufri Uday (42.12), followed by Kufri Jyoti (39.08 mg/kg) and lowest in 302 (21.38) (Table 1). The zinc level in the following potato varieties was determined over 30 mg/kg: Kufri Lalima, Kufri Surya, Diamond, Kufri Lima, Kufri Pukhraj and 5758. The other cultivars had zinc content below 20 mg/kg. Brown *et al.* (2011); Burgos *et al.* (2007) and Rivero *et al.* (2003) studied variations in the zinc level across varieties of potatoes due to genetic variations. They discovered that the concentration of zinc in potato tubers varied between 3 and 37 mg/kg when measured on a dry weight basis.

Boron

The boron content was found to be greatest in Kufri Lima (29.80), followed by Kufri Khyati (25.56) and lowest in Kufri Uday (17.06) (Table 1). The potato tubers exhibited lower boron levels in comparison to other minerals. Every kind had a concentration lower than 30 mg/kg. Pandey *et al.* (2023) also identified the mineral composition of the different potato genotypes.

Copper

According to the statistical analysis, Kufri Uday had the highest copper concentration at 34.00 mg/kg, followed by 302 (31.66) and Kufri Surya with lowest copper value 3.71 mg/kg (Table 1). Many of the varieties were found to have concentrations ranging from 11-25 mg/kg including Kufri Chandramukhi, Kufri Pukhraj, Kufri Mohan, Kufri Khyati, Kufri Chipsona-1, Kufri Himsona and 5758. The remaining varieties had concentrations below 10 mg/kg. Copper is somewhat less abundant in tubers compared to other elements. In their study, Haynes *et al.* (2012) discovered

Table 1: The mineral content of potato tubers by using ICP-OES, expressed in mg/kg, is measured on a dry weight basis.

Varieties	Minerals									
	Iron	Zinc	Boron	Copper	Manganese	Magnesium	Potassium	Phosphorus	Sulphur	Calcium
Kufri Lalima	52.36^{b}±1.02	38.05^{b}±0.18	20.28^{d}±0.19	6.09^{jk}±0.17	18.16^{d}±0.51	1111.66^{b}±1.52	837.66^{d-f}±41.18	340.33^{i}±2.51	1154.66^{d}±1.52	481.33^{k}±1.15
Kufri Uday	55.20^{a}±0.88	42.12^{a}±0.30	17.06^{f}±0.79	34.00^{a}±0.12	13.48^{g}±0.65	1010.66^{b}±14.22	616.00^{h}±3.00	424.00^{g}±3.00	1344.33^{a}±1.52	505.66^{g}±5.50
Kufri Surya	43.46^{e}±0.55	38.25^{b}±0.63	22.04^{c}±0.63	3.71^{m}±0.02	11.34^{h}±0.67	962.00^{c}±4.58	711.66^{i}±2.08	321.33^{j}±3.51	1109.33^{g}±4.50	393.00^{n}±2.00
Kufri Jyoti	44.22^{e}±0.31	39.08^{b}±0.23	21.10^{c-d}±0.79	5.76^{i}±0.01	24.62^{b}±0.89	790.33^{e}±2.51	940.00^{b}±51.09	287.66^{k}±2.51	1494.33^{a}±2.51	453.00^{l}±2.00
Diamond	44.02^{e}±0.45	38.15^{b}±0.63	20.21^{d}±0.51	4.80^{m}±0.03	6.94^{k}±0.34	557.33^{k}±4.16	783.66^{g}±3.05	547.33^{b}±2.08	1177.33^{h}±3.51	597.00^{j}±1.00
Kufri Lima	38.75^{d}±0.26	34.04^{c}±0.56	29.80^{a}±0.43	6.07^{jk}±0.03	6.67^{k}±0.33	610.65^{j}±2.51	512.33^{k}±2.08	266.33^{k}±2.51	1074.66^{m}±3.05	725.33^{i}±4.50
Kufri Chandramukhi	32.46^{j}±0.54	21.63^{h}±0.25	17.74^{e-f}±1.19	13.85^{b}±0.02	26.48^{a}±0.90	576.00^{k}±1.00	1015.00^{a}±100.00	586.66^{a}±1.52	1255.33^{b}±2.08	1084.00^{a}±1.00
Kufri Pukhraj	33.81^{g}±0.24	30.65^{f}±1.19	24.85^{b}±0.80	15.52^{f}±0.02	12.03^{h}±0.54	684.66^{g}±2.51	912.66^{b-c}±0.57	190.00^{n}±7.00	1157.33^{g}±4.04	837.66^{e}±2.51
Kufri Mohan	43.62^{e}±0.26	25.50^{i}±0.33	21.81^{c}±0.80	22.57^{d}±0.01	7.28^{k}±0.38	756.33^{i}±1.52	952.33^{b}±6.50	485.66^{e}±3.05	1369.00^{b}±1.00	1075.00^{b}±2.00
Kufri Khyati	34.26^{g}±0.92	25.82^{i}±0.98	25.56^{b}±0.36	12.16^{h}±0.01	18.51^{c-d}±0.87	648.00^{m}±1.00	1048.00^{a}±2.00	247.00^{m}±2.00	1242.33^{f}±2.51	664.33^{h}±2.08
Kufri Chipsona-1	21.73^{n}±0.24	23.81^{n}±0.25	25.48^{b}±0.96	11.84^{i}±0.01	19.56^{c}±0.34	753.33^{j}±1.52	943.33^{b}±1.52	338.33^{k}±2.51	1147.33^{h}±3.05	937.66^{d}±3.51
Kufri Himsona	31.87^{j}±0.67	26.88^{g}±0.16	18.53^{e}±0.60	17.68^{e}±0.04	15.51^{e-f}±0.46	655.00^{l}±2.00	864.33^{c-d}±1.52	380.00^{e}±7.00	1373.00^{b}±2.00	985.33^{c}±3.05
5758	32.50^{j}±0.19	30.58^{e}±0.84	21.18^{c-d}±0.95	23.46^{c}±0.01	9.50^{k}±0.97	784.66^{g}±1.52	825.33^{d-e}±3.05	169.00^{n}±3.00	1167.33^{g}±2.08	687.33^{g}±8.02
302	22.33^{n}±0.45	21.38^{p}±0.51	21.33^{c-d}±0.26	31.66^{b}±0.01	16.42^{e}±1.71	584.00^{m}±1.00	678.00^{i}±13.07	238.33^{k}±5.03	1327.00^{d}±2.00	567.33^{k}±2.51
3797	29.25^{h}±0.50	23.76^{n}±1.02	18.30^{e-f}±0.82	6.22^{jk}±0.01	14.70^{f-g}±0.24	874.33^{f}±1.52	842.66^{f}±1.52	375.33^{e}±2.51	1237.33^{e}±1.52	426.00^{m}±2.00

that the copper level in tubers was 12 mg/kg, making it the highest among all tubers when measured on a dry weight basis.

Calcium

The calcium content was greatest in the Kufri Chandramukhi, with a concentration of 1084 mg/kg. It was followed by the Kufri Mohan (1075), whereas Kufri Surya variety had the lowest calcium content (393) (Table 1). The varieties that had a content beyond 800 mg/kg were Kufri Pukhraj, Kufri Chipsona-1 and Kufri Himsona, while the other varieties had lower calcium content. Brown *et al.* (2012) and Pandey *et al.* (2023) conducted research on the calcium content found in potato tubers.

Manganese

The manganese content was observed maximum in variety Kufri Chandramukhi (26.48) followed by Kufri Jyoti (24.62) and the minimum content was in variety Kufri Lima (6.67) (Table 1). Manganese is found less in potatoes as compared to iron and zinc. Most of the varieties lied between 11- 20 mg/kg like Kufri Lalima, Kufri Uday, Kufri Surya, Kufri Pukhraj, Kufri Khyati, Kufri Chipsona-1, *etc.* rest of them were below 10 mg/kg. The manganese content found between the average concentrations of 8-14 mg/kg by Haynes *et al.* (2012) on the dry weight basis in the peeled potato tubers.

Magnesium

The magnesium content was found maximum in the potato variety Kufri Lalima (1111.66) followed by Kufri Uday (1010.66) and the minimum was found in the Diamond (557.33) (Table 1). Predominantly, magnesium content was interposed between 550-1112 mg/kg. The concentration of magnesium was also observed by Brown *et al.* (2012) where they determined that the concentration range in the potato tubers, based on dry weight, was between 700 and 1200 mg/kg.

Potassium

Potassium is recorded highest in Kufri Khyati (1048) followed by Kufri Chandramukhi (1015) and lowest was in Kufri Lima (512.33) (Table 1). It is also observed that a few varieties were above 900 mg/kg of potassium content like Kufri Mohan, Kufri Chipsona-1, Kufri Jyoti and Kufri Pukhraj while other varieties were found lower than this value. Pandey *et al.* (2023) examined the phosphorus concentration in several potato genotypes, quantified in relation to the weight of the potato after they were dried.

Phosphorus

Phosphorus needs to be a well-recognized mineral in peeled tubers. As compared to other samples, Kufri Chandramukhi (586.66) and Diamond (547.33) had the greatest levels of phosphorus, while 5758 (169) had the lowest levels (Table 1). Only a limited number of potato types were discovered to have phosphorus levels over 400 mg/kg. Specifically, Kufri Mohan had a phosphorus content

Table 2: Physical and chemical properties of potato tubers.

Varieties	Starch content (%)	Flesh colour	Dry matter (%)	Moisture content (%)	Specific gravity	Ash content (%)	Total soluble solids (OBrix)
Kufri Lalima	10.98^{l}±0.18	White	14.19^{e,f}±1.29	85.81^{e,f}±1.29	1.027^{h}±0.001	0.66^{m}±0.01	5.90^{l}±0.02
Kufri Uday	11.43^{h}±0.18	Yellow	15.22^{d,e}±1.34	84.78^{d,e}±1.34	1.056^{c,d,e,f}±0.002	1.86^{b}±0.03	6.01^{h}±0.00
Kufri Surya	12.21^{g}±0.13	Cream	17.33^{c,d,e}±2.08	82.66^{c,d,e}±2.08	1.075^{b,c,d}±0.011	0.91^{k}±0.01	6.47^{d}±0.02
Kufri Jyoti	13.80^{e}±0.13	Cream	16.66^{c,d,e}±3.05	83.33^{c,d,e}±3.05	1.044^{e,f,g,h}±0.028	1.03^{j}±0.01	5.67^{l}±0.02
Diamond	13.11^{f}±0.13	Cream	22.33^{b}±1.52	77.66^{b}±1.52	1.077^{a,b}±0.021	0.87^{k}±0.01	5.32^{n}±0.01
Kufri Lima	11.31^{h}±0.13	Cream	15.66^{d,e}±1.52	84.33^{d,e}±1.52	1.060^{b,c,d,e}±0.004	0.74^{j}±0.01	5.86^{j}±0.00
Kufri Chandramukhi	17.76^{c}±0.28	White	26.00^{a}±1.00	74.00^{a,b}±1.00	1.079^{a,b}±0.007	2.95^{a}±0.02	6.85^{b}±0.03
Kufri Pukhraj	12.27^{g}±0.22	Yellow	18.00^{c,d}±1.00	82.00^{c,d}±1.00	1.054^{d,e,f,g}±0.010	1.16^{i}±0.03	5.41^{m}±0.01
Kufri Mohan	12.00^{g}±0.22	White	14.33^{e,f}±2.08	85.66^{e,f}±2.08	1.025^{h}±0.001	1.53^{h}±0.03	5.81^{j}±0.01
Kufri Khyati	11.94^{g}±0.13	White- cream	16.12^{c,d,e}±1.19	83.87^{c,d,e}±1.19	1.052^{e,f,g}±0.003	1.66^{c}±0.02	6.25^{f}±0.02
Kufri Chipsona-1	18.81^{b}±0.27	White- cream	25.66^{a}±2.51	74.33^{a}±2.51	1.097^{a}±0.002	1.37^{f}±0.02	6.58^{c}±0.07
Kufri Himsona	19.71^{a}±0.18	Cream	25.33^{a}±1.52	74.66^{a}±1.52	1.073^{b,c,d}±0.016	1.46^{e}±0.02	7.01^{a}±0.00
5758	13.98^{e}±0.13	Yellow	19.25^{c}±1.40	80.74^{c}±1.40	1.036^{f,g,h}±0.003	1.28^{h}±0.01	6.32^{e}±0.00
302	15.72^{d}±0.13	White	15.18^{d,e}±1.73	84.82^{d,e}±1.73	1.045^{e,f,g,h}±0.003	1.32^{g}±0.01	6.07^{g}±0.02
3797	13.08^{f}±0.22	Cream	11.58^{f}±1.01	88.41^{f}±1.01	1.034^{g,h}±0.003	1.12^{j}±0.02	5.73^{k}±0.01

of 485.66 mg/kg, while Kufri Uday had 424 mg/kg. All other varieties had phosphorus levels below this threshold. Pandey *et al.* (2023) observed the variation in phosphorus content in several potato genotypes.

Sulphur

Sulphur is an essential element for human health. The concentration of this element was greatest in Kufri Jyoti (1494.33), followed by Kufri Himsona (1373.00) and minimum in Kufri Lima (1074.66). The differences in concentration between varieties were statistically significant, as shown in Table 1. A study done by Brown *et al.* (2012), determined that the levels of sulphur in potato tubers varied from 1169 to 1408 µg/g on dry weight basis.

Physical and chemical properties

Starch content

It is found that Kufri Himsona (19.71%) and Kufri Chipsona-1 (18.81%) found to have the highest and Kufri Lalima (10.98%) the lowest starch content among the 15 varieties (Table 2). According to Salunkhe *et al.* (1991), the primary component of potato is comprised of starch, which accounts for 65-80% of its dry matter. The variance in starch content might be ascribed to the fact that various cultivars of potatoes have variable amounts of dry matter.

Flesh colour

The flesh colour of various potato varieties ranged from white to yellow. It is found that the Kufri Lalima, Kufri Mohan and 302 have white flesh colour while yellow flesh-coloured varieties were Kufri Uday, Kufri Pukhraj and 5758; remaining varieties were cream and white-cream coloured (Table 2). Previous studies have also shown similar findings regarding flesh colour (Gaur *et al.,* 1999). The colour of the flesh of a tuber greatly influences its economic worth as it is a highly prized characteristic in the processing sector. Prior research has shown that the pigmentation of potato tubers is affected by the levels of carotenoids and anthocyanins (Nesterenko and Sink, 2003). The presence of lesser quantities of carotenoids is indicated by white-coloured tuber flesh, whereas the presence of high carotenoid content results in yellow colour (Zhang *et al.,* 2009).

Dry matter content

The dry matter was highest in Kufri Chandramukhi (26%) followed by Kufri Chipsona-1 (25.66%) and Kufri Himsona (25.33%), whereas line 3797 (11.58) were found to be the lowest (Table 2). The dry matter content of potatoes is a crucial factor in potato processing. A greater dry matter content results in reduced absorption of oil, a desired texture and improved yields in the final products (Marwaha, 1997). There is a significant degree of variation across cultivars when it comes to the quantity of dry matter that is present in tubers, as stated by Abbas *et al.* (2011). Amin *et al.* (2021) also found variations in dry matter in several genotypes of potato.

Moisture content

The moisture content was found minimum in Kufri Chandramukhi (74%), Kufri Chipsona-1 (74.33%) and Kufri Himsona (74.66%) and maximum in line 5797 (88.41%) followed by Kufri Lalima (85.81%) (Table 2). The observed disparity in moisture content may be attributed to the distinct varietal traits. High moisture content in potato tubers is an undesirable trait as it affects shelf life of tubers, less recovery of dry matter in processing industry, *etc*. The moisture contents of potato tubers from various cultivars align with results published by Rai and Verma (1989) and Raj *et al.* (2007).

Specific gravity

Specific gravity was found maximum in Kufri Chipsona-1 (1.097) followed by Diamond (1.077) and Kufri Chandramukhi (1.079) whereas, minimum in Kufri Lalima (1.027) (Table 2). These variances may be attributed to genetic variability among various cultivars. Prior studies have shown similar findings for several types of potato cultivars Sandhu and Parhawk (2002). It has been observed that cultivars that have a high specific gravity have a higher percentage of dry matter content. In contrast, cultivars with a low specific gravity had a lower dry matter content (Abbas *et al.,* 2011).

Ash content

The ash content in this study ranged between 0.65% (Kufri Lalima) and 2.96% (Kufri Chandramukhi) (Table 2). Data are consistent with the findings of Nesterenko and Sink (2003) published for different potato varieties. It is possible that genotype is responsible for the variance in ash content.

Total soluble solids

The total soluble solids of several cultivars varied between 5.41 and 7.01 ^{o}Brix, with the highest TSS observed in Kufri Himsona and the lowest in Kufri Pukhraj (Table 2). The values of total soluble solids that were found in cultivars were somewhat higher than those that were reported in earlier investigations by Sandhu and Parhawk (2002) and Sandhu *et al.* (2002). The increase might be ascribed to a greater concentration of soluble proteins and vitamins.

CONCLUSION

Given that the present per capita potato intake in India, which stands at about 23 kg on fresh weight basis, it is crucial to acknowledge that potatoes provide essential mineral nutrients to the diet. This investigation determined that Kufri Uday had the highest levels of iron, zinc and copper and a significant amount of magnesium, potassium and sulphur. On the other hand, Kufri Chandramukhi had higher levels of calcium, manganese, potassium and phosphorus. But Kufri Jyoti revealed greater sulphur content compared to the other varieties. Conversely, Kufri Chipsona-1, Kufri Himsona and Kufri Chandramukhi were the top processing varieties because they had the greatest levels of dry matter content, starch content and specific gravity. By prioritizing the nutritional values of crop, it is possible to achieve large improvements *via* various breeding strategies.

ACKNOWLEDGEMENT

This research was supported by Lovely Professional University, Punjab.

Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect loss resulting from the use of this content.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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