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# Technofunctional and bioactive properties of flours obtained from six native potato varieties (*Solanum tuberosum*) from the Cundiboyacense region

## Propiedades tecnofuncionales y bioactivas de harinas obtenidas de seis variedades de papas nativas (*Solanum tuberosum*) de la región Cundiboyacense

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## ABSTRACT

**Background**: In Latin America, approximately 4,732 native potato varieties have been recorded, representing an autochthonous product that plays a crucial role in food security and nutrition for the population. However, there remains a need to explore new forms of consumption, such as native potato flour, and to recognize its technological potential and antioxidant capacity, positioning it as an alternative and innovative ingredient for the food industry. **Objective**: This research evaluated the technofunctional properties, color, and antioxidant capacity of six varieties of native potato flours. **Methods**: Six native potato varieties (*Solanum tuberosum*): Yana Shungo, Puca Shungo, Alcarrosa, Quincha, Valvanera, and Sangre de Toro, were studied. For analysis, the samples were dried and ground. Water and oil absorption capacities, swelling power, color parameters, total phenolic content, and antioxidant capacity (DPPH, ABTS, and FRAP) were determined. **Results**: The Puca Shungo variety exhibited the highest water absorption capacity (4.61 ± 0.28 g/g), while Valvanera showed the greatest swelling power (5.45 ± 0.40 mL/g). Sangre de Toro presented the highest oil absorption capacity (2.75 ± 0.03 g/g). Regarding color parameters, Valvanera displayed the highest lightness (L* = 78.91 ± 0.81), whereas Puca Shungo and Alcarrosa exhibited intense yellow coloration (b* = 21.25 ± 2.77 and 22.76 ± 2.67, respectively). In contrast, Sangre de Toro showed an intense red coloration (a* = 21.65 ± 1.32) and lower lightness (L* = 48.57 ± 1.73). Furthermore, the Sangre de Toro variety demonstrated significantly high antioxidant properties, with antioxidant capacities of 5.386 ± 0.209 µmol TE/g DM (ABTS), 3.528 ± 0.153 µmol TE/g DM (DPPH), and 5.104 ± 0.144 µmol TE/g DM (FRAP), as well as a total phenolic content of 1.442 ± 0.06 mg GAE/g DM. The Yana Shungo variety ranked second in terms of antioxidant capacity. **Conclusion**: The flours obtained from the evaluated varieties exhibit high antioxidant content and high water and oil absorption capacities. This study contributes to the recognition and characterization of native potatoes cultivated in the Cundiboyacense region of Colombia for their use as ingredients in the food industry.

**Keywords:** Antioxidant capacity, total phenolics, water absorption capacity, oil absorption capacity, swelling power, anthocyanins.

## RESUMEN

**Introducción:** En Latinoamérica se registran aproximadamente 4.732 variedades de papa nativa, un producto autóctono que desempeña un papel crucial en la seguridad alimentaria y en la nutrición de la población. No obstante, persiste la necesidad de explorar nuevas formas de consumo, como la harina de papa nativa, así como la necesidad de reconocer su potencial tecnológico y su capacidad antioxidante, con el fin de posicionarla como un ingrediente alternativo e innovador para la industria de alimentos. **Objetivo:** Evaluar propiedades tecnofuncionales, color y capacidad antioxidante de seis variedades de papas nativas. **Métodos:** Se estudiaron seis variedades de papas nativas (*Solanum tuberosum*): Yana Shungo, Puca Shungo, Alcarrosa, Quincha, Valvanera y Sangre de Toro, para su análisis, estas fueron secadas y molidas. Se determinaron capacidad de absorción de agua y aceite, poder de hinchamiento, color, contenido fenólico total y capacidad antioxidante (DPPH, ABTS, FRAP). **Resultados:** La variedad Puca Shungo mostró la mayor capacidad de absorción de agua (4.61±0.28 g/g) y la variedad Valvanera el mayor poder de hinchamiento (5.45±0.40 mL/g). Sangre de Toro tuvo la mayor absorción de aceite (2.75±0.03 g/g). En cuanto al color, Valvanera presentó mayor luminosidad (L* 78.91±0.81), y las variedades Puca Shungo y Alcarrosa presentaron un color amarillo intenso (b* 21.25±2.77 y 22.76±2.67 respectivamente) mientras la variedad Sangre de Toro presentó un rojo intenso (a*21.65±1.32) y menos luminosidad (L* 48.57±1.73). Se demostró que la variedad Sangre de Toro tiene propiedades antioxidantes significativamente altas, capacidad antioxidante ABTS (5.386 ± 0.209 µmol TE/g DM), DPPH (3.528 ± 0.153 µmol TE/g DM) y FRAP (5.104 ± 0.144 µmol TE/g DM) y contenido de fenoles totales (1.442 ± 0.06 mg GAE/g DM). Yana Shungo le sigue en segundo lugar. **Conclusión:** Las harinas de las variedades evaluadas poseen un contenido de antioxidantes alto, junto con capacidades de absorción de agua y aceite altas. Este estudio contribuye al reconocimiento y la caracterización de las papas nativas cultivadas en la región Cundiboyacense en Colombia para su uso como ingrediente en la industria alimentaria.


**Palabras clave:** Capacidad antioxidante, fenoles totales, capacidad de absorción de agua, capacidad absorción de aceite, poder de hinchamiento, antocianinas

## BACKGROUND

Potato production in Colombia reached 2,573,450.49 tons in 2023, according to FAO (1). According to the International Potato Center and studies conducted by the CGIAR (2), the Andean region is characterized by the production of native potatoes, mainly in Peru and Bolivia, with approximately 4,000 identified varieties. According to the Colombian Agricultural Research Corporation, by 2009, a germplasm bank was conserving 1,000 potato accessions, among which 400 distinct native varieties were identified, belonging to the species *Solanum tuberosum spp. andigena, Solanum phureja, and Solanum chaucha* (3). In a recent study of the Colombian Central Potato Collection (CCC) (4), 1,141 potato accessions were identified, mainly composed of native varieties, of which 670 are of Colombian origin. The diversity of the CCC is considered the most extensive collection of native potatoes in the world.

Native potatoes have played a fundamental role throughout history, both from a nutritional and a cultural perspective, contributing significantly to food security and food sovereignty. This is because they represent an opportunity to enrich and diversify the human diet, can help ensure food availability, and are better adapted to environmental and agroecological conditions, being more resistant to climate change and potentially more tolerant to pests and diseases (5–7). The potato (*Solanum tuberosum* L.) is one of the most important crops worldwide, both in terms of production volume and dietary relevance (8,9).

Current consumer trends are driving greater appreciation of the nutritional and technological potential of native potatoes due to their content of dietary fiber and antioxidant compounds (10,11). High levels of bioactive compounds have been reported, especially anthocyanins, which are water-soluble polyphenolic pigments belonging to the flavonoid group. These compounds are responsible for the characteristic coloration of pigmented tubers due to their chromophoric structures (12,13). In addition, native potatoes contain carotenoids, phenolic compounds, minerals, and vitamins, all of which are beneficial to health (10,14).

In Colombia, the cultivation of native potatoes is being reestablished; however, most production remains oriented toward household consumption. They are being commercialized in restaurants and mainly as chip-type flakes, largely due to limited research and insufficient knowledge of this raw material in the country(2). Although these varieties are often considered underutilized, they present considerable nutritional potential for technological applications in the food industry. Nevertheless, further research is required on the varieties cultivated in Colombia.

The objective of this study was to analyze the production of flour from six native potato varieties from the Cundiboyacense region—Yana Shungo, Puca Shungo, Alcarrosa, Quincha, Valvanera, and Sangre de Toro—and to characterize their techno-functional properties, color, and bioactive compounds, in order to identify their potential for industrial food applications.

## METHODS

### Vegetal Materials

Six varieties of native potato (*Solanum Tuberosum*) from the Cundiboyacense region were obtained from the company Tesoros Nativos S.A.S: Yana Shungo, Puca Shungo, Alcarrosa, Quincha, Valvanera and Sangre de toro, all varieties were used to make the flour.

### Native potato and flours

The production of native potato flour was carried out at the Universidad Nacional Abierta y a Distancia (UNAD) at the laboratory scale, following an adapted methodology described by Zhu et al. (15). Potato tubers were selected, washed, peeled, sliced, and disinfected with 0.05% sodium metabisulfite solution. The slices were then dried using a Thermo Scientific dryer (Madrid, España) in a hot-air cabinet at 50 °C for 48 hours. The dried slices were finely ground into flour using a blender (Vitamix 5200 Blender, professional-grade, Cleveland, OH, USA). The resulting flour was passed through a 500 µm sieve, packed in transparent polyethylene zip-lock bags, and stored at room temperature until further analysis

### Technofunctional properties of native potato flours

Water Holding Capacity (WHC), Oil Holding Capacity (OHC), and Swelling Power (SP) were evaluated following Mojo-Quisani et al.(16). Native potato flour samples (0.5 g) were mixed with 10 mL of distilled water, stirred, and centrifuged (Hettich EBA 20 centrifuge, Germany) at 3000 rpm for 30 minutes at room temperature. WHC and OHC were calculated from the difference between dry sample weight and pellet weight, relative to the initial mass Equation 1. SP was determined as the ratio of wet sediment weight to dry flour weight Equation 2. All measurements were performed in triplicate, and results were expressed as percentages.

$$WHC\ or\ OHC = \frac{Mp - Mm}{Mm} x100 \qquad \text{Ec. 1}$$

Mp is the mass of the precipitate, Mm is the mass of the sample

$$SP = \frac{WSP}{WS - WDS} \qquad \text{Ec. 2}$$

WSP is the weight of sedimentary paste, WS is the weight of the sample, WDS is the weight of the supernatant dry

### Color of native potato flours

The color analysis of native potato samples was studied in the CIELab color space using a Konica Minolta colorimeter (Tokyo, Japan). The evaluated CIELab coordinates were lightness (L*, where 0 represents black and 100 represents white), redness (a*, red/green coordinate), and yellowness (b*, yellow/blue coordinate), along with the color intensity chroma parameter (Cab* (chroma)), calculated according to Equation 3, following the standard conditions set by the International Commission on Illumination (CIE) (17).

$$Cab^{*}\sqrt{a^{*2} + b^{*2}} \qquad \text{Ec. 3}$$

### Preparation of extracts for antioxidant analysis of native potato flours

According to Campos et al. (18) with modifications, 2 g sample was homogenized with 20 mL of (99%) methanol and stored at 4 °C for 16 h before filtration. The extract was centrifuged at 5000 RPM for 15 min, and the supernatant was filtered through a membrane filter to obtain the final extract.

### Total phenolic content analysis

The total phenolic content was determined using the method described by Campos et al. (18) with some modifications. Briefly, 20 µL of the extract was mixed with 1.58 mL of distilled water and 100 µL of Folin Ciocalteu reagent (Panreac®, Barcelona). After a stand time of 1 to 8 min, 300 µL of 17% sodium carbonate was added, and the mixture was allowed to react for 2 h in the dark. Absorbance was measured at 765 using a spectrophotometer (Mapada®, China). The calibration curve was prepared using different concentrations of gallic acid (Sigma-Aldrich®, Germany). The results were expressed as mg of gallic acid (GAE)/g of potato. All assays were performed in triplicate.

### DPPH• scavenging activity

DPPH• radical scavenging activity was determined according to Zhang et al. (19), with slight modifications. The method is based on the reaction between antioxidants and the stable radical 2,2-diphenyl-1-picrylhydrazyl (DPPH•) (Sigma Aldrich®, Germany) dissolved in 95% ethanol (Emsure®, Germany). A 60 µmol/L DPPH• solution was prepared in 95% ethanol. Subsequently, 30 µL of the sample extract was mixed with 1 mL of the DPPH• solution and allowed to react for 30 min. Absorbance was measured at 517 nm using a spectrophotometer (Mapada®, China), with 95% ethanol used as the blank. All assays were conducted in triplicate.

### ABTS scavenging activity

ABTS•+ antioxidant activity was determined according to Zhang et al.(19) with slight modifications. Mixing 10 µL of the extract with 1 mL of ABTS solution, followed by absorbance measurement at 734 nm after 6 min of reaction in the dark, using a spectrophotometer (Mapada®, China). Results were calculated based on a Trolox (Sigma Aldrich®, Germany) calibration curve and expressed as µmol Trolox equivalents/g of potato. All analyses were performed in triplicate.

### FRAP scavenging activity

FRAP assay was determined according to Sabuncu et al. (20) with modifications, 20 µL of the extract was mixed with 450 µL of FRAP reagent (ferric–TPTZ complex) (Sigma Aldrich®, Germany) and 735 µL of distilled water. After 30 min of reaction in the dark, absorbance was measured at 593 nm using a spectrophotometer (Mapada®, China). Results were expressed as mmol Trolox/g.

### Statistical analysis

The data were analyzed using analysis of variance (ANOVA), followed by Tukey's and Fisher's tests. Antioxidant capacity and phenolic content results were analyzed using Pearson's correlation test, and a principal component analysis (PCA) was performed to explore the relationships among the parameters evaluated in the flours, using the software STATGRAPHICS XVII (2015) and Orange Data Mining 3.40.0.

## RESULTS

### Technofunctional properties of native potato flours

The mean values of the technofunctional properties of the native potato flours, including swelling power, holding capacity of water and oil, are presented in Table 1.

**Table 1.** Technofunctional properties of native potato flours

| Varieties of native potato flours | Water Holding Capacity (g/g)DM | Oil Holding Capacity (g/g)DM | Swelling Power (mL/g)DM |
|---|---|---|---|
| Yana Shungo | 4.04±0.08$^{a}$ | 2.24±0.07$^{a}$ | 4.54±0.14$^{a}$ |
| Puca Shungo | 4.61±0.18$^{b}$ | 2.26±0.05$^{a}$ | 5.31±0.17$^{b}$ |
| Alcarrosa | 3.80±0.30$^{a}$ | 2.59±0.08$^{b}$ | 4.29±0.35$^{ac}$ |
| Quincha | 3.40±0.26$^{c}$ | 2.48±0.05$^{c}$ | 3.91±0.36$^{d}$ |
| Valvanera | 4.56±0.13$^{b}$ | 2.41±0.03$^{c}$ | 5.45±0.40$^{b}$ |
| Sangre de Toro | 3.42±0.03$^{c}$ | 2.75±0.03$^{d}$ | 4.02±0.01$^{c}$ |

values presented like Means ± standard deviation

Values not sharing letters are significantly different according to Fisher's LSD test ($p < 0.05$)

WHC, expressed as grams of water retained per gram of native potato flour, varied among the evaluated varieties. The lowest values were observed for Quincha (3.40 g/g) and Sangre de Toro (3.42 g/g), whereas the highest values were recorded for Puca Shungo (4.61 g/g) and Valvanera (4.56 g/g). These differences were statistically significant ($p < 0.01$), indicating that Puca Shungo and Valvanera exhibit the greatest water retention capacity. OHC, expressed as grams of oil retained per gram of native potato flour, ranged from 2.22 to 2.75 g/g, with significant differences among varieties ($p < 0.01$). Sangre de Toro exhibited the highest OHC compared with the other native potato varieties. SP ranged from 3.91 to 6.57 mL/g and varied significantly among the varieties ($p < 0.01$). Puca Shungo showed the highest SP values, whereas Quincha and Sangre de Toro, followed by Alcarrosa, presented the lowest values.

## Color native potato flours

Color is one of the most important visual quality parameters of raw materials, as it can provide valuable information about the chemical composition of the product (21,22). The appearance of the evaluated native potato flours is shown in Figure 1.


**Figure 1**. Native potato flours Cundiboyacense

Table 2 presents the color parameters (L*, a*, b*, and C*ab). Statistically significant differences ($p < 0.05$) in lightness (L*) were observed among the native potato varieties, with Sangre de Toro exhibiting the lowest value (48.57, $p < 0.05$). The red–green coordinates (a*) were significantly higher ($p < 0.05$) in Sangre de Toro and significantly lower ($p < 0.05$) in Valvanera. Conversely, the yellow–blue coordinates (b*) were significantly higher ($p < 0.05$) in Puca Shungo and Alcarrosa, while Yana Shungo and Sangre de Toro exhibited the lowest values ($p < 0.05$). Accordingly, similar statistical differences were observed in Chroma (C*ab), with Yana Shungo registering the lowest value (10.96).

**Table 2.** Color parameters of native potato flours

| Varieties of native potato flours | L* | a* | b* | Cab* |
|---|---|---|---|---|
| Yana Shungo | $57.03\pm1.72^{a}$ | $3.17\pm0.99^{ac}$ | $10.50\pm2.22^{a}$ | $10.96\pm2.14^{a}$ |
| Puca Shungo | $57.54\pm2.32^{a}$ | $9.90\pm2.27^{b}$ | $21.25\pm2.77^{bd}$ | $23.45\pm2.61^{be}$ |
| Alcarrosa | $66.41\pm2.13^{b}$ | $4.42\pm2.13^{c}$ | $22.76\pm2.67^{d}$ | $23.19\pm2.92^{be}$ |
| Quincha | $65.15\pm2.021^{b}$ | $10.59\pm2.02^{b}$ | $17.51\pm2.01^{be}$ | $20.47\pm2.66^{bd}$ |
| Valvanera | $78.91\pm0.81^{c}$ | $0.59\pm0.81^{a}$ | $16.89\pm1.53^{e}$ | $16.90\pm1.52^{d}$ |
| Sangre de Toro | $48.57\pm1.73^{d}$ | $21.65\pm1.32^{d}$ | $11.89\pm1.62^{a}$ | $24.70\pm1.86^{e}$ |

Values presented like Means ± standard deviation

Different letters on the same line represent significant differences between the averages at $p < 0.05$.

### Antioxidant capacity and total phenolic content of native potato flours

Table 3 presents the results of the evaluation of antioxidant capacity and total phenolic content.

**Table 3**. Mean values and standard deviation of Antioxidant Capacity and Total Phenolics content of different native potato flours

| Varieties of native potato flours | Antioxidant Capacity by ABTS (μmol de TE /g DM) | Antioxidant Capacity by DPPH (μmol de TE /g DM ) | Antioxidant Capacity by FRAP (μmol de TE/g DM ) | Total Phenolics Content -TPC (mg de GAE/g DM) |
|---|---|---|---|---|
| Yana Shungo | 2.474 ± 0.175$^{d}$ | 1.830 ±0.113$^{b}$ | 2.513 ± 0.234$^{c}$ | 0.834 ± 0.03$^{b}$ |
| Puca Shungo | 0.960 ± 0.129$^{b}$ | 0.573 ± 0.066$^{c}$ | 0.981 ± 0.072$^{b}$ | 0.443 ± 0.02$^{c}$ |
| Alcarrosa | 0.525 ± 0.073$^{a}$ | 0.094 ± 0.014$^{a}$ | 0.409 ± 0.057$^{a}$ | 0.235 ± 0.02$^{a}$ |
| Quincha | 1.737 ± 0.203$^{c}$ | 0.373 ± 0.016$^{d}$ | 0.932 ± 0.080$^{b}$ | 0.566 ± 0.03$^{d}$ |
| Valvanera | 0.208 ± 0.020$^{a}$ | 0.044 ±0.000$^{a}$ | 0.305 ± 0.069$^{a}$ | 0.231 ± 0.01$^{a}$ |
| Sangre de toro | 5.386 ± 0.209$^{e}$ | 3.528 ± 0.153$^{e}$ | 5.104 ± 0.144$^{c}$ | 1.442 ± 0.06$^{e}$ |

Values not sharing letters are significantly different according to the Tukey LSD test ($p < 0.05$)

In this study, significant differences were observed in the antioxidant capacity of the six native potato flours. The ABTS assay values ranged from 0.2 to 5.4 μmol Trolox/g dry weight (DW), the DPPH assay ranged from 0.1 to 3.5 μmol Trolox/g DW, and the FRAP assay ranged from 0.3 to 5.104 μmol Trolox/g DW. The highest antioxidant capacities across the three assays were observed in the Sangre de Toro and Yana Shungo varieties. For the Yana Shungo variety, an ABTS antioxidant capacity of 2.474 ± 0.175 μmol TE/g DW was obtained, corresponding to 619.167 μg TE/g DW. This value is comparable to those reported by Samaniego et al., (23), for the same variety, which ranged from 332.41 to 751.76 μg TE/g fresh weight (FW). In the case of the Puca Shungo variety, an ABTS value of 0.960 ± 0.129 μmol TE/g DW was recorded, which is lower than the value reported by the same authors (5.53 μmol TE/g DW). For the Sangre de Toro variety, a DPPH antioxidant capacity of 3.528 ± 0.153 μmol TE/g DW was obtained, which is lower than that reported by other authors (5.84 μmol TE/g DW) (21). Additionally, a total phenolic content (TPC) of 1.442 ± 0.06 mg gallic acid equivalents (GAE)/g DW was determined, which is also lower than the value reported in the same study (3.048 mg GAE/g DW).

### Pearson's correlation among antioxidant activity methods

The correlation was significant among the antioxidant capacity analysis methods, with a p-value ≤ 0.05 for all variables, as shown in Table 4. The highest correlation was observed between the FRAP and DPPH methods (r = 0.995), followed by the pairs TPC–ABTS and TPC–FRAP. This indicates a strong relationship between antioxidant capacity and the content of phenolic compounds.

**Table 4**. Pearson's correlation among antioxidant activity methods

| | DPPH | ABTS | FRAP | TPC |
|---|---|---|---|---|
| DPPH | 1 | | | |
| ABTS | 0.968 | 1 | | |
| FRAP | 0.995 | 0.979 | 1 | |
| TPC | 0.978 | 0.988 | 0.985 | 1 |

Significant correlation at 95.00% probability

Figure 2 shows the clustering of native potato flour samples and the correlation between ABTS antioxidant capacity and TPC. A significant difference among samples and a linear relationship between the ABTS evaluation method and total phenolic content were observed for each sample.

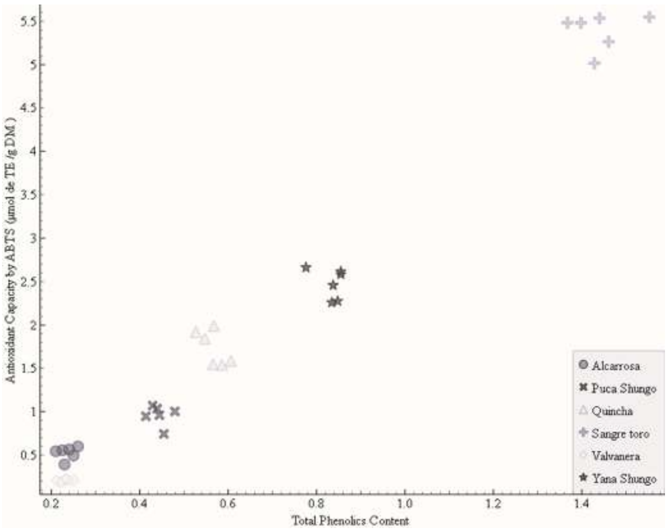


**Figure 2**. Scatter Plot of Pearson's correlation between ABTS and Total Phenol Content

## Correlation and multivariate analysis

Principal Component Analysis (PCA) was performed to integrate the antioxidant capacity, color parameters, and technofunctional properties of the native potato flours (Figure 3). The first two principal components accounted for approximately 83% of the total variance (PC1 = 63%, PC2 = 20%), demonstrating a robust representation of the system's variability. PC1 was primarily associated with antioxidant capacity (ABTS, DPPH, and FRAP) and total phenolic content; it also exhibited a positive correlation with the a* color parameter and oil holding capacity, while showing a negative correlation with lightness (L*), water holding capacity, and swelling capacity. Conversely, PC2 allowed differentiation of samples based on the chromatic parameters b and C*ab, as well as oil-holding capacity, indicating separation by color intensity and functional performance in lipid-based matrices. Overall, the PCA revealed a clear distinction among the flours, highlighting those with superior antioxidant bioactivity and intense pigmentation versus those with a higher affinity for hydration and starch expansion, underscoring their potential for specialized food industry applications.

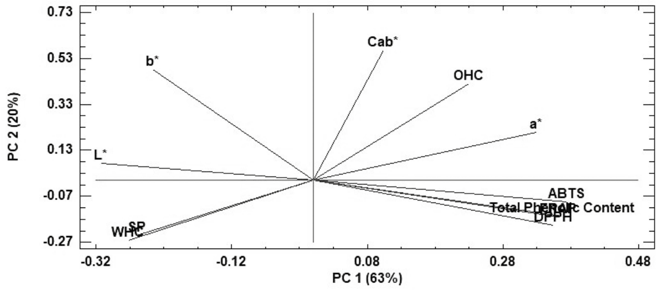


**Figure 3**. Multivariate analysis (PCA) integrates the antioxidant capacity, color parameters, and technofunctional properties of the native potato flours

## DISCUSSION

### Technofunctional properties of native potato flours

The water retention capacity, oil retention capacity, and swelling power of native potato flour showed higher values compared to other plant-based matrices, such as oats, amaranth, quinoa, chickpeas, and lentils (24). This behavior can be attributed to the structure of starch and fiber present in tuber flours, which tend to swell to a greater extent than the proteins found in legumes. This is mainly due to the abundance of hydroxyl groups in polysaccharides, which promote stronger interactions with water through hydrogen bonding (24–26). Swelling capacity is also influenced by processing treatments. According to Schmitz, Karlsson, and Adlercreutz(27), potato pulp is a highly moist material, and drying processes induce structural changes that affect its swelling power. In their study, higher drying temperatures resulted in a 45% reduction in swelling capacity (8.8 ± 0.9 mL/g). In contrast, the swelling power values obtained for the native potato varieties evaluated in the present study were considerably lower, suggesting differences associated with the processing conditions.

According to the results, these alternative flours are a promising technological option for the food industry, owing to their high capacity to interact with oils and fats. This behavior is associated with the type of proteins present and the contribution of nonpolar chains (24,26). In addition, their high water-absorption capacity helps maintain a desirable texture, thereby increasing their versatility across diverse food formulations.

### Color of native potato flours

According to the results presented, significant differences in flour color were observed, reflecting variations in the chemical composition of the potato flour samples (28). Some samples fall within the dark color spectrum(11), which may be associated with higher pigmentation intensity and, consequently, elevated concentrations of phenolic compounds, particularly anthocyanins (29), contributing to the reddish, purple, and pink hues observed in some flours in this study. Additionally, research suggests that higher amylopectin content in native potato flour correlates with lower luminosity (L*) values, and has also reported variability in the colorimetric parameters of native potatoes are influenced by their genetic and geographical origin (11,30).

### Antioxidant capacity of native potato flour

Bioactive compounds in foods are synthesized by plants as secondary metabolites with diverse biological functions, including pigmentation, organoleptic properties, and defense mechanisms, among which antioxidant activity is particularly relevant(28,31). In native potato flour, antioxidant capacity is mainly attributed to the presence of phenolic compounds and anthocyanins, which have been widely investigated by several authors (32–39). Tejeda et al. (40) evaluated 52 native potato varieties from Bolivia and reported antioxidant capacity values ranging from 0.2 to 4.8 µmol Trolox/g DW using the ABTS assay and from 1.1 to 7.4 µmol Trolox/g DW using the FRAP assay. These values are comparable to those obtained in the present study. The Sangre de Toro and Yana Shungo varieties are characterized by red and purple pigments that significantly contribute to their antioxidant capacity. In Sangre de Toro potato flour, these pigments correspond mainly to anthocyanins, with reported contents of 59.21 mg cyanidin-3-glucoside per 100 g of raw potato (37), as well as the presence of pelargonidin-3-O-rutinoside, a pelargonidin derivative (23.5 mg/kg DW). This pigment is characteristic of red-violet potato flour and is found in higher concentrations in the potato skin (41).

In the Yana Shungo variety, pigments corresponding to anthocyanins, phenolic compounds, and carotenoids have also been identified. Reported contents range from 43.4 to 172.53 mg of anthocyanins per 100 g fresh weight, 79.0 to 206.7 mg of carotenoids per g fresh weight, and 0.9 to 3.25 mg of total phenolics per kg DW (32). The contribution of anthocyanins and phenolic compounds to antioxidant capacity has been demonstrated by Samaniego et al.(32), who applied Pearson's correlation analysis between bioactive compounds and antioxidant capacity in several native potato varieties. They reported correlation coefficients of $r = 0.31$ ($p < 0.05$) for vitamin C, $r = 0.25$ ($p < 0.05$) for anthocyanins, and $r = 0.64$ ($p < 0.05$) for total phenolics.

Pearson's correlation analysis demonstrates the contribution of phenolic compounds to antioxidant capacity, in agreement with the findings of Albishi et al.(42). These authors evaluated the contribution of free, esterified, and bound phenolic compounds to antioxidant activity using ABTS, DPPH, FRAP, and oxygen radical absorbance capacity (ORAC) assays in four Canadian potato varieties. The relationship between total phenolic content and antioxidant activity was assessed using Pearson's correlation, revealing that total bound phenolics exhibited a strong positive association with antioxidant activity.

## CONCLUSIONS

The results demonstrate that native potato flours exhibit higher water and oil retention capacities than commonly used plant-based ingredients, such as oats, amaranth, quinoa, chickpeas, and lentils, highlighting their potential for use in food formulations.

The antioxidant profile confirmed the contribution of the total phenol content to the antioxidant capacity measured by ABTS, DPPH, and FRAP. The pigmented varieties, particularly Sangre de Toro and Yana Shungo, showed the highest values among those analyzed. These findings support the functional use of pigmented varieties in future food-industry applications.

The obtained results demonstrate that the native potato flour variety Sangre de Toro exhibits the lowest lightness (L*) values, ranging from 48.57 to 78.91, which is directly associated with the presence of natural pigments responsible for its high antioxidant capacity. This reduced lightness can largely be attributed to a higher concentration of bioactive compounds, particularly anthocyanins and other phenolic compounds, which function as secondary metabolites with both antioxidant roles.

Overall, the findings demonstrate that native potato flour represents a valuable source of bioactive compounds for the food industry. Their incorporation not only enables the development of value-added functional food products but also contributes to biodiversity conservation, as well as to food security and food sovereignty.

## CONFLICT OF INTEREST

The manuscript's authors declare that no conflicts of interest are associated with this work.

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## AUTHORS' CONTRIBUTION

The authors confirm their contribution to the article as follows: study conception and design: RMBG, YMOP, IRG, acquisition of data and information: RMBG, YMOP, IRG, analysis and interpretation of data: RMBG, YMOP, IRG, planning of the article: RMBG, YMOP, IRG, review of intellectual content: RMBG, YMOP, IRG, final approval of the version to be published: RMBG, YMOP, IRG.

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