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Unearthing Unique Value: Exploring the Potential of Protected Designation of Origin on the Tangerine Industry of Patate, Tungurahua

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Abstract

The purpose of this study is to analyze the potential of the Tangerine of Patate (*Citrus x* clementina) to obtain a Protected Designation of Origin (PDO). The study emphasizes the crucial role of local climatic conditions, unique soil characteristics, and traditional cultivation techniques in determining the fruit's organoleptic properties. The methodology consists of applying two stages of the virtuous circle proposed by Vandecandelaere: (1) Identification and (2) Proposal of Qualification. Information on cultural practices and post-harvest techniques was gathered through surveys. Qualitative data from surveys were processed using the MAXQDA software. Tangerine and other samples were analyzed with normalized physicochemical analyses in the lab. The first data were compared with samples from two different cantons to validate the intrinsic value of Patate's tangerine. Results demonstrate that the tangerine exhibits differentiated characteristics in terms of aroma, color, and flavor, as well as a traditional inherited practice that is part of the attributes supporting its potential DO status. It is concluded that the mandarin meets the requirements to obtain a Protected Designation of Origin based on specific conditions of production and harvest, as well as a potential economic aspect to consider increasing farmers' incomes.

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Introduction

Over the last two decades, the global food market has undergone remarkable transformations, influenced by consumers' escalating demand for fresh and authentically regional products (Grunert, 2005). The concept of food origin has developed beyond a mere product attribute, becoming a distinct brand element that adds a unique value proposition (Rangnekar, 2004).

The consumer preference for products with a traditional regional association (Sforzi & Mancini, 2015) has been amplified by an increasing interest in the traditional methods of production and processing. According to Moreno *et al.* (2019), elements such as tradition, the production process, and rural development within a specific region play key roles in product differentiation and enhanced quality.

In this context, geographical indications (GIs) have gained prominence. As defined by the World Intellectual Property Organization (WIPO, 2017), GIs are labels that identify products with a specific geographical origin. Protected Designations of Origin (PDO), a special category of GIs, refers to products that are known for their high quality and have earned recognition from consumers. PDOs place rigorous requirements on producers, demanding the entire production process occur within the designated territory, thus offering a higher degree of protection compared to GIs (Granados, 2004).

The importance of PDOs can be seen through various lenses, with the benefits extending well beyond simple product differentiation. Traditionally, PDOs have been frequently applied in competitive product sectors such as wines and cheeses, especially within the European Union (Tsakiridou *et al.*, 2011). This use has not been arbitrary, but rather a strategic method for producers to elevate their products and compete in saturated markets.

This study focuses on tangerines, specifically a variety of Clementine (*Citrus reticulata* Blanco) cultivated in the Sierra region of Ecuador. While global tangerine production is dominated by major players like China, Spain, and Japan, with Brazil and Peru leading in the South American market (FAO, 2016), Ecuador has carved out its niche. In 2017, tangerine production in the country reached 42,560 tons (ESPAC, 2017), with the province of Tungurahua notably excelling in tangerine cultivation. In particular, the "Tangerine of Patate", grown on approximately 390 hectares in the canton of Patate, has gained local market recognition.

1. Background

DOs play a pivotal role in safeguarding the uniqueness of products. In an era of mass production and commoditization, products that carry a PDO are imbued with an authentic story, associated with a specific region, and bound by traditional methods of production (Barham, 2003). This not only helps preserve cultural heritage and biodiversity but also adds a unique value proposition that sets these products apart from their generic counterparts. A clear example of this value proposition is seen in the market dynamics of the "Zagorin" apple, which is cultivated in the village of Zagora and holds a PDO status (Zagorin, 2019).

More than just a marker of authenticity, PDOs can significantly enhance the economic viability of producers. By recognizing and enhancing the value of unique regional products, PDOs can help farmers obtain a price premium, thus improving their economic returns (Belletti *et al*., 2015).

Moreover, PDOs can be a powerful marketing tool. They can offer consumers assurance about the quality and origin of products, which can be a significant competitive advantage in markets where consumers value authenticity, tradition, and quality (Teuber, 2011). In more recent years, PDO has proven to be a substantial factor in the fruit industry (Benedetto, 2007). The case of Ecuador, with five registered PDOs across a variety of manufactured and agricultural products, illustrates the role of PDOs in protecting endangered varieties against displacement by new alternatives (Quintana & Aguilar, 2018).

The study of PDO products, closely tied to GIs is of paramount scientific importance in the realm of international trade and product authenticity. According to the World Intellectual Property Organization (WIPO), PDOs operate as a signifier for products that highlight specific characteristics related to local culture and traditions. Scientifically analyzing these products ensures that their distinct attributes are genuinely tied to their place of production, thereby establishing a clear and verifiable link between the product and its original place of production. Such studies provide a robust framework for producers to protect their products against misuse by third parties (Millán *et al*., 2016). Beyond meager product differentiation, these studies play a crucial role in preserving cultural heritage, promoting sustainable rural development, and ensuring that consumers receive genuine, high-quality products. In essence, scientific investigations into PDOs and GIs delve deep into the intricate relationship between products, their geographical origins, and the unique attributes they derive from these origins (WIPO, 2023).

For smaller regions, acquiring PDO status can lead to profound economic transformations. It provides a unique selling proposition, differentiating products in the marketplace. This differentiation often translates to increased demand and allows for premium pricing, benefiting local producers (Skuras & Vakrou, 2002). Moreover, regions with products holding PDO can experience an upsurge in tourism, as consumers and tourists are increasingly interested in authentic regional experiences related to origin-specific products (Bramley *et al*., 2009).

Beyond the immediate economic advantages, PDO can foster local entrepreneurship and stimulate investments in sectors such as marketing, packaging, and transportation. Moreover, it can serve as a protective measure for traditional practices, ensuring the preservation of both biodiversity and cultural practices (Belletti, 1999).

However, the rewards of PDO are not automatic. Effective implementation, stringent quality control, and efficient promotional efforts are crucial. Failing to uphold these standards might lead to missed economic opportunities or even potentially harm the reputation of the product and the region (Mancini & Arfini, 2018).

The primary aim of this research is to evaluate the potential of the Tangerine of Patate (*Citrus x* clementina) for acquiring PDO condition. The study seeks to explore the unique cultivation traditions, production techniques, and post-harvest practices in the Tungurahua province, nestled in the central Sierra region of Ecuador. This objective is pursued using a virtuous circle methodology, drawing insights from the analysis of farms growing the Tangerine of Patate in the Puñapi parish of the Pelileo canton.

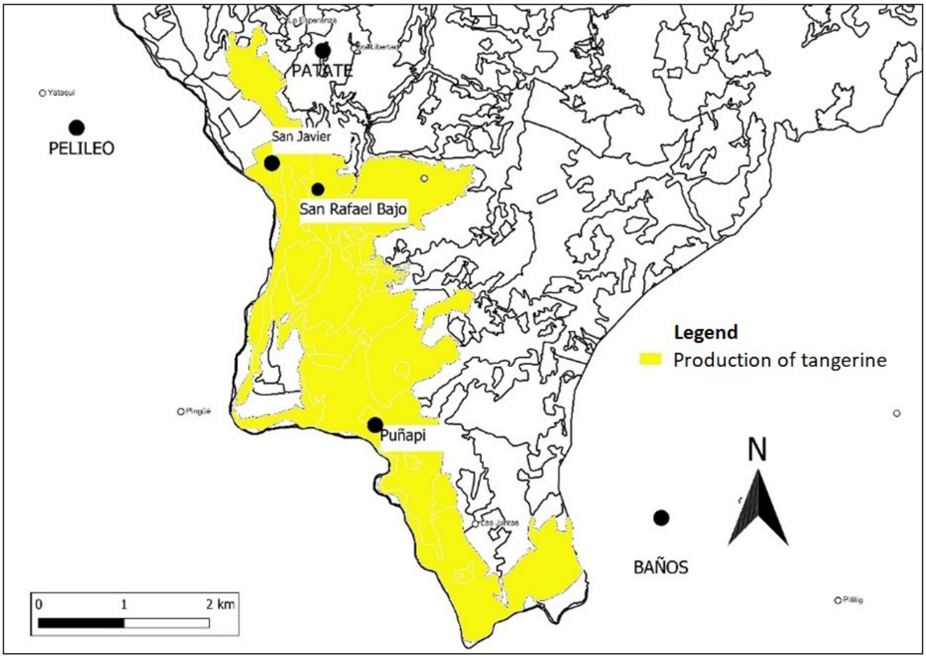
2. Materials and Methods

The methodology of this study was designed to systematically analyze and characterize the specific cultivar of tangerine (*Citrus reticulata*. Blanco) from the canton of Patate in Ecuador, to support its eligibility for Protected Designation of Origin (PDO) status. Primary data were collected via open-ended surveys with local farmers, an approach mirroring the work with the strategy applied by Bowen and Zapata (2009) for engaging the farmers' participation after a workshop with the information of the study goals. This integrated approach combining social, environmental, and biological research allowed for a holistic understanding of the distinctive nature of the Patate tangerines.

Geographic Area Description

This study was conducted in the Patate canton, located in the Tungurahua province in the central Andean region of Ecuador (Lavín *et al.*, 2017). The region boasts a temperate-dry climate, which is well-suited for citrus cultivation, as well as legumes and vegetables (Correa & Granda, 2013).

Figure 1 - Location of producers in the tangerine production area



Tangerine production rises during the months of June and August when temperatures tend to decrease and relative humidity increases (min. 12.4°C and max. 24°C). Topographically, the study area presents moderate slopes ranging from 14% to 55%.

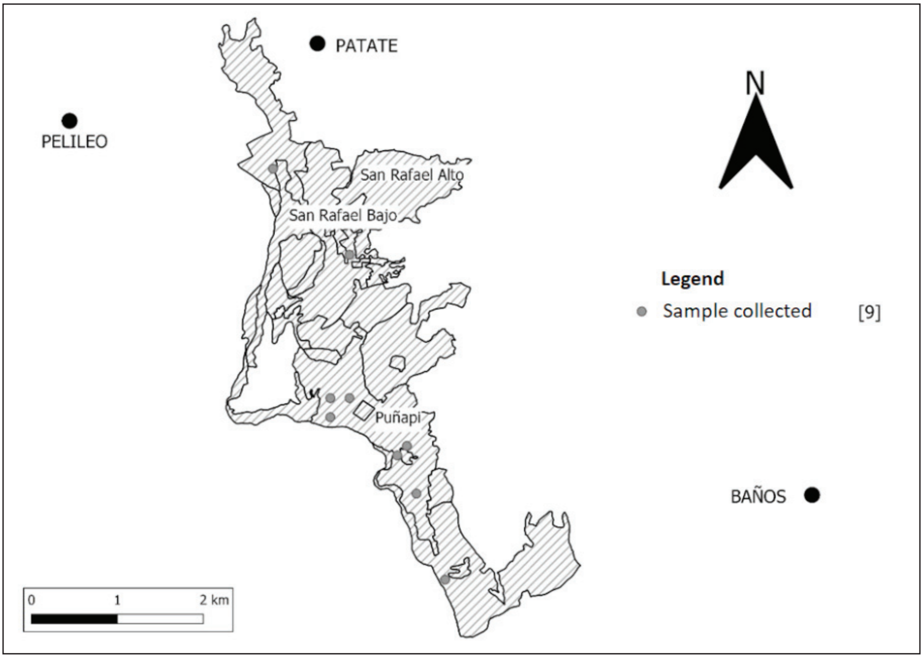
The farms are situated at altitudes ranging between 1,896 and 2,155 meters above sea level. Tangerine samples were collected during the months of March-May 2019. The geographic delineation of the study area followed the approach proposed by Vandecandelaere *et al.* (2010). For this, a Garmin for Global Positioning System (GPS) was utilized. Data derived from the composition analysis of the tangerines were compared with the food composition table of Ecuador (Ramírez *et al.*, 2017) (see Figure 2). A comprehensive soil analysis was conducted, coupled with climate data collection to understand the unique environmental conditions influencing the fruit's properties.

The relative humidity of the environment ranges between 73.2% and 90.4% (PACT, 2012). The annual precipitation in the Patate Valley zone fluctuates between 350 and 1000 mm.

Data collection

To delineate the study area, data on production and farmers' census provided by the local agricultural department were utilized. Primary data was collected through open-ended surveys with local farmers, and members of the association, who provided insights into traditional cultivation techniques, agricultural practices, and local knowledge. The interview applied to the producers was unstructured with open questions, taking Bernal's (2010) methodology for structured questions with a common language adapted to the farmers' comprehension. The validation of the instrument was conducted by experts. In total, nine surveys were established, equivalent to 70% of the members of ASOPUÑAÑI, selected at random.

Figure 2 - Sampling was collected in a random selection of farms



Surveys were conducted in the Puñapi community (including Puñapi, San Javier, and San Rafael Bajo communities) between April and July of 2019 in the farms. The period corresponds to the first cycle of production of the year. Harvest and farm managers were part of the sample analyzed. The georeferenced points signify the locations of tangerine-producing farms involved in the survey (See Figure 1). Participation in this study was voluntary after the researchers communicated the goals and intentions to the farmers' organization in Puñapi. Farmers' knowledge of tangerine production and post-harvest practices were the focus of this study, to understand the common activities that are identified by PDOs. All the surveys were applied in situ to corroborate activities and practices used in tangerine production.

The fruit was obtained in the farms that are part of the Association of Agricultural Production Fine Tangerine of Aroma "ASOPUÑAPI". The harvest was done manually, keeping the peduncle in the fruit. During the harvest, the absence of dew or fog is sought. The containers used in the collection were plastic drawers. The sample was replicated three times and gathered from each farm under identical conditions – manually while preserving the peduncle, with producer assistance, and stored in plastic crates (see table 1). The experiment considered a design of repetition of the analysis to validate the data obtained from each sample.

Furthermore, for the comparison process, the study compiled, following the same procedure, from the neighboring cantons of Pelileo and Baños. The proposal is based on finding differences/similarities in the composition of the fruit between the samples. Tangerine samples were coded based on their origin and stored in breathable bags. They were placed in suitable containers and stored at a temperature of 4°C.

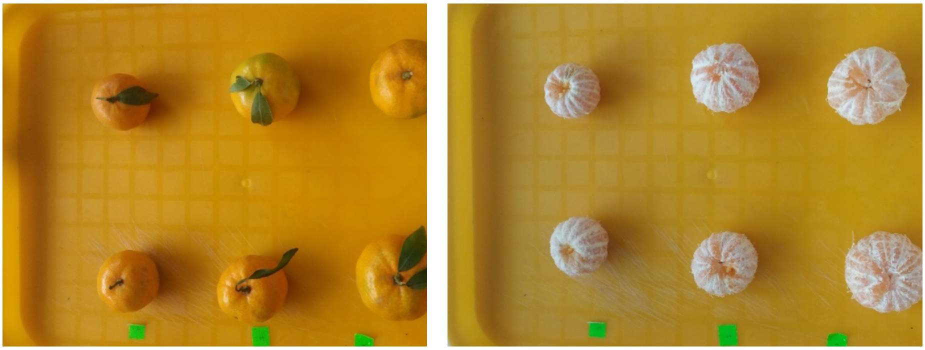
Completely, soil samples involve random collection on the tangerine zone studied, ensuring unbiased representation. Concurrently, temperature and humidity measurements are taken at these random points to capture a comprehensive snapshot of the environmental conditions. Soil analysis was conducted using the FIARG chemical analysis method. The methods employed in soil analysis included the pH/conductivity meter Orión 550A (Electrochemical), Bouyoucos Blender (Bouyoucos), Gravimetric, Kjeldahl, and Olsen Mod methods.

Sample analysis

The tangerines' organoleptic qualities such as color, aroma, taste, and size were evaluated through laboratory analysis. Furthermore, quantitative measures like the fruit's juice content, maturity index, and soluble solids content were assessed following the standards set by the Codex Alimentarius Commission.

The fruit samples were classified to discard those with bumps, bruises, insect damage, or foreign odors and then washed and classified according to current standards (FAO, 1999; NTE-INEN-1930, 1992) (see Figure 3).

Figure 3 - Classification of collected tangerine samples



The number of soluble solids present in the tangerine juice was assessed using a HANNA digital refractometer with a range of 0-85°Brix at room temperature (20°C). Subsequently, the pH of the juice was determined using a Mettler Toledo Seven Compact digital potentiometer, and acidity was measured using a Mettler Toledo G-20 Compact potentiometric titrator. The fruit's maturity index was estimated using the ratio of soluble solids to acidity (Arias & Toledo, 2007). The fruit's moisture content was determined using an MRC MB50 digital moisture balance with an approximation of ±0.0001g, utilizing the infrared light method. For this, 5g of homogenous, seed-free sample was weighed, adhering to the procedure outlined in the standard (NMX-F-428, 1982).

The fruit's weight was recorded using an analytical balance with an approximation of ±0.001g. The polar and equatorial diameter measurements were made using a Vernier caliper. The color index was determined by sampling five points on the fruit, thereby obtaining the CIELab parameters (L*, a*, b*) (Villalba *et al*., 2017). Physical properties such as volume were analyzed using the water displacement method (Alvarado, 1996). The physical and chemical characteristics of the fruits were classified into first, second, and third classes, considering the fruit's diameter and weight. The classification was done according to the current NTE-INEN 1930 standard for fresh fruits, the Codex Alimentarius-FFV-14 standard, and the CEPE standard for citrus fruits.

Virtuous Circle

For this study, two stages of the Virtuous Circle proposed by Vandecandelaere *et al*. (2010) were implemented: (1) Identification and (2) Proposal for Qualification, as they represent the study phase in the methodology of PDO labels. This methodology is based on the phases of the virtuous circle of quality, linked to origin. Within each phase, specific activities are developed that allow producers to appreciate a product's potential for achieving a PDO.

The study focused on the method where it is observed a unique blend of a region's natural resources and the inherent human skills and traditions, leading to the production of distinctive items. These products, due to their unique attributes, gradually establish a market reputation. As their reputation solidifies, they attain a higher market value, with consumers more inclined to pay a premium for their unique qualities. The ensuing economic benefits encourage producers to further invest in maintaining the product's distinctiveness, emphasizing its quality and deep-rooted traditions.

Data systematization

The study employed a meticulous systematization methodology, as outlined by Kothari (2004). This approach began with a thorough data collection phase, utilizing open-ended surveys and comparative sample analyses. The gathered data was then systematically organized into structured matrices and tables, facilitating ease of interpretation and comparison. This structured data was subsequently analyzed to discern patterns and insights, with a particular emphasis on the nuances of tangerine production and the significance of PDO and Geographical Indications. To ensure the study's robustness, we integrated pertinent references, including insights from the Ecuadorian national institution of normalization.

Qualitative Data Analysis

Excel was used for data handling, and the MAXQDA 2018 software was employed for analyzing discourses derived from semi-structured surveys. Through this, qualitative data analysis was conducted, employing a system of codes and subcodes by the research hypothesis. The results were then graphed, and their similarities were evaluated.

A Garmin brand GPS was used to identify georeferenced sampling points. The QGIS Desktop 2.17 software was used to develop the maps.

3. Results

Information from open-ended surveys and similarities in agricultural practices were discerned, particularly in the domain of fruit harvesting. Furthermore, a comparative analysis was conducted between samples from two distinct sectors, Patate (study area) and Pelileo-Baños (counterexample), to determine differences and similarities in the fruit's composition. This analysis encompassed parameters such as humidity, fat content, fiber, ash, and color index. The subsequent results section delves into the detailed findings from these evaluations, presenting a matrix of similarities, compositional analyses, and physicochemical characteristics of the tangerines, offering insights into the nuances of tangerine production and its inherent qualities.

Cultural Practices

As for agricultural practices for tangerine production, similarity in discourse was assessed through open-ended surveys. (See Table 1). The results indicate a strong correlation in the responses of the different producers. A value greater than 0.7 agrees with producers regarding the harvesting and post-harvest practices.

Table 1 - Results of qualitative data from farmers' surveys

Producer	**P001**	**P002-P003**	**P004**	**P005**	**P006**	**P007-P008**	**P009**
P001	1	0,79	0,77	0,71	0,81	0,69	0,7
P002-P003	0,79	1	0,72	0,85	0,84	0,78	0,72
P004	0,77	0,72	1	0,76	0,77	0,76	0,67
P005	0,71	0,85	0,76	1	0,83	0,81	0,73
P006	0,81	0,84	0,77	0,83	1	0,76	0,7
P007-P008	0,69	0,78	0,76	0,81	0,76	1	0,69
P009	0,7	0,72	0,67	0,73	0,7	0,69	1
Average	0,75	0,78	0,74	0,78	0,79	0,75	0,7

* P00* represents a code for each survey.

Table 1 shows the degree of similarity in crop maintenance techniques, especially focusing on fruit harvesting practices, among the different producers (P001 to P009). The values represented a range from 0.67 to 0.85, with an average similarity score of 0.75, well above the 0.7 threshold. This suggests a substantial agreement among producers, reflecting a shared knowledge and practice concerning tangerine production in the area.

In particular, the most significant similarity is found between producers P003 and P005, with a score of 0.85. This high similarity score implies that these producers employ highly comparable practices and techniques in their tangerine cultivation.

Conversely, the lowest similarity score, 0.67, is between P004 and P009, suggesting slightly more divergence in their practices compared to others. Nonetheless, it is important to note that even this lowest score is close to the overall average, indicating that a common base of knowledge and procedures exists across the interviewed producers.

Soil

Regarding soil conditions, the area is dominated by Mollisols and Inceptisols classes, with a sandy texture, including Sandy Loam and Loamy Sand. The soil pH should ideally be close to neutral, but the range typically falls between 7.38 and 8.16. The soil analysis (PM006-L1 and PM007-L1) indicates the presence of Inceptisol soils. Furthermore, soils with loamy textures are identified. For the samples taken at point PM006-L1, there is organic matter – OM (2.1% OM), which compared to PM007-L1 has a high variation (37.1% OM). Likewise, the soil pH is within a range of 7.5 to 8.5 pH. For the nitrogen analysis for PM006-L1, the content is 16 ppm, whereas the average nitrogen content in the PM007-L1 sample is 37.1 ppm.

Sensory characteristics

The proposed analysis establishes the comparison of samples from two sectors (Patate – study area and Pelileo – counterexample). The content of fat, fiber, and ash show significant differences ($p<0.05$) between the two cultivars analyzed, the composition of the fruit varies according to environmental and agronomic factors. In the same way, they are higher than those reported for fruits Clementines: Fat 0.4%, Fiber 2%, and Ash 0.31%.

Table 2 - Composition analysis in Tangerine

Parameters	**Sample**	**Witness**
Humidity (%)	85,25 ± 0,36a	85,60 ± 0,17a
Fat (%)	0,91 ± 0,04a	0,74 ± 0,07b
Fiber (%)	5,51 ± 0,35a	8,04 ± 0,69b
Ash (%)	0,61 ± 0,05a	0,71 ± 0,02b

* Different superscripts indicate significant differences between samples.

Humidity

The humidity in the samples does not present significant differences ($p>0.05$). The value obtained is similar to that reported in the food composition table, where a water content for tangerine of 85.17% is presented (Fabroni *et al.,* 2016).

Color

Fruit color evaluation shows, according to the data presented in Table 3, a significant difference was observed in the coordinates a* and b* ($p < 0.05$). These correspond to variations in the yellow-orange hue of the fruit (intense yellow), related to its degree of maturity.

Table 3 - Determination of Color Index in Tangerines

Parameters	**Sample**	**Witness**
L*	61,46 ± 2,33a	63,15 ± 0,45a
a*	15,37 ± 5,52a	22,88 ± 3,69b
b*	60,24 ± 4,27a	69,71 ± 2,13b
Color Index (100×a*/L*×b*)	0,41 ± 0,13a	0,52 ± 0,10a

* Different superscripts indicate significant differences between samples.

The results obtained present a Color Index – CI: 0.41±0.13, which represents a yellowish hue in its bark because it is in the first quadrant with a HUE angle greater than 60°. These results are comparable with those presented by Fabroni *et al.* (2016) for clementine fruits, especially in subtropical areas. For the volume of the samples, a significant difference was observed in its similarity to the canton Pelileo ($p<0.05$).

Physicochemical evaluation

Table 4 shows the physicochemical evaluation where the weight presents significant differences ($p<0.05$) for its similars, obtaining a value of 70.57±10.38 g, this value is similar to that reported by other authors for Clementine.

Table 4 - Physicochemical characteristics evaluated in tangerines

Parameters	**Sample**	**Witness zone 1**	**Witness zone 2**
Physicists			
Weight (g)	70,57 ± 10,38a	96.90 ± 12.1b	98 ± 1,23
Equatorial diameter (cm)	5,50 ± 0,27a	6,27 ± 0,23b	5,0 ± 0,44
Volume (cm^3)	72,40 ± 10,06a	103,33 ± 13,66b	96,3 ± 12
Juice content (%)	44,79 ± 4,85a	45,83 ± 4.68a	–
Shell (%)	25,75 ± 3,84a	27,07 ± 3,82a	22,6 ± 3,7
Chemists			
pH	3,84 ± 0,17a	4,05 ± 0,17b	4,97 ± 0,04
SST (°Brix)	12,02 ± 1,16a	10,97 ± 0,87a	6 ± 0,2
Titratable total acidity (%)	1,18 ± 0,25a	0,79 ± 0,12b	0,9 ± 0,23
Maturity Index (OSH/ATT)	10,64 ± 2,67a 6:1	13,94 ± 2,14a 7,5:1	9,52 5:1

* Different superscripts indicate significant differences between samples.

Due to the existing variability in both shape and size, the tangerine weighs 70-100 g with a size that varies from medium to small. The pH value presents significant differences ($p < 0.05$) between the two samples of tangerines analyzed; the highest value was obtained for the fruit from the Pelileo canton. Moreover, °Brix, and SST/AAT degrees, no significant difference was found in the samples. (see table 4). Regarding the percentage of total titratable acidity, it can be observed that there are significant differences ($p < 0.05$), finding higher content in the fruit of the Patate canton. This variation is due to several factors that directly affect the acidity of the fruit, among them the use of fertilizers, the growing season, the choice of the graft holder, environmental factors such as temperature, the brightness of the day, the climatic season, or even the irrigation water.

Evaluation of the Virtuous Circle

Based on the interview findings, it is identified the practices employed in the sampled agricultural sites. The plantations are, on average, four years old, with two harvests per year. Pruning and maintenance activities are manual, as is the application of fertilizers and pest control measures, which adhere to the Good Agricultural Practices (GAP) guidelines established by the Ministry of Agriculture. The evaluation is presented in Table 5.

Table 5 - Virtuous circle analysis for the Patate's tangerine

Virtuous Circle Factors	Analysis
Natural and Human Factors	• Unique Soil Conditions: Dominance of Mollisols and Inceptisols classes, specific pH ranges, organic matter percentages, and nitrogen content. • Shared Knowledge Base: Strong consistency in tangerine production practices across different producers indicating shared tradition and knowledge (see Table 1). • Traditional Techniques: Use of specific grafting options based on soil conditions, manual pruning and maintenance, adherence to Good Agricultural Practices (GAP) guidelines, and distinct irrigation systems.
Product Characteristics	• Distinctive Sensory Properties: Unique color, aroma, taste, and high juice content of Patate tangerine. • Physicochemical Characteristics: Parameters like pH value, °Brix, SST/AAT degrees, and percentage of total titratable acidity highlight the fruit's superior quality and the influence of various factors such as soil condition, cultivation practices, and environmental variables. • Compliance with Standards: Satisfaction and exceeding of the Codex Alimentarius Commission's standards, making it a prime candidate for differentiation in the market.
Reputation	• Distinctive Branding: The presence of a distinctive brand, logo, and packaging emphasizing the fruit's origin and unique qualities. • Identity Preservation: Emphasis on labels like "Fine Aromatic Mandarin" ensures consumer trust and authenticity of the product.
Economic Value	• Premium Quality: The unique characteristics and rigorous standards adhered to for the fruit ensure it can command a higher price in the market. • Packaging Strategies: Use of specific packaging dimensions, logos, and labels emphasizing the origin "Patate" ensures that the fruit's identity and quality are communicated effectively to consumers, further supporting its economic value.
Reinvestment	• Commitment to Quality: The strong consistency in cultivation practices, marketing strategies, and commitment to quality among Patate mandarin producers indicates a dedication to maintaining and further enriching the product's quality. • Preservation of Traditions: The emphasis on traditional cultivation methods and adherence to local guidelines ensures that local traditions and practices are upheld and further invested in.

Table 5 - continued

Virtuous Circle Factors	**Analysis**
Enhanced Natural and Human Factors	• Continuous Improvement: The cycle of investment and reinvestment in both natural and human factors, from soil quality to cultivation practices, ensures the continuous enhancement of the Patate quality. • Sustainable Growth: By upholding and investing in traditional practices and local resources, there's a sustainable growth trajectory, ensuring its continuous quality and reinforcing its potential for achieving a PDO status.

The analysis reveals that Patate's tangerine has an origin from plantations 40 years old. During the harvest, farmers rely on parameters such as color, the presence of peduncles, and the necessity to avoid damage to the fruit caused by rainfall or physical impact. The fruits are sorted into six classes based on size and quality and then packed into boxes weighing 20 pounds. The fruit is marketed directly from the farms at current market prices.

Cultivation techniques

It includes the use of tools such as hoes or spades for weed clearance. The planting density for tangerine varies from 5×5 to 6×6, depending on the terrain's slope. The plants and grafts used must be free from pests or diseases. Organic fertilizers such as biol, compost, cattle manure, and chicken manure are used to enhance the soil's physical, chemical, and nutritional properties. Depending on the soil conditions, grafting options include lime for poorly drained soils, lemon-tangerine for sandy soils, or bitter orange or sweet lemon.

A vigorous rootstock and a tangerine bud with more than a year's production are selected. Pruning is performed after the tangerine tree's second year of production when the plant is young. In plants with a good fruiting period, it is performed annually to eliminate dead or diseased branches. Irrigation is conducted weekly, with each farmer having a distinct irrigation system, either flood or focused. The area relies on underground springs for its water supply.

During the harvest, ripe tangerines with the appropriate commercial maturity level are picked. The fruit should be at least one-third yellow and harvested with a peduncle. Scissors are typically used to avoid pulling on the branch and causing the fruit's skin to peel off, with a cut made 1 to 2 centimeters from the peduncle.

Commercialization

The sampled farms have a brand and product logo. The logo carries the name of the origin for identification and differentiation, with representative colors based on orange and green. To maintain its origin identification, the fruit must be sold in corrugated cardboard containers, each weighing approximately 20 pounds. The containers' dimensions are 19 cm high, 30 cm long, and 23 cm wide. The external part of the packaging must bear the name "Tangerine" and the origin "Patate", along with the corresponding distinctive seal. The label authorized by the appropriate regulatory entity must state "Protected Designation of Origin" and the distinctive name "Fine Aromatic Tangerine" or "Patate Tangerine".

Overall, this comprehensive evaluation of the "Virtuous Circle" underscores the strong consistency in cultivation practices, marketing strategies, and commitment to quality and origin recognition among Patate tangerine producers. It thus provides robust evidence of the potential for a successful PDO status for these exceptional fruits.

Fruit Quality Characteristics

The Patate tangerine exhibits an optimal Maturity Index (MI) of 10. The results suggest that the soluble solids content is high, and the MI fluctuates in a range exceeding 10. Both mature and immature fruits maintain a satisfactory quality level and pleasing organoleptic characteristics.

According to the CX-FFV-14 standard (Codex Alimentarius Commission. CEPE Standard for Citrus Fruits FFV-14, 1998), the juice content should exceed 40%, manually extracted through pressing. The Patate tangerine boasts a juice content higher than 45%.

The fruit exhibits a color range from immature (greenish) to intense yellow, without reaching the typical orange color of citrus fruits from tropical regions. This parameter is measured using colorimetry as the Color Index (CI). Moreover, the fruit exhibits an aroma that producers categorize as "Fine". Beyond being fine or soft, the aroma is deep, a characteristic distinctive to the Patate tangerine. Similarly, the taste is classified as sub-acidic, which is characteristic of this tangerine variety. The acidic taste is tempered by the fruit's sweetness, making it a preferred choice as a snack.

The exceptional organoleptic properties of Patate's tangerines, characterized by their unique color, aroma, taste, and high juice content, contribute significantly to their high-quality status. These attributes not only satisfy the standards established by the Codex Alimentarius Commission but also offer a unique and enjoyable sensory experience to consumers. This bolsters the case for the recognition of Patate tangerines as a high-quality, distinctive fruit, reinforcing their potential for a PDO status.

Table 6 - Optimal months of fine aroma tangerine production

Season	**Production period**
Loud	February-August
Optimal	June
Casualty	September-January

4. Discussion

The effectiveness of PDO transcends mere market differentiation and encompasses broader dimensions of environmental sustainability and territorial development. From a market perspective, PDO provides products with a competitive edge, often leading to premium pricing and enhanced consumer trust, as evidenced by Skuras and Vakrou (2002) in their study on origin-labeled wine. Environmentally, PDO can promote sustainable agricultural practices, as products must adhere to specific regional practices to attain and maintain the designation, which often means preserving traditional methods that are environmentally benign (Belletti *et al.*, 2015). Furthermore, from a territorial development viewpoint, PDO can stimulate local economies by boosting tourism, fostering entrepreneurship, and preserving cultural heritage, creating a holistic growth model that integrates economic, environmental, and social pillars, as underscored by Bramley *et al.* (2009) in his evaluation of the economic impact of PDO status on regions.

Agricultural practices and related research from various regions highlight the intricate interplay of natural and human factors in shaping the unique attributes of agricultural products. In Mexico region (Rodríguez, 2007), there have been other studies that delve into agricultural practices and their implications on the local community. For instance, a study aimed at characterizing agricultural practices in the community in Oaxaca mentioned a phenomenon of multi-activity among producers (López, 2018), where agricultural activities are combined with other forms of work, which is key to sustaining agricultural labor in the region.

The examination of agricultural practices for tangerine production revealed a strong correlation in the methodologies employed by different producers. The similarity matrix (Table 1) underscores a shared knowledge base among the producers. With an average similarity score of 0.75, the findings suggest a cohesive approach to tangerine cultivation. This cohesion is further evidenced by the high similarity scores between certain producers, such as P003 and P005, pointing towards highly analogous practices. These findings resonate with other studies, highlighting the importance of standardized practices in enhancing product quality and consistency, crucial prerequisites for PDO status (Jones *et al.*, 2005). This is in line with studies on other citrus fruits, suggesting that soil type, combined with other environmental factors, plays a pivotal role in determining the fruit's quality and distinctiveness (van Leeuwen *et al.*, 2018). Moreover, the presence of organic matter and variations in pH within the studied range further underscores the unique soil conditions favorable to Patate tangerine cultivation.

The Patate tangerine's distinct organoleptic properties, characterized by its unique aroma, taste, and color, place it in a favorable position for PDO recognition. This reinforces the notion that the Patate tangerine offers a unique sensory experience, distinguishing it from other citrus fruits. David *et al.* (2019) observed similar unique organoleptic characteristics in fruits from specific regions, further emphasizing the role of terroir in shaping these properties. Furthermore, results show a profile of the tangerine which information is similar to studies on citrus fruits from other regions that have similarly emphasized the role of terroir in shaping their unique organoleptic properties (van Leeuwen *et al.*, 2020). Thus, considering the amassed evidence from our study and the benchmarks set by similar research, the Patate Tangerine appears well-positioned to achieve PDO status, offering it protection and differentiation in the global market.

Such recognition of a PDO as a primary product not only elevates its market value, often allowing producers to command premium prices but also incentivizes reinvestment into local traditions and resources, thus perpetuating a virtuous circle of continuous product quality and regional development (Lou *et al.*, 2023). As observed in the case study, the interplay between natural and human factors, product characteristics, reputation, and reinvestment play a pivotal role in driving economic prosperity for the Andean region of Ecuador (Grijalva, 2020).

Conclusions

Comprehensive research showcases that the Patate tangerine variety (*Citrus reticulata*. Blanco) distinctively meets the criteria for PDO status, setting it apart from other citrus cultivars in the Tungurahua province. The fruit's unique attributes, deeply rooted in Patate's climatic and soil conditions combined with traditional agricultural practices, emphasize its potential for PDO recognition. Advocating for its acknowledgment under the "Mandarina

Patateña" label not only stresses the fruit's distinctiveness but also underlines the importance of preserving the region's agroecological traditions and enhancing the local farming community's socioeconomic prospects.

However, while the study underscores the Patate tangerine's potential for PDO recognition and the associated economic benefits, it also highlights certain limitations. The emphasis on traditional agricultural practices might pose challenges to scaling production to meet potential increased demand. Furthermore, a broader study scope could unveil additional factors influencing the fruit's characteristics within the Tungurahua province.

For future research can focus on merging sustainable farming practices with technological interventions to maintain the fruit's unique qualities while expanding production. Additionally, a deeper socio-economic analysis and comparative studies with other citrus varieties can offer further insights into the Patate tangerine's distinctiveness and its position in the global market.

Data Availability Statement

The data are available from the corresponding author.

Conflict of interest

The authors declare that there are no conflicts of interest in this study.

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