Original scientific paper
Journal of Central European Agriculture, 2025, 26(3), p.656-666

DOI: /10.5513/JCEA01/26.3.4450

Anti-nutrient properties of different potato (*Solanum tuberosum* L.) and physicochemical properties of their extracted starches

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Received: July 5, 2024; accepted: July 1, 2025

ABSTRACT

This research characterized the isolated starches and calcium oxalate content of seven different potato tuber samples: BARI Alu-72, BARI Alu-77, BAU Alu-1, BAU Alu-3, BAU Alu-4, BAU Alu-5, and BAU Alu-7. The composition of the isolated starches was determined through proximate analysis, revealing significant differences ($P<0.05$) among the samples. The highest starch yield was observed in BAU Alu-7 (2.51%), while the lowest was in BARI Alu-77 (1.85%). Moisture content ranged from the lowest in BARI Alu-77 (2.84%) to the highest in BAU Alu-5 (5.46%). Ash content varied, with the lowest recorded in BAU Alu-1 (0.12%) and the highest in BARI Alu-72 (0.75%). The highest pH was recorded in BARI Alu-72 (6.15), while BAU Alu-3 exhibited the lowest pH (5.91). WHC varied significantly among the samples, with BAU Alu-3 displaying the highest value (30.97%) and BAU Alu-4 showing the lowest (12.61%). The highest calcium oxalate content was observed in BAU Alu-7 (543.05 mg/100 g), while the lowest was recorded in BAU Alu-3 (526.52 mg/100 g), suggesting a high level of anti-nutrients, which may make these potatoes unsuitable for raw consumption. However, processing techniques such as boiling, soaking, or fermentation may help to reduce calcium oxalate levels, making them more suitable for consumption. Future research should explore the optimization of such processing methods to enhance the nutritional quality and usability of these potato varieties in food production.

Keywords: potato, tuber, starch, calcium oxalate, anti-nutrients

INTRODUCTION

A balanced diet plays a crucial role in preventing chronic illnesses and promoting overall well-being. In recent years, there has been a growing demand for functional foods that can provide essential elements for a nutritious meal (Vignesh et al., 2024). Consumers have increasingly recognized the proliferation of plant-based products in the rapidly expanding food market (Cruz and Boukid, 2024). Fruits and vegetables are rich sources of dietary fiber, abundant proteins, bioactive compounds, sterols, and polyunsaturated fatty acids, which benefit specific bodily processes (Wang et al., 2023).

Potatoes (*Solanum tuberosum* L.) are the third most important food crop in Bangladesh, following rice and wheat (Paul et al., 2023). They serve as a major source of carbohydrates, vitamins, and minerals for the population, with a production of over 10 million metric tons annually (Li et al., 2024). The crop is widely cultivated across different agro-ecological zones, with multiple local and improved varieties growing to meet the rising demand for fresh consumption and industrial processing (Rana and Jhilta, 2021). Potatoes supply essential nutrients such as carbohydrates, dietary fiber, potassium, magnesium, and iron, as well as vitamins B and C, crucial for maintaining healthy bodily functions and reducing the risk of chronic and acute ailments (Paik et al., 2024). They contain bioactive compounds like phenolic acids, anthocyanins, and glycoalkaloids, which have health-promoting properties, including antioxidant effects and potential roles in preventing diseases like heart disease, diabetes, and cancer (Kaur et al., 2024). Biofortification efforts have enhanced the nutritional quality of potatoes, increasing the concentration of micronutrients like zinc and iron, which are crucial for addressing deficiencies in populations with limited access to diverse diets (Rashid et al., 2024). The phytochemical makeup of potato tubers is influenced by various factors, including the genetic background and environmental conditions (Solovyeva et al., 2024). Potatoes thrive in temperate climates and can be cultivated in many regions of the nation during the winter season, given optimal conditions such as well-drained soil, sufficient sunlight, and soil moisture (Berdugo-Cely et al., 2023).

However, potatoes' nutritional quality and safety, particularly their anti-nutrient content, remain an area of concern. Potatoes contain certain anti-nutrients, such as glycoalkaloids (e.g., α-solanine and α-chaconine), protease inhibitors, lectins, phytic acid, and calcium oxalate, which can interfere with nutrient absorption and digestion (Bhatt and Tiwari, 2024; Tiwari and Dubey, 2025). Among them, calcium oxalate can bind to minerals like calcium, reducing its bioavailability and potentially leading to kidney stone formation in susceptible individuals (Levy-Lior et al., 2003). The levels of this anti-nutrient vary depending on genetic factors, environmental conditions, and post-harvest handling of potatoes (Khan et al., 2023).

The presence of this anti-nutrient in potatoes has several potential health implications. Calcium oxalate stones account for more than 80% of kidney stones, highlighting the significant role of oxalate in stone formation (Allam, 2024; Chen et al., 2023).

Oxalate can bind with calcium in the urine to form insoluble crystals, which aggregate to form stones (Wesson, 2025). Hyperoxaluria, an elevated level of oxalate in the urine, is a major risk factor for calcium oxalate stone formation (Bao et al., 2023; Grocholski et al., 2023). High dietary oxalate intake is associated with an increased risk of stone formation, particularly in individuals with low dietary calcium intake (Chew et al., 2012). Metabolic disorders, such as primary hyperoxaluria, lead to excessive endogenous oxalate production, further increasing the risk of stone formation (Chew et al., 2012; Grocholski et al., 2023). Oxalate's ability to bind calcium reduces the bioavailability of this essential mineral, potentially leading to deficiencies if dietary calcium intake is not sufficient (Nayagam and Rajan, 2021).

The presence and concentration of this compound influence the nutritional quality and safety of potatoes as a staple food. Excessive levels of anti-nutrients can pose health risks, especially for individuals with conditions such as kidney disorders, digestive sensitivities, or nutrient deficiencies (Kamalasundari et al., 2019). Understanding the variation in anti-nutrient content among different potato varieties can help in selecting cultivars with lower levels of these compounds for improved consumption safety. Additionally, processing techniques such as peeling, cooking, and soaking can significantly reduce anti-nutrient levels, making it important to assess how different varieties respond to these treatments (Ngungulu et al., 2024).

In recent years, there has been an increasing interest in potato starch extraction for use in food, pharmaceuticals, and industrial applications. Moreover, potato starch is a high-quality carbohydrate polymer extensively used in food, pharmaceutical, textile, paper, and adhesive industries (Tong et al., 2023). It is known for its high water-binding capacity, excellent gelatinization properties, and desirable pasting behavior, making it a preferred ingredient in food processing and industrial applications (Fan et al., 2024). The physicochemical characteristics of starch vary significantly depending on botanical source, environmental conditions, processing methods, and the presence of intrinsic compounds, including anti-nutrients (Yuan et al., 2024).

In Bangladesh, the demand for locally produced potato starch has been increasing due to its potential applications in the bakery, confectionery, noodle, and processed food industries, as well as in biodegradable packaging and pharmaceutical formulations (Mhaske et al., 2024). Despite the economic and industrial significance of potato cultivation in Bangladesh, limited research has been conducted on the anti-nutrient content of different local potato varieties and its physicochemical characteristics of extracted starch. A comprehensive analysis of these factors is essential for improving potato utilization in food and non-food sectors.

Therefore, this research aimed to conduct a comparative investigation of anti-nutrient properties of different potato varieties and physicochemical properties of their extracted starches.

MATERIAL AND METHODS

Tuber selection

This research used seven purple potato varieties (Figure 1), namely BAU Alu-4, BARI Alu-77, BAU Alu-7, BARI Alu-72, BAU Alu-5, BAU Alu-3, and BAU Alu-1. Experiments were conducted at the Department of Nutrition and Food Engineering, Daffodil International University, Dattapara, Ashulia, Dhaka, Bangladesh.

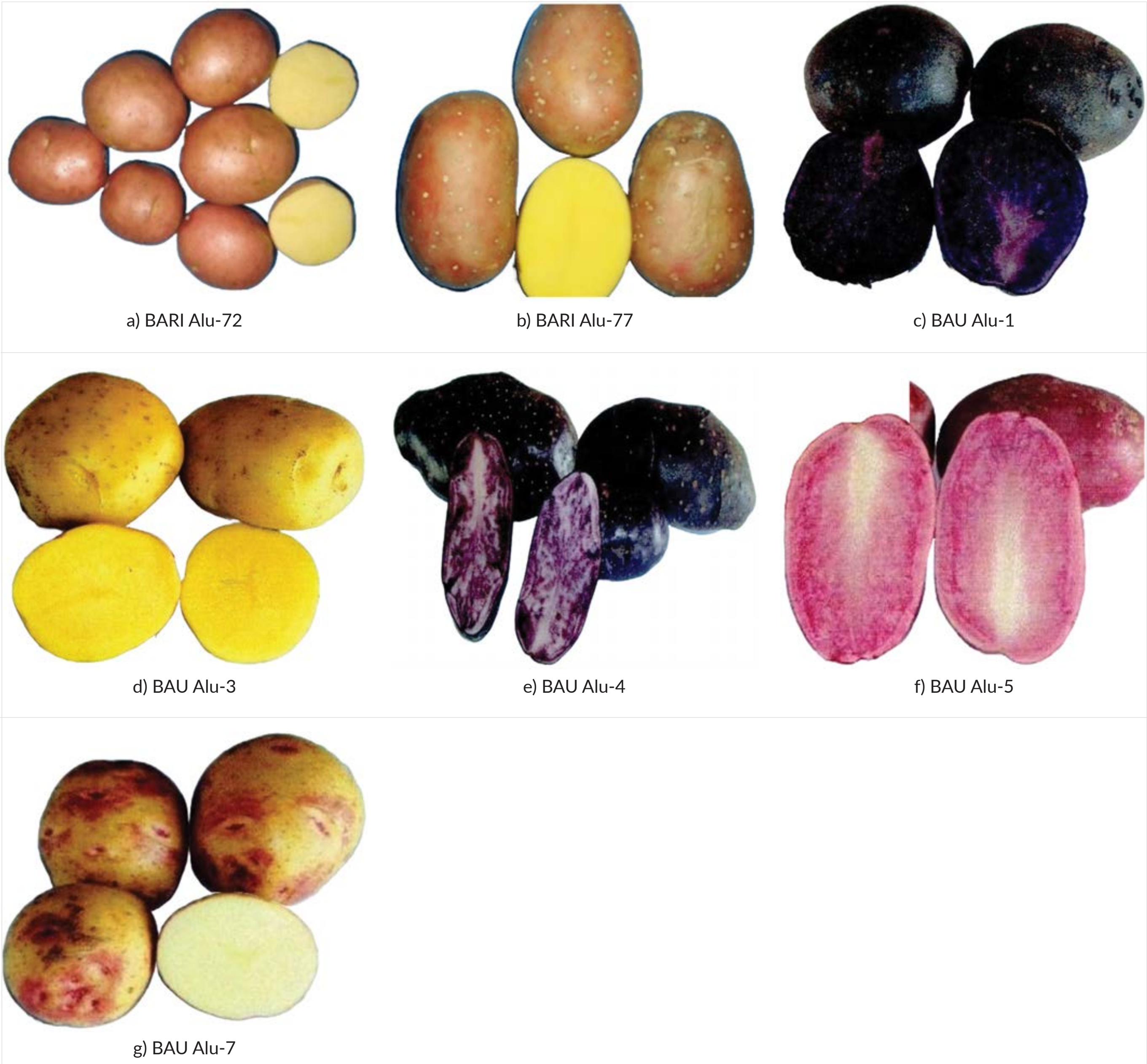

a) BARI Alu-72 b) BARI Alu-77 c) BAU Alu-1
d) BAU Alu-3 e) BAU Alu-4 f) BAU Alu-5
g) BAU Alu-7

Figure 1. Seven different potato (*Solanum tuberosum* L.) varieties; a) BARI Alu-72, b) BARI Alu-77, c) BAU Alu-1, d) BAU Alu-3, e) BAU Alu-4, f) BAU Alu-5, g) BAU Alu-7

The tuber samples were collected from plots situated in a randomized complete block design with three replications in two sites. Tubers were collected 160 days after seeding at Bangladesh Agriculture University, located on BAU Main Road in Mymensingh, Bangladesh, as well as at Bangladesh Agricultural Research Institute (BARI) in Joydebpur, Garipur, Bangladesh, after they had achieved commercial maturity. From each site, a 2 kg sample of undamaged and disease-free tubers was collected. The samples were placed in a plastic zip bag, appropriately labelled, and sent to the Nutrition and Food Engineering laboratory.

Sample preparation

For each experiment, 2 to 3 typical tubers were selected. These tubers were washed thoroughly with water to remove any remaining soil particles and then sliced into three longitudinal pieces. Additionally, five slices were collected from each portion and then cut them into small squares.

Starch isolation

The starches from seven potato varieties, namely BAU Alu-4, BARI Alu-77, BAU Alu-7, BARI Alu-72, BAU Alu-5, BAU Alu-3, and BAU Alu-1, respectively, were extracted using the traditional method as described by Ascheri et al. (2014) with slight modification (Figure 2).

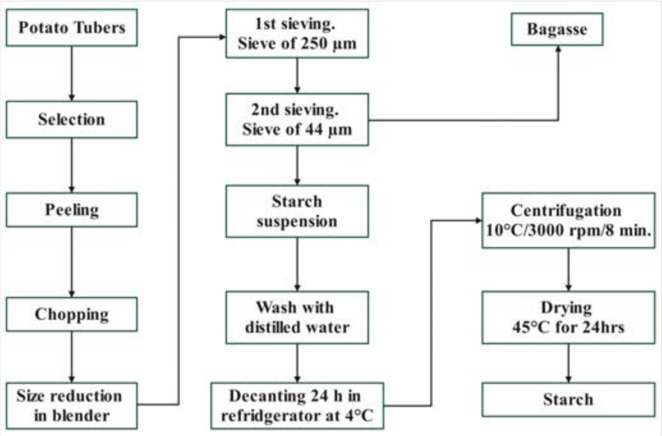


Figure 2. Flowchart of starch extraction from different potato cultivars (*Solanum tuberosum* L.) using distilled water as the extraction solvent

In this study, after peeling and chopping, the tubers were subjected to size reduction using a blender instead of a manual grating process to ensure uniform particle size. The blended potato slurry was then passed through two sequential sieves (250 μm and 44 μm) to remove fibers and larger residues. The starch suspension was washed with distilled water to remove residual impurities and then subjected to decantation at 4 °C for 24 hours to facilitate starch sedimentation. The collected starch was further purified through centrifugation at 10 °C and 3000 rpm for 8 minutes. The final starch precipitate was dried at 45 °C for 24 hours to obtain a powdered form. The percentage of extraction yield was calculated using the method described by Hasmadi et al. (2021). In this method, the yield of starch extracted from potato tubers is calculated based on the ratio of the weight of the dried extracted starch to the initial weight of the raw potato tubers, expressed as a percentage. The calculation is performed using Equation (1).

$$Extraction\ Yield\ (\%) = \frac{Weight\ of\ extracted\ starch\ (g)}{Weight\ of\ fresh\ potato\ tubers\ (g)} \times 100 \tag{1}$$

Proximate composition analysis

The proximate composition of potato and starch was determined as methods described by AOAC (2016). The determination of moisture content in starch using the AOAC 2016 method begins with pre-drying a moisture dish in an oven at 105 °C for 30 minutes to remove any residual moisture. The dish is then cooled in a desiccator and weighed. Next, 2 g of the starch sample is accurately weighed into the dish, and the total weight was recorded. The sample was then placed in a hot-air oven at 105 °C until a constant weight is achieved. After drying, the sample was cooled in a desiccator for 30 minutes and weighed again. The moisture content was calculated using Equation (2).

$$Moisture\ content\ (\%) = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \tag{2}$$

where, W_1 = Weight of the empty moisture dish (g), W_2 = Weight of dish + fresh starch sample (g), W_3 = Weight of dish + dried starch sample (g).

The ash content of starch was determined by a muffle furnace. A clean crucible was preheated in a muffle furnace at 550 °C for 30 minutes to remove any contaminants. The crucible is then cooled in a desiccator and weighed. A 2 g dried starch sample was added to the crucible, and the total weight was recorded. The sample was then incinerated in the muffle furnace at 550 °C for 6 hours. Once ashing is complete, the crucible is removed, cooled in a desiccator, and weighed again. The ash content was calculated using Equation (3).

$$Ash\ content\ (\%) = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \qquad (3)$$

where, W_1 = Weight of the empty crucible (g), W_2 = Weight of crucible + starch sample before ashing (g), W_3 = Weight of crucible + ash residue (g).

Functional properties analysis

Water holding capacity (WHC) was determined according to the method of Jiang et al., (2012). A centrifuge tube with 0.5 grams of sample was weighed, 10 ml of distilled water was added, and the sample was vortexed for 1 min. After that, the sample was stood for 30 min with intermediate shaking for 5 s every 10 minutes. The content was then centrifuged at 3000 rpm for 25 minutes. The tube was weighed again after decanting the supernatant. Water holding capacity (WHC) was calculated using Equation (4).

$$WHC\ (\%) = \frac{Water\ bound\ (g)}{Initial\ sample\ weight} \times 100 \qquad (4)$$

The determination of pH reported by AOAC (2016) in starches using a pH meter Hanna HI 8424 involves a simple procedure of calibration and measurement. Starch suspensions (1 g starch in 10 mL distilled water) were stirred for 5 minutes, and the pH was recorded after calibration of the pH meter with standard buffer solutions of pH 4, 7, and 10.

Anti-nutrient contents analysis

Calcium oxalate content for the starches was determined as the method described by Kumar et al. (2017) and expressed as mg/100 g. A 0.5 N sulfuric acid (H_2SO_4) solution (30 mL) was added to 0.5 g of the sample in a test tube and heated in a water bath at 100 °C for 15 minutes. The mixture was then filtered using Whatman No. 41 filter paper and rinsed with 30 mL of distilled water. Next, 10 mL of the filtrate was combined with 40 mL of 0.5 N H_2SO_4 and heated at 100 °C for 5 minutes. The sample was then immediately titrated with 0.05 N potassium permanganate ($KMnO_4$) until a light red color indicated the titration endpoint. Before analysis, the 0.05 N $KMnO_4$ solution was standardized. This was done by dissolving 0.0405 g of oxalic acid dihydrate ($C_2H_2O_4 \cdot 2H_2O$) in 30 mL of 0.5 N H_2SO_4 in a test tube and heating it at 100 °C for 5 minutes. The standard solution was then titrated with 0.05 N $KMnO_4$ until the endpoint was reached, as indicated by a light red color. The procedure was repeated in triplicate. Calcium oxalate content was calculated using Equation (5).

$$Calcium\ oxalate\ conten\ (\%) = \frac{V \times N \times MW \times df}{W_s} \qquad (5)$$

where: V = titration volume in mL, N = Normality of $KMnO_4$, MW = Molecular weight of Calcium oxalate, df = dilution factor, W_s = weight of sample (g).

Statistical analysis

Data were analyzed using IBM SPSS 26 (Armonk, 2020). One-way ANOVA was applied to determine significant differences among samples, followed by Tukey's post-hoc test to compare means at a significance level of $P<0.05$. All experiments were conducted in triplicate, and results were reported as mean ± standard deviation (SD).

RESULTS AND DISCUSSION

Proximate composition

The purpose of this study was to characterize the physicochemical and functional properties of starches isolated from seven different potato tuber cultivars. The results of the proximate composition of different starches are presented in Table 1. Starch content ranged from 1.85% to 2.51% in the samples. At 2.51%, BAU Alu-7 had the most starch, whereas BARI Alu-77 had 1.85%. Research on different potato cultivars has shown that starch content can range from as low as 12.44% in some varieties to as high as 20.19% in others, such as the Ishcupuru variety (Ignacio-Cardenas et al., 2020). In a study of potato hybrids, starch content was found to be not less than 16% in several hybrids, with one hybrid having a starch content of more than 18.22% (Semenova et al., 2022). Another study focusing on the physicochemical properties of potato starches in Brazil reported significant variations in starch content among different cultivars, further supporting the notion that starch content was generally higher than our findings (Garcia et al., 2019).

Table 1. Proximate composition of seven different potato starches

Sample	Yield	Proximate Composition of Potato Starch	
	Starch Content %	Moisture %	Ash %
BARI Alu-72	1.97 ± 0.01^{b}	3.94 ± 0.06^{c}	0.75 ± 0.02^{f}
BARI Alu-77	1.85 ± 0.01^{a}	2.84 ± 0.02^{a}	0.44 ± 0.02^{e}
BAU Alu-1	2.35 ± 0.01^{e}	3.56 ± 0.02^{b}	0.12 ± 0.01^{a}
BAU Alu-3	2.21 ± 0.01^{d}	4.28 ± 0.03^{d}	0.31 ± 0.02^{c}
BAU Alu-4	1.98 ± 0.01^{b}	4.84 ± 0.04^{f}	0.37 ± 0.01^{d}
BAU Alu-5	2.11 ± 0.01^{c}	5.46 ± 0.02^{g}	0.23 ± 0.02^{b}
BAU Alu-7	2.51 ± 0.01^{f}	4.55 ± 0.02^{e}	0.44 ± 0.01^{e}

Letters within the column indicate a significant difference ($P<0.05$)

The productivity and efficiency of potato tuber starch extraction depend on starch concentration variation. Industrial applications that value starch production depend on starch concentration (Altemimi, 2018). The samples also had moisture levels of 2.84% in BARI Alu-77 and 5.46% in BAU Alu-5. High moisture levels may affect starch storage and longevity. BARI Alu-77's 2.84% moisture content may help preserve stored items and reduce microbial growth (Xia et al., 2018). The moisture content of native potato starch is typically around 4.5% as reported in studies focusing on the extraction and characterization of starches from different sources (Usman et al., 2022). When potato starch undergoes heat-moisture treatment, the moisture content can be adjusted to specific levels to achieve desired physicochemical properties. For instance, optimal heat-moisture treatment conditions have been reported at a moisture content of 23.56% (Deng et al., 2022). Other studies have explored moisture contents ranging from 12% to 24% during heat-moisture treatment, showing significant effects on the starch's properties (Bartz et al., 2017). In treatments involving electron beam irradiation, the initial moisture content of potato starch has been varied between 11.74% and 29.84% to study its effects on digestibility and structural changes (Nguyen et al., 2021)

Ash concentration, which indicates mineral composition, varied from 0.12% in BAU Alu-1 to 0.75% in BARI Alu-72. BAU Alu-1 has the lowest ash percentage, 0.12%, making it ideal for low-mineral applications. Ash may reduce the purity and quality of starch used in cooking and industry (Lizarazo et al., 2015).

A study found that starch extracted using a combination of physical, chemical, and enzymatic methods had an ash content of 0.26% (Neeraj et al., 2021). When compared to other plant foods, potato starch generally has a lower ash content. For example, roots and tubers, including potatoes, typically have ash content ranging from 1.18% to 1.38% (Deepika et al., 2024).

Functional properties

The water absorption capacity and pH of seven different potato types were investigated and recorded in Table 2. Water absorption capacity refers to the starch's propensity to absorb water and expand, resulting in enhanced consistency in meals. Enhancing production and uniformity, as well as providing substance to food, is highly sought after in food systems. Water holding capacity (WHC) is a crucial functional attribute that has an impact on the texture, longevity, and sensory experience of food items (S. Wang et al., 2020). The water holding capacity (WHC) of the potato starch samples showed substantial variation, with BAU Alu-3 exhibiting the greatest WHC (30.97%) and BAU Alu-4 having the lowest WHC (12.61%). BAU Alu-3 (30.97%) and BAU Alu-1 (27.89%) had the greatest water holding capacity (WHC). Having a high-water holding capacity (WHC) is advantageous in gluten-free recipes as it enhances the ability of the final product to retain water and improves its texture (Horstmann et al., 2018). It is important to mention that earlier research has shown greater capabilities (Mbougueng et al., 2015; Yang et al., 2018; Zhang et al., 2021), indicating that the cultivars examined in this study had abnormally low water holding capacities.

Table 2. Functional properties of potato starches

Sample	pH	WHC %
BARI Alu-72	6.15 ± 0.01^{f}	14.37 ± 0.01^{b}
BARI Alu-77	6.05 ± 0.01^{de}	14.66 ± 0.01^{c}
BAU Alu-1	6.03 ± 0.01^{d}	27.89 ± 0.01^{f}
BAU Alu-3	5.91 ± 0.01^{a}	30.97 ± 0.01^{g}
BAU Alu-4	6.07 ± 0.01^{e}	12.61 ± 0.01^{a}
BAU Alu-5	5.98 ± 0.01^{c}	16.03 ± 0.01^{e}
BAU Alu-7	5.95 ± 0.01^{b}	14.75 ± 0.01^{d}

Letters within the column indicate a significant difference ($P<0.05$). WHC – water holding capacity.

The pH of the starch samples ranged from 5.91 (BAU Alu-3) to 6.15 (BARI Alu-72), aligning with the standard pH range of 5.5–6.5 for potato starches (Bemiller, 2011). This near-neutral pH suggests that these starches are chemically stable and suitable for various food processing applications. The pH level of starch has a crucial role in influencing the gelatinization process, enzyme activity, and the overall stability of starch in different applications (Bemiller, 2011). Cultivated potato varieties generally exhibit a pH range from 5.5 to 6.2, which is considered standard for potato starch (Kiszonas and Bamberg, 2010). Wild *Solanum species* have been reported to have lower pH values, with *Solanum microdontum* showing an average pH of 5.17 and the lowest observed reading of 4.99 (Kiszonas and Bamberg, 2010). The pH of potato starch can be influenced by the soil pH where the potatoes are grown. Tubers grown in more acidic soils (pH 5.64-6.05) tend to have higher starch content compared to those grown in neutral or alkaline soils (Werner, 1933). Environmental conditions such as soil pH and storage duration can influence the pH of potato starch. Long storage generally does not significantly affect the pH of wild species tubers, except for *S. jamesii*, which showed a reduction from 5.78 to 5.54 (Kiszonas and Bamberg, 2010). The processing and preparation methods of potato starch can also alter its pH. The pH of potato flour films can vary significantly depending on the pH of the film-forming dispersion, with pH values tested from 3 to 11 (Fu et al., 2024).

Anti-nutrient contents

The calcium oxalate content as an anti-nutrient in raw potatoes was determined. The results are listed in Table 3. The calcium oxalate concentration showed significant variability across the samples, with levels ranging from 526.52 mg/100 g in BAU Alu-3 to 543.05 mg/100 g in BAU Alu-7 (Figure 3). The observed disparities suggest that both genetic and environmental variables have an impact on the amounts of oxalate in potato tubers (Kumar and Belur, 2018). BAU Alu-3 had the minimal amount of calcium oxalate, measuring at 526.52 mg/100 g. The calcium oxalate content was highest in BARI Alu-72 (537.24 mg/100 g), BARI Alu-77 (537.17 mg/100 g), and BAU Alu-7 (543.05 mg/100 g).

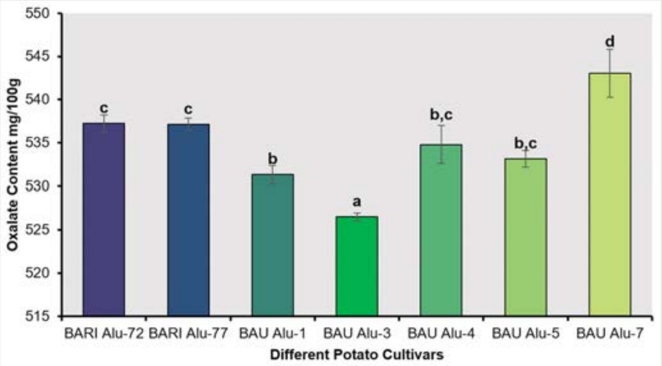
Table 3. Calcium oxalate content in different edible potato tubers

Sample	Oxalate content
BARI Alu-72	537.24 ± 0.99^{c}
BARI Alu-77	537.17 ± 0.73^{c}
BAU Alu-1	531.34 ± 1.06^{b}
BAU Alu-3	526.52 ± 0.46^{a}
BAU Alu-4	534.82 ± 2.22^{bc}
BAU Alu-5	533.17 ± 0.98^{bc}
BAU Alu-7	543.05 ± 2.75^{d}

The results are shown as the average ± standard deviation, with a sample size of 3. The lowercase characters a, b, c, and d, rewritten in the same column, exhibit a statistically significant difference ($P<0.05$) according to Tukey's test.

The elevated levels of oxalate in these potatoes might be problematic for persons who are susceptible to kidney stones or have special dietary limitations (O'Kell et al., 2017). The variation in calcium oxalate levels across the potato tuber samples highlights the need to choose suitable cultivars for eating and processing. Boiling, soaking, and fermenting are processing techniques that may decrease the amount of oxalate in potatoes, hence improving their nutritional value and safety (Liu et al., 2018).

The calcium oxalate content of the potato samples is concerning (Figure 3), as high calcium oxalate consumption is associated with kidney stone formation and reduced calcium bioavailability (SIENER et al., 2021; Zainodini et al., 2023). Comparison with previous studies reveals that the calcium oxalate levels observed in this study are higher than those reported in some commercial potato cultivars but comparable to levels found in other starchy tubers such as taro and yam (Zi et al., 2024). Potatoes (*Solanum tuberosum* L.) have been found to contain significant levels of oxalate, with a concentration of 216.9 mg/50 g, making them one of the vegetables with higher oxalate content compared to others like cauliflower and tomato (Roshini, 2021). This suggests that these potato cultivars may pose similar health risks if consumed in excess or without appropriate processing.



The bars represent the mean oxalate content, with error bars indicating standard deviation. Different letters above the bars denote statistically significant differences (*P*<0.05) among the cultivars.

Figure 3. Oxalate content (mg/100 g) in different potato cultivars

In Kimpul taro flour, physical treatments such as boiling and steaming, especially with activated charcoal, significantly reduce calcium oxalate levels, with the lowest levels recorded at 25.82 mg/100 g (Noviasari et al., 2024). Elephant foot yam has been found to have high oxalate content, which can be reduced by various methods, including ultrasound-assisted techniques, achieving a reduction of up to 43.2% (Srivastava et al., 2024). Purple yam also contains high levels of calcium oxalate, which can be reduced by soaking in NaCl solution, with a reduction of 22.89% achieved at optimal conditions (Rofi'ana et al., 2018). Boiling has been shown to reduce soluble oxalate content in vegetables by 30-87%, which is more effective than other cooking methods like steaming or baking. This reduction is due to the leaching of oxalates into the cooking water, which can then be discarded, effectively lowering the oxalate content in the consumed food (Chai and Liebman, 2005). In spinach, a common high-oxalate vegetable, boiling for extended periods can lead to a significant reduction in oxalate levels. Boiling spinach for 8 hours resulted in a 26% reduction of calcium oxalate, with changes in the crystal structure of oxalate compounds observed over time (Ishii, 1991).

Soaking raw potatoes in water, acidic solutions (e.g., lemon juice), or salt solutions can significantly reduce oxalate content before cooking. Acidic solutions, such as lemon juice or citric acid, are effective in reducing oxalate levels. The acidity helps to break down oxalate compounds, making them more soluble and easier to remove. In a study on taro, a 5% citric acid solution reduced calcium oxalate levels by 41.75%, while a 5% lime juice solution achieved a reduction of 47.67% (Purwaningsih and Kuswiyanto, 2019). Lemon juice pretreatment not only helps in reducing oxalate content but also enhances the texture and nutritional quality of potatoes (Yahya et al., 2024). Salt solutions can also be used to reduce oxalate content. The ionic nature of salt can help in breaking down oxalate compounds. In a study on porang tubers, a 14% salt solution was found to be effective in reducing oxalate levels (Sugiarto et al., 2023). The use of oxalate oxidase enzyme in the treatment of taro tuber flour has been shown to reduce oxalate content by up to 97%. This enzymatic process does not significantly alter the physicochemical properties of the starch, making it suitable for various food applications, including baby food formulations (Kumar and Belur, 2018). Incorporating these processing techniques into food preparation guidelines could enhance the safety of these potato cultivars for consumption, particularly for individuals prone to kidney disease.

CONCLUSION

This study analyzed starches extracted from seven different potato cultivars, evaluating their proximate composition, functional properties, and anti-nutrient content, particularly calcium oxalate levels. The findings revealed significant variations among potato varieties, with some exhibiting higher calcium oxalate concentrations that could pose health risks if consumed raw. These results emphasize the need for appropriate processing techniques to mitigate oxalate levels and enhance the safety of these potato varieties for consumption. The implications of these findings extend to both potato processing and cultivation practices. Food industries and consumers can adopt processing methods such as boiling, soaking, fermentation, and peeling to reduce calcium oxalate content, making these potatoes more suitable for dietary intake. Additionally, cultivation strategies could focus on selecting or breeding potato varieties with naturally lower oxalate levels, ensuring safer and more nutritionally beneficial crops. Future research should explore the efficiency of different processing methods in reducing oxalate levels while preserving the nutritional and functional qualities of potato starches. Moreover, investigating the genetic and environmental factors influencing calcium oxalate accumulation in potatoes could contribute to the development of low-oxalate cultivars. Understanding these mechanisms will help enhance the nutritional value of potatoes and their suitability for broader food applications, particularly in regions where potatoes serve as a staple food source.

ACKNOWLEDGMENTS

Authors are thankful to the Department of Nutrition and Food Engineering, Daffodil International University (DIU), for providing lab facilities to carry out the research work.

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