Native Potato Valorization through Innovative Bakery Products: Sensory Acceptance, Colorimetric Characterization, and Women's Engagement in Food Innovation

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Abstract–

Abstract–Approximately 4,732 native potato varieties have been identified in Latin America, representing an indigenous crop of high nutritional, cultural, and agricultural value. This study evaluated the sensory acceptance and color of innovative food products made from native potatoes. It also highlights the contribution of women to research and food innovation by promoting their scientific leadership and participation in developing sustainable strategies for agri-food resource utilization. Bakery products were developed using native potato flour for ring-shaped pastries and native potato puree in cinnamon rolls from the Puca Shungo, Alcarrosa, and Sangre de Toro varieties cultivated in the Cundiboyacense region of Colombia. Sensory acceptance tests and instrumental color analyses were conducted using the CIELab color scale (L*, a*, b*).The ring-shaped pastries achieved consumer acceptance. Compared with the control, treatment T1 showed significantly lower lightness , higher redness , and lower yellowness , reflecting darker and more reddish tones. Cinnamon rolls were also well accepted. Treatment CT2 presented the lowest lightness in both crust and crumb and the highest red coordinate in the crumb, associated with anthocyanins from the Sangre de Toro variety. These findings demonstrate that transforming native potatoes into flour and puree is a viable strategy for developing innovative foods, while supporting food sovereignty and strengthening women's participation in science and technology.

Keywords— Native potatoes; Food innovation; Colorimetric analysis; Women in STEM; Food sovereignty

I. Introduction

Native potatoes have played a fundamental role in the nutrition, culture, and food security of various Latin American communities, becoming a strategic resource for food sovereignty and rural development [1]. Potato (*Solanum tuberosum* L.) is one of the most relevant crops worldwide, both in terms of production volume and its contribution to human nutrition [2,3]. In Colombia, native potato varieties have gained renewed interest due to their nutritional richness, genetic diversity, and agro-industrial potential; however, a large portion of their production is still destined for household consumption, limiting their valorization within higher value-added production chains. From an engineering perspective, the use of native raw materials such as native potatoes represents an opportunity to develop innovative value-added products, while simultaneously strengthening regional production chains and promoting sustainable alternatives for the agri-food sector. These varieties may provide high levels of bioactive compounds, particularly anthocyanins, carotenoids, and phenolic compounds, which are associated with antioxidant properties and potential health benefits [4–6]. Likewise, their incorporation into processed food matrices has demonstrated technological feasibility, especially in the development of functional foods and bakery products, without significantly affecting their sensory and physicochemical properties [7–9]. This utilization not only promotes food innovation but also contributes to the preservation of traditional crops and the strengthening of food sovereignty by encouraging more resilient production and consumption systems based on local resources. In this context, women's participation in research, innovation, and technology transfer within STEM fields (science, technology, engineering, and mathematics) is essential for driving sustainable solutions with high social impact. Women's leadership in scientific projects focused on the use of local resources not only contributes to the generation of applied knowledge but also strengthens equal opportunities and the visibility of women in traditionally underrepresented academic spaces. Furthermore, these experiences serve as references that encourage girls and young women to pursue engineering careers by demonstrating the transformative potential of these disciplines in solving real-world challenges.

Therefore, this study evaluates the incorporation of potato flour through sensory and colorimetric analysis of two products developed from native potato flour and puree, aiming to assess their acceptance and potential application in the development of innovative food products. Three female faculty members from the fields of Food Science and Food Technology, along with three female Food Engineering students belonging to a research seedbed, participated in the implementation of the

project. The students developed research projects as part of their degree requirements, participated in scientific events, and strengthened their research skills and competencies through the development of research products and innovative proposals. This experience contributed to the academic and professional development of the participating women, while promoting their active engagement in research, innovation, and the application of knowledge in the food engineering field. The results demonstrate how engineering, can contribute to the design of functional products, the valorization of native crops, and the strengthening of regional food security and food sovereignty, while simultaneously consolidating academic participation spaces for women in science, technology, and engineering.

II. METHODOLOGY

A. *Vegetal Materials*

Three varieties of native potatoes from the Cundiboyacense region were obtained from the company Tesoros Nativos S.A.S: *Puca Shungo, Alcarrosa y Sangre de toro* which are evidenced in Figure 1.



Fig 1. varieties *Puca Shungo, Alcarrosa y Sangre de toro*

B. *Native Potato Flour*

Native potato flour was carried out at laboratory scale at the Universidad Nacional Abierta y a Distancia (UNAD), adapting the methodology described by Zhu et al.[10], Benavides-Guevara et al., [11]. Potatoes were selected, washed, peeled, sliced, disinfected with 0.05% sodium metabisulfite, dried at 50 °C for 48 hours, milled into flour, packaged in polyethylene bags, and stored at room temperature.

C. *Native potatoes puree*

Native potato purée is made by selecting, washing, peeling, blanching, cooling, cooking to 70 °C, discarding excess water, and mashing to prevent browning and ensure proper texture [12]

D. *Products containing native potatoes*

*1)Preparation of Product 1: Ring-shaped pastry:*Ring-shaped pastries were prepared with 19% rice flour, 13% native Puca Shungo potato flour, 0.1% stevia, 0.5% salt, 15% costeño cheeses, 17% fresh cheese, 22% milk, and 14% butter. After mechanical mixing, the dough rested, was shaped, baked at 170 °C for 12 minutes, cooled, and then packaged for storage. 2)*Preparation of Product 2: Cinnamon rolls:* The cinnamon rolls were made from a mixture of 37% wheat flour, 29% native potato puree (2 varieties Alcarrosa and Sangre de Toro), 0.2% apple cider vinegar, 0.2% baking soda, 15.4% stevia, 7.2%, 10.3% milk butter, the mixture was beaten and kneaded for 30 min, the dough was left to rest for 30 min and mixed with 1.0% Cinnamon, butter and Stevia for the filling, finally baked at 180°C for 15 min.

E. *Sensory analysis of baked products*

Sensory acceptance was evaluated using a structured hedonic scale for taste, texture, crunchiness, appearance, color, aroma, and overall liking with 60 untrained UNAD participants aged 20–60 years [13].

F. *Color*

The color of the samples was expressed as chromaticity a * (red-green), b * (yellow-blue), and luminosity (L *) using a Smart Probe 400 colorimeter (MacDougall,2002).

G. *Statistical analysis*

Data were analyzed using ANOVA, Tukey, Fisher, Kruskal–Wallis, and Friedman tests, with acceptance evaluated statistically in STATGRAPHICS XVII (2015).

III. RESULTS AND ANALYSIS

A. *Sensory evaluation of products*

1)Sensory evaluation of the ring-shaped pastry: In the sensory evaluation of the ring-shaped pastry product, the inclusion of a native potato flour variety was analyzed (Control – T0, Puca Shungo – T1). No significant differences were detected for attributes such as texture, crispness, appearance, color, and aroma, apart from color, as shown in Figure 2.

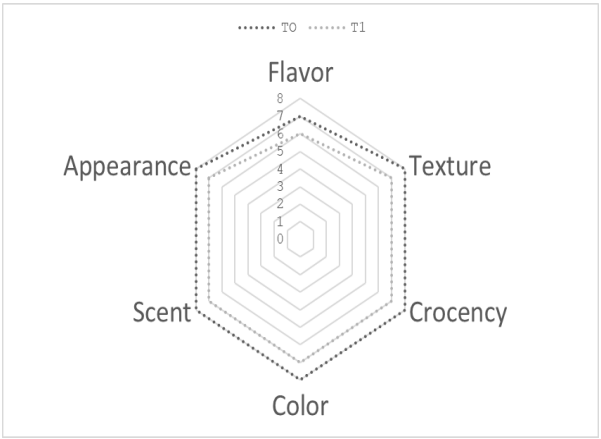


Fig 2. Sensory evaluation by attributes of ring - shaped pastry (T0 and T1),values presented as the median of the assigned scores (n=60)

No significant differences were detected in the sensory attributes evaluated when substituting 40% potato flour (baker's percentage). These findings are consistent with those reported by Cerón et al. (2014) [14], who observed good acceptability in cookies formulated with 30% potato flour. Similarly, other authors evaluated bread with substitution levels of 5%, 10%, and 15%, reporting improvements in texture by preventing firming, increasing moisture retention, and improving starch digestibility [15].

2)Sensory evaluation of cinnamon rolls: In the sensory evaluation of the cinnamon roll product, the inclusion of two native potato varieties was analyzed (Control – T0, Alcarrosa – T1, Sangre de Toro – T2). The analysis revealed differences between the control sample and those containing potato purée. The control sample showed differences in texture, receiving a score of 5 on the hedonic scale, whereas samples T1 and T2 obtained a score of 6, as shown in Figure 3. No significant differences were observed in other attributes such as color, odor, appearance, and flavor.

Additionally, the product containing Sangre de Toro potato achieved the highest purchase intent (40.3%). Although there are no specific studies on cinnamon rolls incorporating potato purée, the use of potato purée in baked products has been reported: heating the potato improves starch water-absorption properties and thus yields a softer dough, which helps explain enhanced texture perception. In a study on white bread with mashed potatoes, higher water absorption was reported than the control (70.7% for the mashed potato formulation versus 66.5% for the control). The authors concluded that the mono- and disaccharides present in mashed potatoes likely promote yeast fermentation. Furthermore, in the same study, sensory evaluation showed better flavor and texture scores relative to the control [16]. This study also underscores that visual appearance significantly influences product acceptance. In our results, panelists mistakenly attributed the reddish color of the cinnamon roll containing Sangre de Toro mashed potatoes to the inclusion of chocolate, illustrating how natural potato pigments can shape consumer perception.

The sensory results obtained in this study are consistent with previous findings reported in potato-enriched bakery products. Similar to the gluten-free potato bread developed by previous authors, where all formulations achieved acceptability scores above 5, the incorporation of native potato flour and puree in the present study resulted in good consumer acceptance. These findings suggest that potato-based ingredients can be successfully incorporated into bakery formulations without negatively affecting overall acceptability [17]

B. Color analysis

1) Color varieties native potatoes: Table 1 presents the color parameters of the flours obtained from the native potato varieties studied, showing significant differences due to the presence of pigments in each variety.

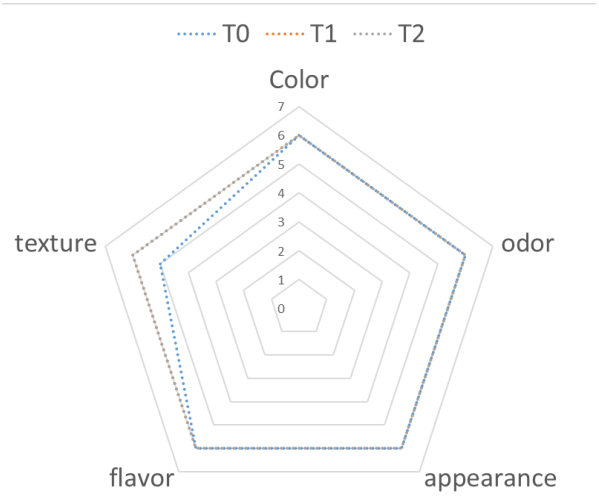
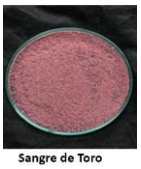


Fig.3 Sensorial evaluations by attributes of cinnamon rolls, values presented as median of the assigned scores (n=60)

TABLE I.
COLOR OF VARIETIES NATIVE POTATOES

	L*	a*	b*
 Alcarrosa	66.41±2.13^{b}	4.42±2.13^{c}	22.76±2.67^{c}
 Puca Shungo	57.54±2.32^{a}	9.90±2.27^{b}	21.25±2.77^{b}
 Sangre de Toro	48.57±1.73^{c}	21.65±1.32^{a}	11.89±1.62^{a}

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

The L*, a*, and b* values of the native potato flours showed some significant differences. Regarding lightness, lower values, corresponding to darker tones, were found in the Sangre de Toro, and Puca Shungo varieties. This may be attributed to the different hues of these flours, which are associated with the pigments present in these tubers. It is worth noting that these pigments are related to bioactive compounds such as phenolic compounds, carotenes, betalains, and vitamins, which have been reported to contribute to health promotion [5].

2)Color evaluation of ring-shaped pastry: In Table II, it can be observed that the luminosity of the control sample (T0) was significantly higher than treatment T1 ($p < 0.05$), this means that the inclusion of 40% native potato flour "Puca Shunga"

influences darker shades. The a* coordinate was significantly higher for T1 inducing a more reddish hue, while the b* coordinate shows that T1 is significantly less yellow than T0.In ring-shaped pastry, T1 shows a decrease in lightness, with more reddish tones, an increase in the red component (a*), and a stronger tendency toward yellow (b*). The pigments in native potatoes can alter the color of bakery products, a favorable result due to the high antioxidant capacity of native potatoes [18,19].

TABLE II
COLOR EVALUATION OF RING-SHAPED PASTRY

Treatments		L*	a*	b*
T0		51.96 ±0.97[a]	1.50 ± 0.08[a]	53.05±0.56[a]
T1		45.11 ±0.70[b]	17.89 ±0.62[b]	33.58 ±0.60[b]

T0: Control; T1: Puca Shungo - 40% native potato flour
Different letters on the same line represent significant differences between the averages at $p < 0.05$

2)Color evaluation of cinnamon rolls product: Table III shows the color results of the crusts of the cinnamon rolls. Significant differences in color were observed, mainly in the treatment that included potato purée from the Sangre de Toro variety. In terms of lightness (L*), darker tones were evident for CT2, whereas the a* value did not present relevant significant differences. Table IV presents the crumb color parameters, showing significant differences for lightness (L*), with lower values observed in the samples containing native potato purée. For the a* coordinate, the highest values were recorded in CT2, indicating a more reddish hue, whereas the b* coordinate did not show significant differences among treatments. In the cinnamon rolls, CT2 showed reduced lightness (L*) in both crust and crumb, an increase in a* in the crumb (more reddish), and no significant differences in b*. The increase in a* in the crumb may be related to the presence of anthocyanins, which tend to intensify reddish tones during baking [20]. Meanwhile, in CT1, the a* value in the crust was lower than in CT0 and CT2, attributable to greenish tones after baking. In the crumb, the a* value increased compared with the control, indicating a shift in the red–green axis. Matsushita et al. (2019)[21] observed that in white bread supplemented with crushed potato, the crust darkened, while in the crumb, a* significantly decreased and b* notably increased, indicating greater yellowness. However, the potato material used in that study was a common non-pigmented variety.

Unlike previous studies using non-pigmented potato varieties [17], this study demonstrated that pigmented native potatoes significantly influenced product color. The reduction in lightness and increase in red tones observed in products containing Puca Shungo flour and Sangre de Toro puree suggest that anthocyanin-rich native varieties contribute distinctive visual characteristics. Interestingly, these color changes did not reduce acceptance; instead, panelists associated the reddish tones with chocolate, indicating that natural pigments may positively influence consumer perception and purchase intention.

TABLE III.
CRUST COLOR OF CINNAMON ROLLS.

Treatments		L*	a*	b*
CT0		58.60 ± 6.35[a]	14.00 ± 5.79[a]	43.20 ± 21.02[a]
CT1		49.00±10.34[a]	12.00 ± 5.05[a]	23.80 ± 15.12[ab]
CT2		26.80 ± 13.8[b]	16.20 ± 3.35[a]	7.40 ± 6.62[b]

CT0: Control; CT1: Alcarrosa - 29%; CT2: Sangre de Toro - 29% native potato puree
Different letters on the same line represent significant differences between the averages at $p < 0.05$

TABLE IV
COLOR OF THE CRUMB OF THE CINNAMON ROLLS

Treatments		L*	a*	b*
CT0		80.00 ± 7.71[a]	1.00 ± 2.00[a]	0.20 ± 4.38[a]
CT1		50.80 ± 20.74[b]	6.00 ± 6.04[a]	3.00 ± 5.83[a]
CT2		37.20 ± 11.54[b]	17.40 ± 3.97[b]	3.60 ± 5.86[a]

CT0: Control; CT1: Alcarrosa - 29%; CT2: Sangre de Toro - 29% native potato puree
Different letters on the same line represent significant differences between the averages at $p < 0.05$.

III. CONCLUSIONS

The incorporation of flour and puree from native potato varieties into bakery products showed promising potential for the development of differentiated foods, maintaining good sensory acceptance while generating specific changes in attributes such as texture and color. The use of Puca Shungo, Alcarrosa, and Sangre de Toro resulted in products with distinctive sensory and colorimetric characteristics, demonstrating that the valorization of native agricultural resources can constitute a strategy for innovation and value-added development in the food industry.

The development of these products also contributes to highlighting the contribution of women to research, food engineering, and agri-food innovation, particularly in processes

aimed at the sustainable utilization of native raw materials and the development of value-added food alternatives. In this context, women's participation in research and technological development contributes to strengthening innovation processes that bring together scientific knowledge, local resources, and opportunities for transforming food systems.

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