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Article

Livestock cultural landscape in the territory protected by the Paipa cheese Designation of Origin

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Abstract:

Paipa cheese, the only ripened cheese made from raw cow's milk with a Designation of Origin (DO) in Colombia, reflects a differentiated quality based on a particular livestock cultural landscape. Nevertheless, there are no studies that define or document this landscape as a structured unit that supports such differentiation. This study aimed to analyze the natural, productive, and sociocultural factors that make up the livestock cultural landscape in the municipalities of Paipa and Sotaquirá, to understand their contribution to the territorial differentiation of Paipa cheese protected with a DO. An exploratory-descriptive approach was used, combining participant observation, surveys, and interviews in 24 production systems in the municipalities of Paipa and Sotaquirá during the years 2023 and 2024. The findings reveal that high mountain conditions, the use of adapted breeds, grazing practices with fresh forage, and traditional knowledge transmitted in family environments are central components of the livestock cultural landscape. These elements enable to advance in the

understanding of the link between territory, production system, and agrifood differentiation of Paipa cheese.

Keywords: Milk production, Livestock systems, Grazing, Territorial identity, Differentiated quality.

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Introduction

Designations of origin (DO) are instruments of protection for agrifood products whose differentiated quality is determined by the specific characteristics of the territory where they are produced, integrating natural, productive, and sociocultural factors that influence their distinctive attributes[(1)]. These certifications are based on the interaction of natural and human factors that determine the characteristics of the product, consolidating its identity and differentiation in the market[(2)].

In Colombia, Paipa cheese is the only ripened cheese that has a designation of origin (DO) officially recognized by the Superintendency of Industry and Commerce of Colombia[(3)]. It is made by hand from raw cow's milk in a high mountain region, in the municipalities of Paipa and Sotaquirá, located in the Cundiboyacense Altiplano of the department of Boyacá (Figure 1). This area has a high altitude, cold temperatures, and fertile soils, conditions that, according to the DO Resolution, contribute to generating a favorable environment for the dairy production system that supports the production of Paipa cheese[(3)]. In this resolution, the natural factors are described mainly from the geographical location, the agroclimatic conditions, and the production of milk linked to the use of traditional practices, without describing in detail the livestock landscape that sustains the particularities of the milk with which this differentiated cheese is produced.

Figure 1: Location of the municipalities of Paipa and Sotaquirá in the department of Boyacá and general data of the municipalities (Source: IGAC)

Generalidades del municipio de: Sotaquirá - 15763

Área km 2 municipio	291.56
Cantidad de centros poblados del municipio	2
Cantidad de predios rurales del municipio	7,871
Cantidad de predios urbanos del municipio	431
Cantidad total predios del municipio	8,302

Fuente: IGAC, DANE 2022, Superintendencia de Notariado y Registro 2022, Rama Judicial 2022, Misión de Observatorio Electoral 2022
Realizado: IGAC 2024

The concept of landscape has recently been recognized in the Colombian regulatory field as a key element for the management and planning of the territory. According to Resolution 126 of 2022 of the Ministry of Agriculture and Rural Development of Colombia, the landscape is the result of the interaction between biophysical, sociocultural, and economic factors; this makes it a key unit of analysis for sustainable agricultural and livestock production[4]. In the case of milk production for Paipa cheese, the livestock cultural landscape represents a construction that brings together production systems, traditional knowledge, and environmental characteristics that influence the quality of the product derived from livestock activity[5].

The milk production systems in Paipa and Sotaquirá have been fundamental for the development of Paipa cheese, both for their traditional practices and for their link with the territory. These dynamics shape what can be understood as a livestock cultural landscape: a collective construction that integrates knowledge, environmental conditions, and productive practices. Recognizing and structuring this landscape would strengthen the DO and give greater support to product differentiation[4].

In this context, Resolution 160 of 2022 of the Ministry of Agriculture and Rural Development emphasizes the importance of sustainability and competitiveness in livestock production[6], which highlights the need to articulate territorial assets in the valorization of Paipa cheese.

Although the territorial assets linked to Paipa cheese have been partially recognized, their treatment has been fragmented and lacks strategic articulation, since the landscape that sustains the production of its milk currently remains disconnected from the brand identity and undervalued in its commercial narrative. This disconnection limits the product's potential in specialized markets, where the territorialization of the product is a key attribute of

recognition and prestige valued by consumers[7]. The explicit incorporation of the livestock cultural landscape as part of the identity discourse of Paipa cheese would not only strengthen its differentiation from other cheeses but would also expand its possibilities of competitive insertion in circuits of differentiated quality[8].

Therefore, the purpose of this study was to analyze the natural, productive, and sociocultural factors that shape the livestock cultural landscape in the municipalities of Paipa and Sotaquirá, in order to understand their contribution to the territorial differentiation of Paipa cheese with DO.

Material and methods

The study was conducted in the municipalities of Paipa and Sotaquirá, department of Boyacá, Colombia, during the years 2023 and 2024. This area constitutes the territory protected by the DO of Paipa cheese (ripened cheese made from raw cow's milk), recognized for its differential characteristics linked to the territory[3].

The study adopted an exploratory-descriptive design with a qualitative approach, useful for addressing complex phenomena in which natural, productive, and sociocultural dimensions interact. This type of study makes it possible to identify patterns, characterize territorial configurations, and interpret the meanings attributed by local actors to their productive practices[9,10]. Since the category of "livestock cultural landscape" has not yet been formally delimited in the region, this approach offers a relevant methodological basis for its preliminary identification.

The sampling method used was non-probabilistic, specifically snowball sampling[11]. The strategy began with key informants belonging to the Association of Dairy Producers of Sotaquirá (COAGROSOTAQUIRÁ, by its Spanish acronym) and the Association of Paipa Cheese Producers (ASOQUESOPAIPA, by its Spanish acronym), who recommended other producers with a history in the production of milk for Paipa cheese.

Twenty-four production units were selected (12 per municipality), which met the following inclusion criteria: a) Active participation in the production of raw milk for Paipa cheese; b) Minimum experience of 5 yr in the territory; and c) Linkage with local productive networks. The sample size considered was sufficient to reach saturation[12], since the participants offered in-depth and significant information for the analysis[13].

Three complementary techniques for collecting information were applied (Table 1) as part of the methodological triangulation, which made it possible to contrast findings from different angles and strengthen the internal validity of the study[14,15,16]. The qualitative information was analyzed by axial coding, organizing the findings into three main dimensions: natural, productive, and sociocultural factors. The quantitative data were analyzed with basic descriptive statistics, allowing to visualize trends and support the general characterization of the production systems.

Table 1: Data collection techniques, indicators observed, and level of analysis

Data collection technique	**Indicators**	**Axial coding**
Participant observation	1. Environmental conditions 2. Climate and temperature 3. Water availability 4. High mountain ecosystems 5. Pastures and forages 6. Agroecological conditions 7. Symbolic elements 8. Feeding practices 9. Herd composition and genetics 10. Infrastructure and equipment	Herd management practices, interaction with the landscape, water use, livestock infrastructure, and the presence of symbolic elements were documented.
Semi-structured interviews	1. Scale and structure of the farm 2. Milking system 3. Herd composition and genetics 4. Organization of family work 5. Distribution of roles and activities 6. Transmission of traditional knowledge 7. Productive practices with cultural value 8. Material and symbolic culture 9. Festive practices and local expressions 10. Knowledge of product differentiation	Narratives about milk quality, the role of traditional knowledge, territorial identity, and intergenerational transmission of knowledge were explored.

Structured surveys	1. Milking system 2. Feeding practices 3. Herd composition and genetics 4. Reproductive management 5. Infrastructure and equipment 6. Records and traceability 7. Relationship with the market and the Paipa cheese DO 8. Distribution of roles and activities 9. Guild and associative participation 10. Knowledge of product differentiation	Quantitative data were collected on agroecological characteristics, livestock feeding, cattle breeds, production volume, and labor organization.

Results

Natural factors that constitute the livestock cultural landscape of Paipa cheese

Paipa cheese is distinguished by being produced in a high mountain environment, characterized by a rugged geography and a cold climate that directly influence milk production. The municipalities of Paipa and Sotaquirá, located in the department of Boyacá, have a semi-undulating or undulating mountainous topography, with moderate slopes and altitudes ranging between 2,500 and 3,600 m asl. The details of the municipalities are described in Figure 1. The farms studied in Paipa and Sotaquirá are located between 2,500 and 3,100 m asl, with 67 % concentrated at altitudes between 2,500 and 2,600. The physiography of the observed territory is characterized by the presence of mountains that act as watersheds, both in the municipality of Paipa[17] and in the municipality of Sotaquirá[18].

In most of the farms observed, producers reported good pasture productivity, associated with soils with good organic matter content, dark in color, and with a clayey loam texture; these characteristics coincide with the common properties of soils derived from volcanic ash, present in the region[19,20]. The high mountain climate has average temperatures of 12 to 14 °C, with marked oscillations between day and night. There are minimum temperatures close

to 8 °C and maximum temperatures of 20 °C. Frequent frosts at the beginning of the year cause temperature drops below 0 °C and physiological damage to forage.

The páramos of Guantiva and La Rusia play a crucial role in the water supply of the observed territory. The páramo is a high Andean ecosystem that is located between 3,000 and 4,500 m asl, characterized by its unique vegetation, such as *frailejones* (*Espeletia* spp.), *pajonales* (*Calamagrostis effusa*), and cold-resistant shrubs such as *romerillo* (*Hypericum laricifolium*); this ecosystem plays a vital role for the entire territory as a natural water regulator, acts as a sponge that captures moisture from the air, and releases water gradually, maintaining the flow of the rivers that supply the production systems[17,18]. Among the most important bodies of water are the Chicamocha and Chontales Rivers in Paipa, and the Vargas, Sotaquirá, Piedras, and Ocusa Rivers in Sotaquirá. Although 42 % of the farms capture water from streams born directly in the páramo, 100 % depend on this ecosystem directly or indirectly through village aqueducts, springs, streams, and reservoirs. In all the cases observed, the point of access to water is located within the pasture, eliminating the need to move cattle to external water sources and ensuring better availability of water resources.

The ecological component also included natural runoff and drainage that use the land's contour lines to prevent waterlogging, as well as forest cover on the edges of streams or reserve areas within the farms, where species such as Andean alder (*Alnus acuminata*), Humboldt's willow (*Salix humboldtiana*), *tilo* (*Sambucus peruviana*), and elderberry (*Sambucus nigra*) stand out, commonly associated with stream edges, living fences, or reserve areas. These species, characteristic of the natural environment of the territory, fulfill shade, water protection, and animal feeding functions and are recognized in the territory for the ecosystem services they represent[21].

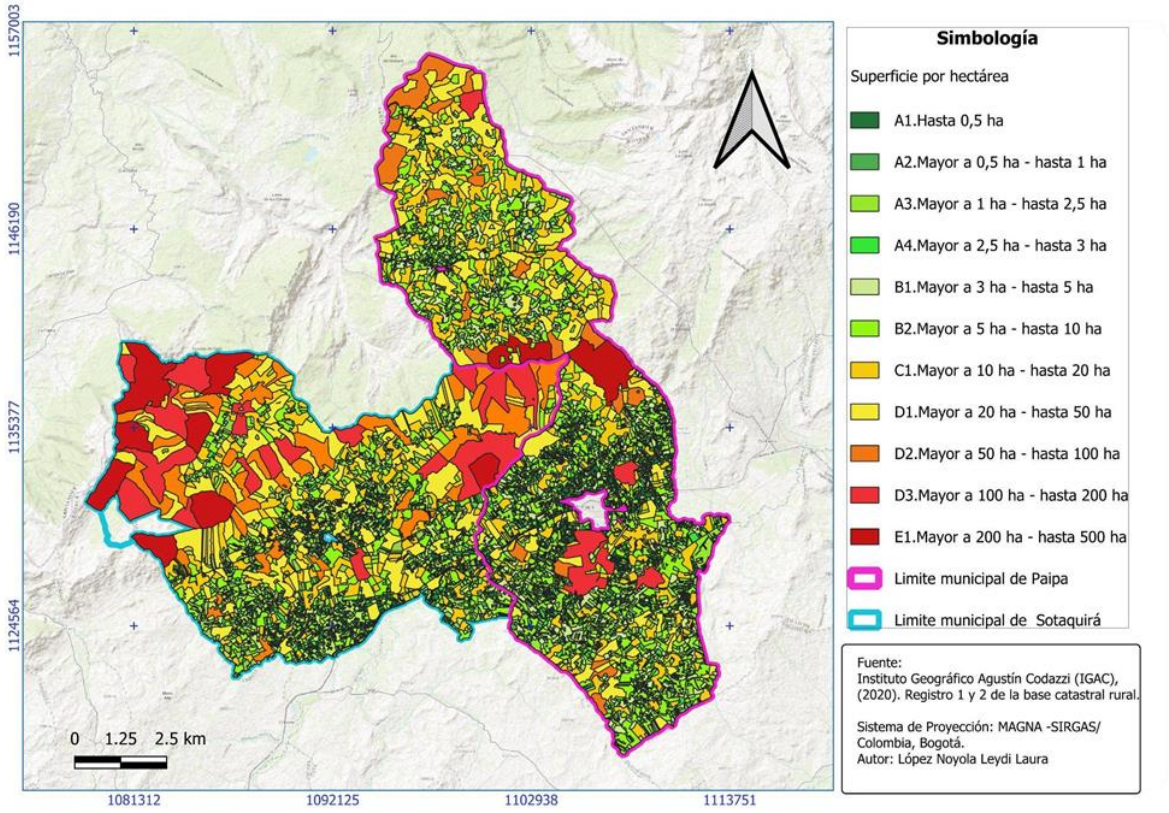
Productive factors in the construction of the livestock cultural landscape

In the municipalities of Paipa and Sotaquirá, more than 90 % of the farms dedicated to dairy farming have an area of less than 5 ha (Figure 2). On the farms observed in this study, 74 % had less than 5 ha, and the average area allocated exclusively to grazing was 3.4 ha. Regarding land tenure, 62.5 % of the farms were owned by the producer, whereas 37.5 % operated under family or lease arrangements.

The Normande breed and its crosses with Holstein and Jersey predominate in the region; they are a distinctive characteristic of the production system. In this study, it was observed that 76 % of the cattle farmers manage herds made up totally or partially by Normande,

consolidating its relevance in milk production and its differentiation within the livestock cultural landscape of the Paipa cheese DO.

Figure 2: Size of rural farms in the municipalities of Paipa and Sotaquirá



Dairy production in the region maintains a traditional management, with manual milking as the predominant practice, used by 62 % of cattle farmers, which allows them direct contact with the animals and, in many cases, favors their welfare[22]. However, the need to optimize processes has led 38 % of producers to implement mechanical milking in pastures, adapting this technology on a small scale without losing the essence of traditional practices. This change responds to both the shortage of labor and the search for greater production efficiency. The most common milking practices were teat drying (90 %), pre-dipping (58 %), forestripping (53 %), and dipping (47 %).

In 100 % of the production systems in the study and throughout the territory observed, it was noted that the feeding system is based on direct grazing of fresh green forage managed with an electric rope. Among the forage species, kikuyu grass (*Cenchrus clandestinus*) was present in 100 % of the cases, followed by red clover (*Trifolium pratense*) 96 %, ryegrass (*Lolium perenne*) 58 %, white clover (*Trifolium repens*) 54 %, tufted grass (*Holcus lanatus*) 54 %, forage oats (*Avena sativa*) 17 %, and alfalfa (*Medicago sativa*) 8 %.

During the dry season, the supply of grass decreases, forcing producers to resort to supplementation strategies. Although silage is used as a method of preserving forages in mountain dairy systems in 21 % of the cases observed, in the case of Paipa cheese, there is a restriction on the part of the master cheesemakers of the territory in the use of fermented forages, because, according to their generational experience, they can alter the sensory composition of the milk, resulting in unwanted flavors that affect the quality of the cheese.

To mitigate the reduction in the forage supply without resorting to fermentation, some producers in Sotaquirá have adopted alternatives such as the preservation of hay, especially alfalfa (4 %), which allows them to maintain a stable food source without compromising the quality of the milk. One hundred percent of cattle farmers supplement cattle feed with mineralized salts, whereas 83 % use commercial concentrate feed, and a smaller proportion resort to supplementation with alfalfa hay (4 %), grass or corn silage (21 %), crop residues (29 %), or corn (13 %). In 42 % of the farms, silvopastoral systems are implemented that integrate species such as tilo (*Sambucus peruviana*), elderberry (*Sambucus nigra*), and Andean alder (*Alnus acuminata*), used for animal feed, shade, and living fences.

On the farms observed, the predominant reproductive system was artificial insemination, implemented in 75 % of the cases. In relation to reproductive parameters, most producers reported age at first calving between 30 and 36 mo, an interval between calvings of approximately 1.5 to 2 yr, and an open days interval between 100 and 150.

One hundred percent of producers vaccinate against brucellosis and foot-and-mouth disease, as a mandatory requirement for the sale of raw milk in Colombia; likewise, it was corroborated that 71 % of cattle farmers have adopted good milking practices. In addition, 79 % of producers allocate more than 90 % of their milk to the production of Paipa cheese, which is marketed through direct links with processors.

Sociodemographic factors in the livestock cultural landscape

The information collected in the observed livestock units allows to characterize how the family environment, the organization of work, and the intergenerational transmission of knowledge are articulated with the dairy activity, providing key elements to understand the social base of the livestock landscape linked to Paipa cheese.

One of the most relevant aspects is the central role of family work in dairy production. In 91.6 % of the farms, productive work is carried out mainly by members of the domestic group, either exclusively or with occasional support from external workers. The households

are small in size (between 2 and 5 members), and in 83.3 % of cases, at least two people from the family nucleus participate directly in livestock tasks.

Labor participation shows both a generational and gender balance. There is an equitable distribution between men (51 %) and women (49 %), and an active presence of different age groups, which reflects a logic of family co-responsibility in the activities of the productive system. This organizational model favors the transmission of practical knowledge and strengthens the sociocultural sustainability of the dairy system.

The production system is mainly composed of smallholdings (Figure 2), which limits expansion and technification, but reinforces the close links between producers and their environment. Knowledge applied to animal feeding, health, reproduction, and behavior does not come from formal technical training, but from direct observation and experience accumulated over the years. In fact, 62 % of the producers mentioned having more than two decades of experience in the livestock activity.

In addition, 83 % of cattle farmers indicated that they could recognize the health status of their cows without the need for electronic records or automation, based on daily observation of animal behavior. Activities such as milking require continuity with the same person, since, according to the producers, the cows "do not recognize" a stranger and do not release the milk. This type of relational knowledge represents a know-how that is not institutionalized, but is central to the daily operation of the system and the quality of the product.

Regarding guild participation, 54.2 % of the producers are affiliated with a cooperative, 25 % with local associations, and 20.8 % are not part of any formal organization. Although there are daily relationships with buyers, neighbors, and processors, the level of institutional articulation around Paipa cheese is still limited, which constitutes a challenge for the territorial governance of the product.

Symbolic-cultural elements of the livestock landscape

Beyond its economic dimension, the dairy system of Paipa and Sotaquirá incorporates cultural and symbolic elements that reinforce its territorial identity. These aspects are fundamental in the construction of the differentiating narrative of the Paipa cheese livestock cultural landscape.

One of the most representative elements is the use of the wool ruana, a traditional garment made by hand with virgin wool from sheep. Its use in productive work was reported by 71 %

of the observed producers. This object of material culture has been institutionalized through the National Festival of the Ruana and the Pañolón, held annually in Paipa, which shows its identity value for the region.

In the architectural field, although there are still vestiges of traditional adobe constructions (8 % of the farms), the use of brick (68 %) as a building material predominates. This trend indicates a progressive loss of rural heritage elements, although material expressions of peasant culture persist.

The productive calendar is also intertwined with religious celebrations and local festivities. Among the most representative are San Isidro Labrador (42 %), La Virgen del Carmen (50 %), and La Cruz de Mayo (38 %). In these events, it is common to bless animals, hold livestock fairs, and sell traditional dairy products, such as *almojábanas* (a type of bread). These festivities reflect a symbolic integration between livestock work and community religious practices.

Another central attribute of livestock know-how is related to the empirical assessment of the sensory characteristics of milk, a key input in the production of Paipa cheese. Producers highlight fat content (92 %), freshness (88 %), and flavor (71 %) as fundamental qualities, and these attributes are perceived as direct indicators of quality. These criteria coincide with the preferences expressed by the traditional cheesemakers of the region, which shows the existence of a technical-cultural consensus among actors in the system on the sensory parameters that should characterize milk destined for artisanal processing.

This type of knowledge, although not institutionalized, contributes to the construction of shared standards that reinforce the territorial identity of the product and sustain its differentiation. In contexts where quality is based on both the sensory and the symbolic, this convergence of criteria between producers and processors constitutes a strategic asset to consolidate the positioning of Paipa cheese as a heritage food linked to its territory of origin.

Discussion

The livestock cultural landscape linked to Paipa cheese constitutes a dynamic territorial construction, in constant transformation based on the interaction between natural, productive, and sociocultural factors. Its recognition not only strengthens the differentiation of the product with DO but also provides a structural basis for its comprehensive valorization and sustainability.

According to Resolutions 126 and 160, the livestock system should be understood as a unit that brings together traditional practices, environmental conditions, and local knowledge that have a direct impact on the quality of milk and cheese[4,5]. Nonetheless, these regulatory frameworks have gaps in the face of recent transformations in the production system, particularly the transition from extensive schemes to intensive low-scale models, characterized by smallholdings and a high dependence on family labor.

The territorial characterization of zones such as Paipa and Sotaquirá reveals particular soil and climatic conditions, which configure an environment conducive to milk production with differentiated attributes[3]. Nevertheless, while the current regulations highlight the suitability of the territory for extensive livestock farming, the findings of this study show an intensive low-scale system, which suggests the need to update the regulatory approach to reflect the current reality of the productive landscape.

Similarly, Resolution 70802 mentions that the slow ripening of cheese is favored by climatic conditions, but omits to address their direct impact on forage production and milk quality[3]. Since seasonal oscillations, frosts, and forage shortages compromise the continuous supply of food, affecting milk production and quality. As documented by Maleko *et al*[23], these factors are critical in high mountain livestock systems, where changes in forage quality and availability can alter the nutritional composition of milk and, therefore, the sensory properties of cheese[24].

In this context, alfalfa hay emerges as a complementary option that maintains the desired sensory profile and maintains high values of protein in milk[25]; however, its use is still minimal. Encouraging fermentation-free preservation practices could strengthen the resilience of the production system without compromising cheese differentiation.

A particularly relevant finding is the strategic role of the páramo ecosystem as a water asset. One hundred percent of the farms observed depend directly or indirectly on sources supplied by the páramo. Despite this, the regulations only mention the basins of the Chicamocha, Chontales, and Tolotá Rivers, without recognizing the role of the páramo as a water regulator or noticing the threats posed by agricultural expansion[26].

Another element undervalued in the regulations is the potential of the remaining forest cover and agroecological and silvopastoral practices, which could strengthen the narrative of the territorial quality of Paipa cheese. Likewise, the feeding based on direct grazing of fresh forages translates into unique sensory profiles. The international award for Paipa cheese at the World Cheese Awards 2021 validates this differentiation by highlighting sensory notes directly associated with the consumption of green grass by cattle[27].

In this context, the use of adapted cattle breeds, such as the Normande, represents both a biological and a cultural resource. These breeds, valued for their efficiency in converting forage into milk with a high solids content, allow complex flavors to develop in ripened cheeses, a characteristic also documented in other protected designations[28].

In the same way, traditional knowledge, transmitted intergenerationally within peasant family units, constitutes a fundamental pillar in the construction of the livestock landscape. This know-how, based on the observation of animal behavior and management adapted to the environment, contrasts with standardized models and reinforces a differentiated quality built from a close relationship with the territory[29].

Nonetheless, the system faces relevant challenges, such as the scarce generational replacement and the weak formal articulation between producers and processors. Although there is active participation of women and men in the nuclear family, the lack of public policies aimed at sustaining production with territorial identity compromises its long-term viability[30]. Likewise, the lack of health certifications limits access to demanding markets, even though producers have adopted safety practices without altering the traditional essence of the system[31].

The symbolic dimension of the territory, expressed in elements such as the ruana or regional festivals, reinforces the authenticity of Paipa cheese as a heritage product. These symbols strengthen the link between material culture and agrifood value, aligning with the principles of Localized Agrifood Systems (SIAL, by its Spanish acronym), where quality is built from territorial roots[32].

Conclusions and implications

The present study allows to identify and characterize natural, productive, and sociocultural factors that make up the livestock cultural landscape of Paipa cheese, evidencing a social and environmental ecosystem that favors its differentiation. This landscape was based on small-scale family production systems located in the high mountains, dependent on páramo ecosystems as a water source, the conservation of which is essential to guarantee the sustainability of the model and its link with the territory. In terms of production, the predominant use of the Normande breed and its crosses, together with grazing cattle on fresh forages, is associated with the generation of differentiated attributes in milk. In the sociocultural aspect, the family organization of work facilitates the intergenerational transmission of practical knowledge and the maintenance of a relational model focused on animal welfare, which constitutes an intangible asset aligned with sustainable models with

territorial identity. The absence of health certifications and the weak institutional articulation pose risks for the preservation and projection of the livestock cultural landscape, which makes it a priority to strengthen the health formalization of the herds and consolidate local governance mechanisms that ensure its sustainability and recognition. The complexity of this landscape, which integrates tangible and intangible assets, raises the need to promote interdisciplinary research that combines physicochemical, microbiological, and sensory analyses of milk and Paipa cheese with participatory studies, to validate their differentiated quality and consolidate a narrative coherent with their tradition, landscape, and regional identity.

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