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Apicultural characterization and sensory analysis of honeys from the Department of Nariño

Caracterización apícola y análisis sensorial de mieles del departamento de Nariño

Alejandra Reina-López[1], Juliana Sabogal-Aguilar[2], Andrés Betancourth-Jurado[1]

[1] Centro Internacional de Producción Limpia–Lope, SENA, Pasto, Colombia, alejitawb16@gmail.com (correspondence), https://orcid.org/0000-0002-8626-2559; andremauricio.bj@gmail.com https://orcid.org/0000-0002-7217-3598

[2] Centro de Pensamiento en Agroecología, Universidad Nacional de Colombia, Palmira, Colombia, jgsabogalag@unal.edu.co, https://orcid.org/0000-0002-5068-8072

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ABSTRACT

In Colombia, the beekeeping sector contributes to the strengthening of the rural economy and promotes the conservation of various strategic ecosystems. For this reason, this study aimed to identify the emergence of beekeeping, characterize beekeepers, and determine the sensory characteristics of honey in the Department of Nariño. Semi-structured interviews were conducted with long-standing beekeepers to identify the origins of beekeeping. Surveys were administered to producers from three identified beekeeping associations. For sensory analysis, honey samples were collected from three geographical zones to identify organoleptic characteristics specific to each area through a sensory panel. The results were analyzed using Multiple Correspondence Analysis (MCA). The results indicate that beekeeping in Nariño is highly heterogeneous and that the strengthening of bee farming originated from the capture of swarms, a product of Africanization. In the characterization of beekeepers, five factors were obtained that explain 44.22% of the variability in beekeeping production in the region; the factor with the greatest variability is related to the size of the productive unit. Regarding the sensory assessment of honey, descriptors for differentiating honey by geographical area were identified. In the sensory evaluation, mild aromas were found in the north, intense sweet and resinous profiles in the center, and complex aromas in the south. Multivariate analysis confirmed consistent groupings between areas, which supports the use of sensory attributes as tools for differentiating honeys and contributes to strengthening the regional beekeeping sector.

Keywords: apicultural practices; beekeepers; honey sensory characteristics; honey quality; Nariño; rural economy; strategic ecosystems

RESUMEN

En Colombia, el sector apícola contribuye al fortalecimiento de la economía campesina y promueve la conservación de diferentes ecosistemas estratégicos. El objetivo de este trabajo fue identificar el surgimiento de la apicultura, la caracterización de los apicultores y las características sensoriales de la miel de abejas en el Departamento de Nariño. Para identificar el surgimiento de la apicultura se realizaron entrevistas semiestructuradas a apicultores de larga trayectoria. Se aplicaron encuestas a productores de tres asociaciones de apicultores identificadas. Para la determinación sensorial, se realizaron muestreos de miel de abejas en 3 zonas geográficas, con el fin de identificar características organolépticas propias de cada zona mediante la implementación de un panel sensorial. Los resultados se analizaron mediante Análisis de Correspondencias Múltiples (ACM). Como resultados, se identificó que la apicultura en Nariño es muy heterogénea y que el fortalecimiento de la apicultura se originó a partir de la captura de enjambres, producto de la africanización. En la caracterización de apicultores se obtuvieron cinco factores que explican el 44,22% de la variabilidad en la producción apícola de la región; el factor con mayor variabilidad se relaciona con el tamaño de la unidad productiva. En cuanto a la evaluación sensorial, se encontraron aromas suaves en el norte, perfiles dulces intensos y resinosos en el centro, y aromas complejos en el sur. El análisis multivariado confirmó agrupamientos consistentes entre zonas, lo que respalda el uso de atributos sensoriales como herramientas de diferenciación de mieles y contribuye al fortalecimiento del sector apícola regional.

Palabras clave: apicultores; calidad de la miel; características sensoriales de la miel; economía rural; ecosistemas estratégicos; Nariño; prácticas apícolas

INTRODUCTION

In Colombia, the beekeeping sector contributes to strengthening the peasant economy and promotes the conservation of different strategic ecosystems (Burgos *et al*., 2022). Bees are insects specialized in visiting flowers, essential for pollination. The pollination of crops and their natural vegetation is an indispensable component of both human well-being and the environmental sustainability (Martinez *et al*., 2018).

Nariño is one of the leading departments in agricultural production and stands out especially for its diversity. In the case of beekeeping, it is developed in low-technical production systems (Rosillo *et al*., 2020). There is little organization among beekeepers, which makes them invisible to government development programs and potential consumers.

Furthermore, technology transfer and technical support in the sector are incipient, which causes producers to adopt new technologies slowly. As a result, the growth of the productive sector remains weak.

In addition to all this, honey is not immune to fraud (Escribano & Cáceres, 2018). It is ranked as the third most adulterated food (APIMONDIA, 2019). In Colombia, counterfeiting of beekeeping products proliferates in all kinds of commercial establishments, and there is little control by the competent authorities (García-Pérez & Fong-Reynoso, 2023).

In this respect, the marketing of honey is a major challenge, as it is impossible to compete on price with counterfeit products (Blas, 2021). Similarly, as a consumer, buying honey is not an easy task when there is so little information about this productive sector and no disclosure of the characteristics of bee honey.

onsequently, it is necessary to generate scientific evidence that allows for the description and comparison of the sensory attributes of the honeys produced in Nariño, to clarify the variability associated with their areas of origin. Under this premise, it is assumed that the honeys of the Department of Nariño present consistent sensory differences among regions, in accordance with the environmental, floral, and productive heterogeneity that characterizes the territory. The consolidation of this knowledge seeks to provide technical bases that contribute to the valorization of the product, as well as to the strengthening and differentiation of the beekeeping sector in Nariño.

MATERIALS AND METHODS

Study area

This study was conducted between February and September 2021, in the Department of Nariño. Three geographical areas of interest were selected: Northern zone (Arboleda, El Tablón de Gómez, and La Unión), Central zone (Pasto, Tangua, and Obonuco), and Southern zone (Ipiales, Córdoba, and Guitarilla). The selection of these areas was based on previously established inclusion criteria, specifically: (i) the concentration of producers linked to legally constituted beekeeping associations and (ii) the presence of beekeepers with more than 40 years of experience in the activity.

Experimental design

Emergence of beekeeping in Nariño. To identify the emergence of beekeeping in Nariño, semi-structured interviews and oral accounts were conducted with 10 beekeepers with

more than 40 years of experience, located in the northern, central, and southern areas of the department. Participant selection was carried out using purposive and snowball sampling, with the sample size defined by theoretical saturation.

The information obtained allowed for the construction of a historical reconstruction of the regional beekeeping process following the methodology of Bastidas and Esquerdo (2021).

Socio-economic, technical, and commercial characterization of beekeepers. The second part consisted of applying a survey to 67 producers belonging to three beekeeping associations of the department: Asociación Agroecocológica de Apicultores de Nariño (ASOAPINAR), Asociación Somos Campo El Tablón de Gómez (ASOCAMPOTG), and Asociación de Apicultores de Colombia (APISCOL). Since the beekeeping associations included in the study have different population sizes, the sample size calculation was performed considering this structural heterogeneity.

To do this, the formula for finite populations proposed by Castillo (2002) was applied, which allows estimating a sample size adjusted to the total number of producers and the expected variability in the population, as presented in Equation 1:

$$n = \frac{N\ Z^2\ p(1-p)}{e^2\ (N-1) + Z^2 p(1-p)} \qquad (1)$$

Where:
n = sample size
N = population size
Z = confidence level
p = expected proportion
e = acceptable margin of error

The use of this methodology made it possible to allocate the number of surveys proportionally to the size of each association, avoiding the over-representation of minority groups and maintaining the correspondence between the population weight of the strata and their participation in the sample. With this procedure, the final sample size was defined based on the weighting of ASOAPINAR, APISCOL, and ASOCAMPO within the total number of producers, guaranteeing a balanced and consistent representation with the actual distribution of beekeepers in the evaluated areas.

Measured variables

The variables evaluated were: gender (V1), age (V2), level of education (V3), family unit (V4), individual activity (V5), external support (V6), formalized enterprise (V7), predominant farming activity (V8), farming activities on the same site (V9), type of estate (V10), reason for which it is engaged in beekeeping (V11), proximity to natural forests (V12), planting of bee plants (V13), type of established forest arrangement [V14], number of apiaries (V15), number of beehives (V16), number of honey harvests per year (V17), kilograms of honey per harvest (V18), honey processing (V19), production of other products (V20), self-consumption of honey (V21), marketing type (V22), presentation for marketing (V23), price per kilogram (V24), and distinctive mark (V25).

Organoleptic assessment of honey. Three honey samples were collected per zone, directly from the producers. Each sample was coded and accompanied by a technical sheet describing the melliferous flora surrounding the apiary, guaranteeing traceability and its subsequent relationship with the sensory profiles.

The sensory panel consisted of 21 participants, representing the entire group of instructors and apprentices in the Technology Control and Quality of Food program at the International Centre for Clean Production LOPE-SENA. The panelists received targeted training to recognize sensory attributes characteristic of honey, including descriptors associated with wax, pollen, propolis, and floral aromas present in the region.

The evaluation was developed following the methodology proposed by Quicazán *et al*. (2018), which establishes the presentation of the samples in randomly coded cups, the use of saltine crackers, water, and coffee powder between samples to avoid sensory saturation, and the prior restriction of perfumes, coffee, and cigarettes to guarantee the sensitivity of the panelists.

A sensory sheet was used, designed for the qualitative recording of the evaluated attributes, which included color, aroma, flavor, texture, presence of impurities, and specific sensory defects (fermented, smoky, metallic, and moldy).

Statistical analysis

The information collected from the surveys and the sensory panel was systematized in the Excel program. Each variable was encoded and assigned exclusive and independent categories. Multiple Correspondence Analysis (MCA) and Cluster Analysis of Producers were conducted using SPAD-Win version 5.6. For the aroma variable, a factorial biplot was constructed based on the 15 most influential aromatic descriptors, using an MCA performed in R with the FactoMineR and factoextra packages.

RESULTS

Emergence of beekeeping in Nariño

In the northern part of the department, respondents reported that Italian bees were introduced around the 1960s. The breeding stock materials and equipment needed for its management were brought by private individuals from the city of Pasto, who purchased farms in the coffee area.

The interviewee's narrative provides information on how beekeeping was established in the region and how he had contact with bees. The narrative also indicates that their training was strengthened by their active participation in the development of bee management activities.

According to their accounts, long-standing beekeepers agree that, through the project "Diversification of coffee areas ", in the 1970s, they had the opportunity to receive more in-depth training on the technical, sanitary, and reproductive management of the species. This was made possible by the beekeeping program created by the Federación Nacional de Cafeteros, which also sponsored some experienced beekeepers from the coffee areas.

In the emergence of beekeeping in the central area, corresponding to the municipality of Pasto and its surroundings, it was identified that many producers started with the swarms produced from the beehives located at CORPOICA (now AGROSAVIA), which were maintained for the pollination of fruit trees.

Although Africanization was an event that brought with it several difficulties, mainly the highly defensive behavior of bees (Gómez-Leyva *et al*., 2022), the interlocutor and other respondents from this sector indicated that the event was an opportunity to start beekeeping. Furthermore, the story shows that the media play a crucial role in the training process of peasants who are in remote regions or who do not have access to other forms of learning (Rojas-Martínez, 2019).

In the southern area, corresponding to Ipiales and its surroundings, bees were present before Africanization. However, beekeeping gained momentum around 1965, when several swarms of bees were found on the banks of the Guáitara River, which aroused curiosity by tasting the honey they produced.

The narrator, like many other interviewed beekeepers, driven by curiosity, captured swarms to obtain honey, regardless of the stings, and found a way to grow them, being currently one of the livelihood activities in the peasant agriculture of the region. Similarly, in other regions of the country, the use and management of honey bees is a productive activity, part of the peasant family economy (Claro *et al*., 2020).

Characterization of beekeepers

Multiple Correspondence Analysis (MCA). The analysis of eigenvalues for the categorical variables evaluated in the characterization of beekeepers showed that the first five factors explain 44.22% of the total variability.

The first factor explains 18.38% of the variability and is called *the size of the bee production unit*, as the variables that contributed most to this factor were the number of beehives, kilograms of honey per harvest, number of apiaries, and production of other beekeeping products. The second factor explains 8.35% of the variability and includes the variables type of marketing, type of presentation used for marketing, number of apiaries, and number of honey harvests per year; in other words, it indicates the variability that exists in *the production and marketing of honey*. The third factor explains 6.47% of the variability and is composed of the type of presentation for marketing, number of apiaries, type of forest arrangement established, and planting honey plants; this factor is referred to as *agroforestry management*. The fourth factor explains 6.01% of the variability and includes planting of honey plants, number of crops, kilograms of honey, and number of beehives; it is called *load capacity*. Finally, the fifth factor explains the 5.01% variability and comprises predominant agricultural activity, age, schooling, and the reason for which it is engaged in beekeeping; this factor is referred to as the *apiculture vocation*.

Cluster analysis of producers. The cluster analysis (Figure 1) identified 5 groups of beekeepers with certain defined characteristics. The first group of beekeepers represented 9% of the total sample. In this group, 60% of households work with 16 to 20 beehives; 57.1% work in beekeeping by tradition; 50% of beekeepers are professionals and operate 2 apiaries; 40% obtain another product besides honey; 36.33% have a distinctive brand; only 19.3% sell to the end consumer, and 18.7% sell in glass containers.

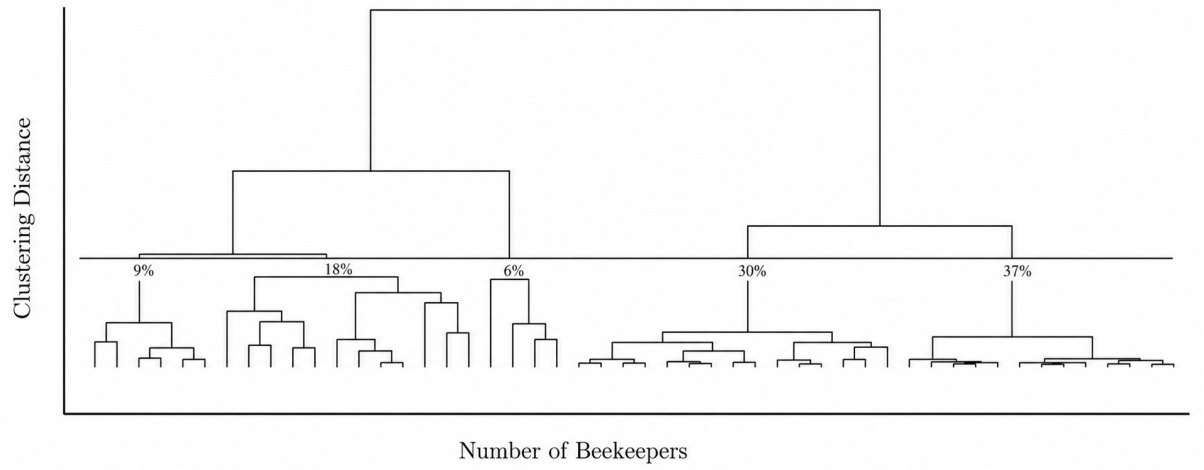

Figure 1. *Cluster of beekeeper diversity in the Department of Nariño*

The second group of beekeepers accounted for 18% of the sample. Of this group, 100% are in beekeeping for conservation purposes and sell honey in recycled bottles; 66.6% produce 41 to 81 kilograms of honey; 54.5% work in sharecropping; 36.6% sell honey at $24,000 per kilogram or more; 35.4% sell to the end consumer; 32.4% of producers are male; and 27.9% have their apiaries near forests.

The third group represents 6% of the sample. Of this group of beekeepers, 100% are formalized and produce 82 to 122 kilograms of honey; 75% sell half of their production with intermediaries and the other half with the final consumer; 66.6% are in an age range ranging from 25 to 30 years old; 50% are professionals and have 21 or more beehives; 36.3% have a brand; 33.3% have beekeeping as their main activity; and 26.7% do not work all the farming activities in the same estate and obtain other beekeeper products.

The fourth group represents 30% of the sample, where 100% sell all their production to the intermediary and sell honey between $16,000 and $19,000 per kilo; 62.5% sell in glass bottles; 58.3% only produce one harvest per year; 43.1% own between 1 and 5 beehives and work in beekeeping for pollination; 40% operate a single apiary and 37% obtain a production of honey ranging from 0 to 40 kilograms.

The fifth and last group represented 37% of the total sample. In this conglomerate, 100% of producers still do not harvest honey; 96.1% do not yet sell honey; 92.5% are still not managing prices or presentation for marketing; 56.8% were female producers with between 1 and 5 beehives; 50% owned only one apiary and worked on their estate; 48.8% did not obtain any other products; 46.3% produced less than 40 kg of honey; and 44.6% did not have a brand.

In this regard, the analysis of the hierarchical conglomerate reveals that the first three groups present similarities, as they bring together producers with larger and more commercially strengthened production units. In contrast, the fourth and fifth groups associate beekeepers with small productive units that do not yet market their production.

Problems identified in beekeeping systems. Figure 2 shows the problems that the surveyed beekeepers present and are currently facing. Of the 16 problems mentioned, seven (low honey production, the presence of pests, varroa infestation, moisture presence, lack of knowledge of technical management, swarms, and accidents with neighboring producers) stem from poor technological transfer in this sector. Two environmental problems are identified: deforestation and the death of beehives from applying insecticides. Three social types are identified: the theft of beehives, the robbery of honey, and the establishment of apiaries in small areas. There are three commercial types: high production costs, supply of counterfeit honey, and marketing problems, specifically brokering. Rincón and Téllez (2019) report similar problems in other areas of the country and determine that they are problems specific to bee production. Finally, the producers surveyed mention the crystallization of honey, which, although a natural process, is limiting for marketing, given the ignorance of its attributes.

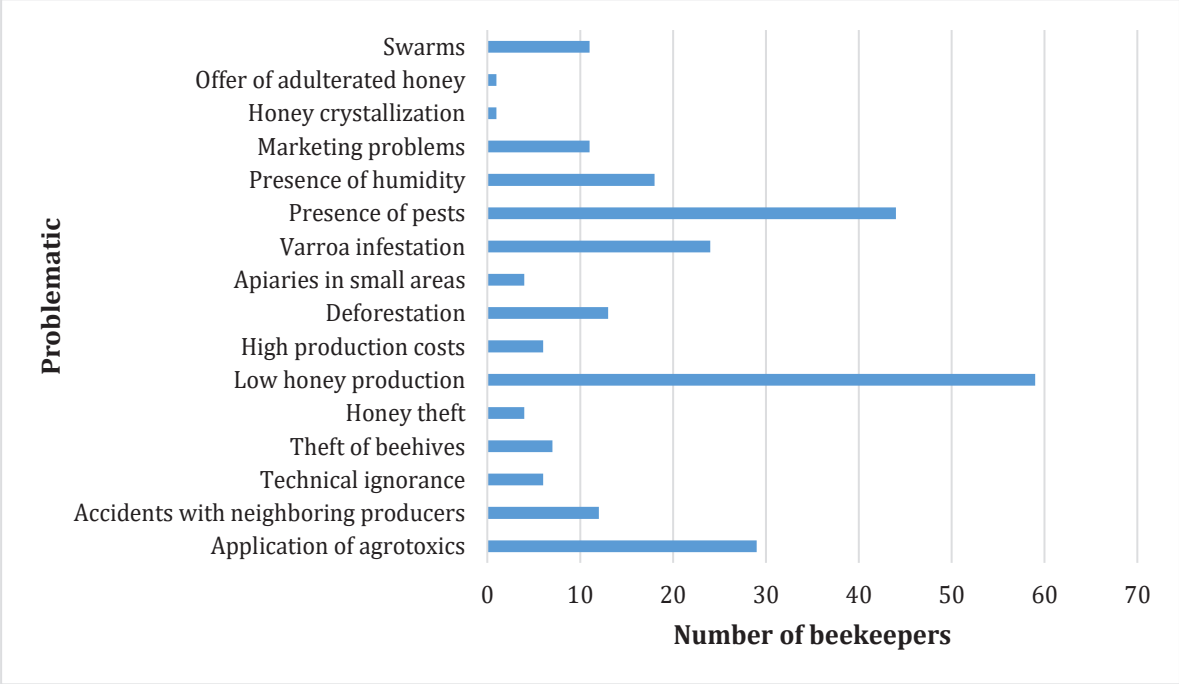

Figure 2. *Problems identified in the surveyed beekeeping associations*

Sensory assessment of honey

The presence of impurities in the honey showed variation between the areas evaluated. The Central Zone recorded the lowest proportion of samples with impurities (4.76%), followed by the Northern Zone with 7.94%, while the Southern Zone presented the highest value (16.00%). In all areas, the absence of impurities was widespread (≥ 84%), which generally indicates adequate handling during harvest and post-harvest. However, the increase observed in the Southern Zone suggests possible differences associated with filtering practices.

In the characterization of the color of the honeys collected in the three evaluated areas, marked differences were observed between regions. In the Northern Zone, the amber color predominated, with 84.13% of the samples classified in this shade, while only 15.87% corresponded to white honeys. In contrast, the honeys from the Central Zone showed a clear trend towards lighter tones, with 97.62% of samples being white and only 2.38% in amber tones. Similarly, the Southern Zone presented a mostly clear composition, with 96.83% white honeys and 3.17% amber in color. These results show a regional variability possibly associated with the flora of the area.

The texture assessment showed a general trend towards the presence of coarse crystals in the three areas analyzed. In the Northern Zone, 71.43% of the samples showed coarse crystallization, while 28.57% showed fine crystals. The Central Zone showed a similar behavior, with 63.10% coarse crystals and 36.90% fine crystals. In the Southern Zone, the proportion of coarse crystals was 68.25%, and the proportion of fine crystals was 31.75%.

The incidence of sensory defects in the honey samples was generally low. Fermentation defects showed a moderate prevalence, with proportions of 7.94% in the Northern Zone, 8.33% in the Central Zone, and 14.29% in the Southern Zone. The smoky defect showed a greater relative occurrence compared to the other negative attributes, with values of 15.87%, 13.10%, and 7.94% in the North, Central, and South zones, respectively, possibly associated with the use of smokers during harvest. In contrast, the metallic defect was practically non-existent in the North and Central zones (0%),

only being recorded in the South Zone with 14.29%. Finally, the presence of mold was minimal in all areas (0% in the North Zone; 1.19% in the Central Zone, and 1.59% in the South Zone). Overall, the results indicate that sensory defects do not significantly compromise the quality of the honeys evaluated and that the differences recorded are mainly due to variations in handling practices.

For the aroma variable, Figure 3 shows a high variability in the aromatic profile of the honeys. Dimension 1 (66.5%) establishes the main discriminating gradient, separating soft and vegetal aromas such as sugar, pollen, vegetable, caramel, and floral from intense and complex aromas, such as animal, dried fruits, cereal straw, and resinous or waxy notes. For its part, Dimension 2 (33.5%) distinguishes between fresh or animal aromas (citrus, dried fruit, animal) and lactic, herbal, and smoky profiles (lactic, mint, floral, smoke). On the sensory map, the three zones show distinct patterns: The North Zone (point 1) is predominantly associated with soft, sweet, and vegetal aromas, including vanilla, caramel, floral, and pollen. The Central Zone (point 2) includes sugary aroma, beeswax, resinous, wood, and smoke, indicating a sweet-intense and resinous profile. Finally, the Southern Zone (point 3) is grouped with the most robust and persistent aromas, including animal, dried fruits, and cereal straw.

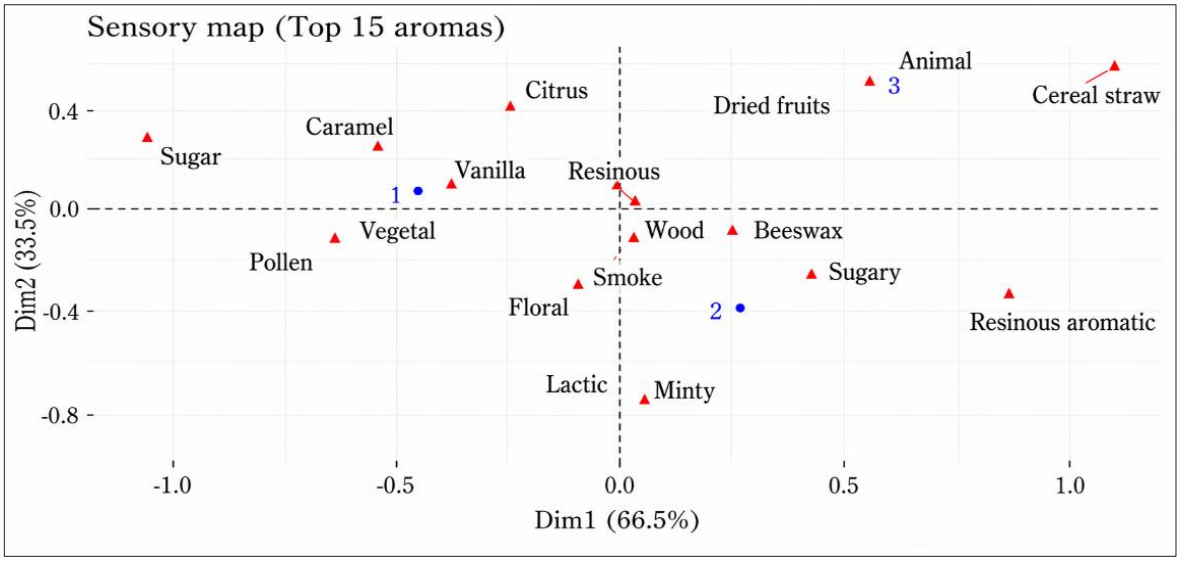

Figure 3. *Map of the most influential aromatic attributes in the evaluated regions*

DISCUSSION

Emergence and development of beekeeping in Nariño

The accounts showed that Africanization marked the development of beekeeping in the area, given that capturing swarms was and remains the main method of acquiring breeding stock. The same trend can be seen at the national level, as according to Humboldt Institute (2021) data, since the Africanization of beekeeping, the number of beehives has increased by 30% and the production of honey by 60%.

Regarding beehive management, the knowledge acquired is local, the result of the experience and observation of the agroecosystems (Flores & Gonzáles, 2020). Moreover, the exchange of experiences with other beekeepers has been the most used methodology, as it allows them to solve similar problems, since beekeeping responds to the conditions of each ecosystem (Bragulat *et al*., 2018). In this context, the environmental conditions influence how societies aggregate and shape both social relations and their ways of generating and accessing knowledge (Longo *et al*., 2021).

Characteristics of beekeepers

In Nariño, there are beekeepers with extensive experience, and at the same time, new producers and/or projects continue to emerge, mainly seeking to contribute to the conservation and use of biodiversity in a context of sustainability (Claro *et al*., 2020). As a result, a high heterogeneity is reflected in the different production schemes developed by beekeepers (Bragulat *et al*., 2018). The most successful beekeepers manage considerably large production units, are legally established, and are more commercially recognized than the relatively younger ones. In other words, the age of beekeeping influences the size of the productive unit.

Culturally, beekeeping is considered a secondary and complementary activity to other production systems. Consequently, many beekeepers regard bee production as a marginal activity or complementary to the main source of income (Gómez-Leyva *et al*., 2022), which is why many producers set up small apiaries in which they spend only a small part of their time.

On the other hand, the size of the productive unit depends on the availability of land and capital. While many producers expand by establishing apiaries on sharecropped or leased land, others face limitations in scaling their operations, given that most plots in Nariño are smallholdings (Lagos *et al*., 2019).

The variability that exists in honey production and marketing depends on multiple factors. In general, technical management, geographical area, the amount of bee flora present around the apiary (Guallpa *et al*., 2020), and the climatic conditions are determining factors in the productive parameters of the beehives. However, in the region, variability in production and marketing is also linked to the coexistence of small-scale, new producers alongside long-established, formalized producers who achieve greater market recognition (Bragulat *et al*., 2018).

Agroforestry management in beekeeping depends largely on land ownership. Beekeepers who work on farms they do not own face limitations when making decisions regarding the establishment of beekeeping species. Moreover, in the Department of Nariño, the size of the farm tends to be small with intensive production (Zapata *et al*., 2023). In this regard, the possibilities of agroecological restoration or the implementation of agroforestry systems in foreign farms are limited.

The loss of plant coverage, deforestation, anthropogenic activities, and the effects of climate change, among others, cause the loss of species (Villalta *et al*., 2016) or a decrease in the food supply for bees, which affects the animal carrying capacity. In other words, it limits the number of beehives that can be established within a plot, as nectar availability may be low, since the diversity of trees and shrubs, along with the herbage layer, represents a valuable resource for beekeepers and contributes to good honey harvests (Baena-Díaz *et al*., 2022).

Finally, concerning beekeeping, the variability presented by this factor is determined by the diversity of agricultural activities carried out in the family farming of peasants and, as mentioned above, beekeeping is mostly a complementary line to other agricultural activities.

Sensory quality of honey

In the sensory analysis, the results showed a clear differentiation between the honeys produced in the three areas evaluated in the Department of Nariño. Although the samples generally showed good hygienic quality, the greater presence of impurities observed in the Southern Zone could indicate differences in filtering practices or environmental conditions during harvesting, which has been reported as a determining factor in product cleanliness (Mora *et al*., 2015). This variability suggests the need to strengthen training processes in post-harvest handling.

The color attribute showed the most marked regional pattern. While honeys from the Northern Zone presented predominantly amber tones, the Central and Southern Zones exhibited mostly light honeys. These differences are probably related to the flora present in each region, as indicated by Tamaño and Cora (2022), who point out that the botanical origin is one of the main determinants of the color of honey. Additionally, Ortega *et al*. (2021) report that lighter honeys tend to have a lower mineral content, in contrast to amber tones that tend to be associated with a higher mineral concentration. These authors also agree that the color differences may be linked to divergent soil and climate conditions between the sites where bees collect nectar.

Regarding texture, the predominance of coarse crystals in all areas suggests that the honeys evaluated have a glucose/fructose ratio that favors this type of crystallization. Proaño and Espinoza (2022) point out that coarse crystallization is characteristic of honeys with higher glucose content and lower moisture. They emphasize that this phenomenon is natural in honey and does not constitute a defect or an indication of adulteration. The similarity observed between areas indicates that this attribute would be more influenced by the floral composition of origin than by the management practices of the beekeepers.

Regarding sensory defects, the higher percentage of fermentation and the presence of the metallic defect in the Southern Zone could reflect harvesting conditions with higher humidity or accidental contact with metallic surfaces. Ortega *et al*. (2021) showed that moisture values above 20% favor the development of fermentation due to yeast growth and the increase in free acidity. On the other hand, the smoky defect, more frequent in the North and Central areas, can be attributed to the intensive use of the smoker.

Overall, the findings indicate that, although the sensory quality of the department's honeys is satisfactory, there are variations between areas that appear to be due to differences in flora, climate, packaging, and storage (Sánchez *et al*., 2025). This highlights the importance of strengthening standardized harvesting and post-harvest protocols, as well as conducting further studies of physicochemical composition to corroborate the identified sensory patterns.

The analysis of the aroma attribute, the sensory map, showed the differentiation between zones. The Northern Zone was characterized by soft and sweet aromatic descriptors, such as vanilla, floral, caramel, and pollen, configuring a light profile that coincides with the profiles reported by Menco-Tovar *et al*. (2022), who in their study found two differentiated aromatic groups: light, floral, and soft honeys, and amber honeys with resinous profiles of medium intensity. This trend is consistent with what was found in the Central Zone of the present study, where resinous, woody, waxy, and smoky notes predominate. The Southern Zone, on the other hand, presented the most complex and intense aromatic profiles, with aromas of animal, dried fruit, and cereal straw. These descriptors coincide with those reported for honeys from Brassica napus, a species whose flowering has been associated with strong, straw-like, and even slightly unpleasant aromatic notes (Vit, 2004; Vit *et al*., 2011). Given that this species is present in the area, its nectar contribution is likely to influence the expression of these robust and persistent profiles.

Overall, the findings indicate that, although the sensory quality of the honeys in the department is satisfactory, there are variations between areas that appear to be due to differences in flora, climate, packaging, and storage (Sánchez *et al*., 2025). This highlights the importance of strengthening harvesting and post-harvest protocols, as well as deepening studies of physicochemical composition that allow corroborating the identified sensory patterns.

Sánchez *et al*. (2025) point out that sensory evaluation is a key tool to characterize the honey of each region and add value to its marketing. In this sense, this background supports the potential of Nariño honeys to develop territorial differentiation strategies and seek specialized markets.

CONCLUSIONS

These findings highlight the need for targeted training programs, technology transfer, and support for small-scale producers, which could strengthen productivity, promote sustainable practices, and enhance the marketing of region-specific honey. Future research should focus on integrating technical, ecological, and socio-economic strategies to improve the resilience and competitiveness of beekeeping in Nariño.

AUTHOR CONTRIBUTIONS

Conceptualization, A.R.L.; Methodology, A.R.L., J.S.A., and A.B.J.; Software, A.R.L.; Validation, A.R.L., JSA, and A.B.J.; Formal Analysis, A.R.L.; Investigation, A.R.L.; Resources, ARL.; Data Curation, A.R.L.; Writing—Original Draft Preparation, A.R.L.; Writing—Review & Editing, J.S.A.; Visualization, A.R.L., J.S.A., A.B.J.; Supervision, A.R.L. and J.S.A.; Project Administration, A.R.L.; Funding Acquisition, A.R.L. and A.B.J.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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