

Perspectives in the beekeeping value chain: innovation and development in the northern region of Colombia

Jalelys L. LEONES-CERPA¹, Martha CUENCA QUICAZÁN¹, Juan F. RESTREPO², Katherine VELANDIA²,

Eduardo SÁNCHEZ-TUIRÁN¹ and Karina A. OJEDA^{1*}

¹ University of Cartagena, Chemical Engineering Department, Cartagena, Colombia

² Colegio Montessori de Cartagena, Cartagena, Colombia

*Corresponding Author

Abstract — Colombia and its regions have abundant botanical wealth and climatic conditions suitable for the development of beekeeping. The Caribbean region is promoting the practice of beekeeping as an activity with benefits to ecosystems, human health, and socioeconomic positioning. The objective of this research is to determine the state of beekeeping in the Colombian Caribbean region and the areas where it is necessary to make improvement actions. The methodology was carried out following bibliographic reviews in databases and government reports, and the surveys were applied through Google Forms. The main results showed the need for more regulations in beekeeping and derived products, the low development of value-added products in the Caribbean region, as well as few technologies for the management of apiaries and the genetic manipulation of bees. The surveys of beekeepers corroborated their perception of some of the areas in which the beekeeping sector requires research and development.

Index Terms — Colombian Caribbean region, Genetic improvement, Honey, Value-added products

I. INTRODUCTION

Colombia is a country characterized by its wide range of animal and plant species, making it one of the most botanically rich countries in the world. In recent years, great expectations of social and economic development have been generated, mainly after the COVID-19 pandemic, when the economy recovered under the growth of agricultural and industrial sectors driven by mass consumerism (World Bank, 2022). Beekeeping is an ancestral economic activity that represents a branch of agriculture (Bartlett, 2022). Beekeeping is an economic activity that involves the care and maintenance of bees in order to obtain a range of products, taking into account factors such as climate, natural resources, diseases, and knowledge of the beekeeper, but beyond this, beekeeping offers many benefits to the agricultural, social, and economic sectors (Abro et al., 2022). Therefore, beekeeping becomes an activity that generates diverse sources of income, allows resilience in families, and avoids dependence on traditional activities (Prodanović et al., 2024). Honey bees (*Apis mellifera*) are the ones that have been mostly used for beekeeping for many years (Sperandio et al., 2019). Honey bees are responsible for a variety of products suitable for human consumption, however, their fundamental task is the pollination of various plants such as fruits, vegetables, and legumes around the planet (El Agrebi et al., 2021). Therefore, bees are necessary for the well-being of ecosystems and global food security (Gonzalez et al., 2021), and they also represent a way of economic income for beekeepers (Gilioli et al., 2018). Bees, as pollinators of the Tropical Dry Forest, generate added value derived from beekeeping, contributing to the control of climate change through the preservation of the Tropical Dry Forest (Miranda & Costa, 2024). Globally, deforestation, the extraction of wild animals, pests, the use of pesticides, and diseases have become the causes of bee mortality (Smriti et al., 2024; Zapata-Hernández et al., 2024).

The hive products depend to a large extent on climatic factors, types of bees, classes of flora, maturation in the extraction, and the equipment used in the handling process (Nunes et al., 2022), among the direct products of the hive are honey, pollen, royal jelly, beeswax, apitoxin, and biological materials. Honey is a complex solution composed of sugars such as fructose and glucose, as well as essential compounds for life such as vitamins, proteins, organic acids, minerals, and enzymes, among others (Machado De-Melo et al., 2018). The use of honey has focused on nutrition and the development of recipes for human health since it

has biological properties, including bioactive compounds such as polyphenols and carotenoids (Alvarez-Suarez et al., 2018). The importance of phenolic compounds in honey lies in the fact that they are effective natural antioxidants that could minimize the appearance of free radicals in the human body, in addition to having multiple health benefits (Nascimento et al., 2018).

Another of the products of the hive is pollen, which is collected by honey bees from the stigma of flowers, whose name is gametophytes (Qiao et al., 2023). Due to its characteristics, pollen has been considered since ancient times as one of the best-known nutritional supplements (Aylanc et al., 2021). The chemical composition of pollen depends on factors such as geographic location, plant characteristics, and field activities of bees (Gardana et al., 2018). Among the components of pollen are vitamins, minerals, lipids, carbohydrates, and proteins, of the latter particularly, it contains approximately 23 % of its composition together with essential amino acids (Yang et al., 2013). When the pollen is carried by the bee and mixed with its saliva and nectar, a new product called pollen bread is obtained (Khalifa et al., 2020). Like other beehive products, pollen bread influences the flavor of fruit trees and flowers (Anderson et al., 2014).

Royal jelly is another beehive product, it is characterized by having a wide variety of bioactive compounds with antioxidant and anti-inflammatory effects (Chen et al., 2023), in addition, it is used as a hypotensive and antiviral (Hou et al., 2019). However, its chemical structure is affected by the temperature and time since extraction (Chen et al., 2023). Beeswax is a natural polymer with wide application in the food industry, with which coatings and containers are modified (Brito-Pereira et al., 2023). Beeswax has a low melting temperature, a characteristic that makes it attractive for different industrial sectors (Tian et al., 2021). Propolis is a complex solution of plant liquids combined with wax. Propolis varies its composition of essential oils, organic compounds, and terpenes, among others, depending on the place where it is produced, the harvest time, the flora, and the environmental conditions (Nada et al., 2022). Apitoxin or bee venom is a pale yellow solution, with an acidic pH and a bitter taste produced by worker bees in two of their abdominal glands (Pascoal et al., 2019). Apitoxin contains more than 80 % water, but this may vary depending on the climate of the area and the type of bee (Moreno & Giralt, 2015). Another of the direct products of the hive is the biological material, among them are the queens, the nuclei, and the larvae, which are commercialized for the improvement of species among apiaries.

The Colombian Caribbean region is divided into seven departments characterized by having great biodiversity, a warm climate, and a high economic dependence on agricultural activities. This region is also characterized by its high social vulnerability, high rates of unsatisfied basic needs, large families displaced by violence, inefficient health system, and education services, etc. All these aspects have been associated with the limited economic development of the region and the little integration between institutions to support agricultural practices, which is why socioeconomic and cultural factors affect the implementation of crops that could generate stability in the region (Tatis Diaz et al., 2022). The beekeeping chain in Colombia a few years ago was organized into associations or federations that ensure compliance with the sanitary measures of the apiaries and the management of the hive products, among them are the Colombian Federation of Beekeepers and Bee Breeders (FEDEABEJAS), the National Federation of Beekeepers (FEDEAPICOL), the Production Chain of Bees and Beekeepers (CPAA), among other regional organizations that leadership training and monitoring of beekeeping, such as The Beekeepers Cooperative of Cauca (COOAPICA), and The Beekeepers Association of Cundinamarca (ASOAPICUN) (Ministry of Agriculture and Rural Development - MADR (Colombia), 2023). At the national level, institutions such as the Colombian Agricultural Institute (ICA) and the Ministry of Agriculture and Rural Development (MADR) are in charge of regulating productive practices involving beekeeping, its products, and bees (Colombian Agricultural Institute (ICA), 2021).

Beehive products in Colombia are of multi-floral origin since this activity is not carried out around large-scale crops or monocultures (Tibatá et al., 2018). Due to the above, beekeeping products that give identity to the regions based on the botanical strength of each one are not remarked, as is the case of honey, a food product of biodiversity, with a chance of recognition of its possibilities by its geographical and phytological origin. In Colombia, the production of the hive is mainly focused on honey, however, depending on the region, ranges of several products are established, due to the characteristics of the flora in the area (Colombian Agricultural Institute (ICA), 2021). According to reports from the MADR of the year 2020,

approximately 3,000 beekeepers in Colombia were quantified with more than 130,000 hives, whose production amounts to 3,800 tons of honey per year (Ministry of Agriculture and Rural Development - MADR (Colombia), 2023).

The distribution process of bee products involves the sale from the beekeeper to collectors, who then sell the products to processors, and finally distribute them to the final consumer. All this process implies an increase in the prices of bee products and is reflected in the low income of beekeepers and the price trend in the market. Today, in Colombia, the beekeeping chain involves producers, marketers, academia, institutions, and suppliers. The products that stand out are honey, pollen, propolis, royal jelly, and bee larvae, and a higher concentration of these products is estimated in the departments of Huila, Valle del Cauca, Risaralda, and Amazonas (Production Chain of Bees and Beekeepers (CPAA), 2020)

Beekeeping in Colombia has been consolidated in recent years, in addition, this activity does not require land ownership, however, there is an abundance of empirical knowledge of the production process that is not scientifically corroborated, and the standardization of production processes is low, as are innovation and the generation of value-added products is a study area with several edges. For its part, imports of products such as honey bees are reported at 110 tons, and exports at 36 tons (Production Chain of Bees and Beekeepers (CPAA), 2020), while national consumption is more than 3,800 tons and per-capita consumption of approximately 77 grams. In addition, the sector has had an annual growth of 5 % in the last seven years (Agronet, 2021). The costs of beekeeping products vary excessively considering the department of Colombia and the availability of technologies; therefore, labor has a greater contribution to low production costs.

Given the aforementioned, beekeeping in Colombia is a sector from which various enterprises could be generated that contribute environmentally and socioeconomically (Agronet, 2021). For some years now, green entrepreneurship has been a topic of interest, particularly for its contribution to economies that require accelerated growth and its emphasis on business sustainability (Silajdžić et al., 2015). The development of new products, equipment, and studies in the beekeeping field would lay the foundations for the creation and recognition of new businesses that contribute to environmental care, food safety, and the health of living beings. The goals of this research are to understand the state of beekeeping research in Colombia and the Colombian Caribbean region; to determine in which area it is possible to innovate for the development of products, practices, and technical equipment that facilitate beekeeping practices, taking into account research carried out in other countries; and, finally, to determine from surveys applied to Colombian beekeepers in which areas beekeeping in the Colombian Caribbean region should be improved.

II. METHODS

In this research databases such as Science Direct, Springer, Taylor & Francis, and Scopus, as well as PatentPulse for a period of ten years (2013 - 2023) were reviewed. The queries in the databases were carried out between January and February 2023. Information on the legal framework for beekeeping in Colombia was obtained from Colombian government databases and reports, including the Ministry of Agriculture and Rural Development (MADR), the Information and Communication Network for the Agricultural Sector (Agronet), and the Colombian Agricultural Institute (ICA), regional and national institutes and associations. The information search was based on the State of the Colombian beekeeping chain and the state of the beekeeping chain in the northern region of Colombia, By-products made from the products of the hive, nationally and internationally, technical equipment (new developments) for the production processes of the beekeeping chain, improvement processes, and genetic crossbreeding between bees. Search criteria were used such as: ("beekeeping" OR "beekeeping value chain" AND "Colombia"), ("state beekeeping" AND "Colombian Caribbean region"), ("beekeeping value chain" AND Latin America), ("beekeeping value-added products"), ("beekeeping value-added products" AND "Colombia"), ("beekeeping value-added products" AND "Colombian Caribbean region"), ("value-added products" AND "honey" OR "pollen" OR "hive products"), ("value-added products" AND "pollen"), ("value-added products" AND "honey"), ("beekeeping TECHNOLOGIES"), ("beekeeping" AND "genetic crossbreeding"), ("beekeeping practices" AND "Colombia").

A. *Survey application*

In this research, a survey was carried out this year (2023) with the CAWI (Computer Assisted Web Interviewing) method. A survey was designed that contained questions about the state of beekeeping in the Colombian Caribbean region, intending to evaluate the points of view of beekeepers about the activity they practice. The personal data were not collected and Law 1581 of 2012 (Personal Data Protection Law) was complied. The study was carried out using the Google Forms web survey platform with four questions, with a random sample of 31 beekeepers from the Colombian Caribbean region. The survey was carried out and applied to beekeepers during January 2023. The survey was shared on several platforms to reach more beekeepers. With the first question, the sample of interest was verified, in the second, the beekeeper was questioned about his economic activity, in the third, the normative knowledge of beekeeping in Colombia was inquired, and in the fourth, several options were generated for the beekeeper choose one or more. The questionnaire was designed so that the answers were saved once they were fully answered and sent. The survey was titled "Survey of beekeepers from the Colombian Caribbean region" and contained 4 specific questions that were easy to answer for those surveyed, among which were: 1. Are you a beekeeper from the Colombian Caribbean region? 2. Do you consider that Beekeeping in the Colombian Caribbean region needs to improve in the areas of innovation, and scientific and technological developments? 3. Do you know about the current regulations and protocols for the management of hives and products? 4. In which aspect(s) do you consider beekeeping in the Colombian Caribbean region should be improved? Can select one or more options. Descriptive statistics were used to evaluate the frequencies, quantity, and graphs based on the responses of the beekeepers.

III. RESULTS AND DISCUSSION

In order to present the current state of the beekeeping sector in the Colombian Caribbean Region, the main regulations in Colombia related to beekeeping practice will be reviewed. The main value-added products developed using beekeeping products generally focused on food and some cosmetics will be described. Some technical equipment designed to improve beekeeping practices (focused on the hive and the beekeeper's health) and genetic improvement in queen bees will be indicated. Finally, the results of a survey applied to beekeepers of the Colombian Caribbean region will be shown, in which the areas that must be improved or enhanced to turn the Caribbean region into a powerhouse of beekeeping in Colombia are highlighted.

a. *Regulations in the Colombian beekeeping sector*

According to the CPAA, Colombian legislation has as its main objective to provide tools that allow the technical and technological development of productive activities in the agricultural sector (Production Chain of Bees and Beekeepers (CPAA), 2020). Beekeeping in Colombia has current regulations for the care, breeding, and handling of the bee, implementation, and development of the direct products of the hive and by-products. Table 1 shows the main resolutions, regulations, and laws.

Table 1: The legal framework in force in Colombia for the practice of beekeeping and its products (Prepared by the authors based on information taken from Ministry of Agriculture and Rural Development (MADR) (Ministry of Agriculture and Rural Development - MADR (Colombia), 2023) and Production Chain organization of Bees and Beekeepers (CPAA) (Production Chain of Bees and Beekeepers (CPAA), 2020).

Regulations	
Law Number 2193 - 2023	Law for the promotion and development of beekeeping in Colombia. With this law, mechanisms are generated to encourage, promote, and protect beekeeping and its complementary activities

Resolution Number 00206 - 2022	By which the manual of animal welfare conditions in the breeding of bees (<i>Apis mellifera</i>) in the agricultural sector is adopted, which is published on the MADR website
Colombian Technical Standard - NTC 1273 - 2007	The current standard for honey from bees. This applies to all kinds of honey produced by worker bees of the <i>Apis mellifera</i> species and regulates all types of presentation forms of honey that are offered for direct consumption
Bill number 431 of 2020 – Chamber of Representatives of Colombia	Which mechanisms are created for the promotion and development of beekeeping in Colombia and other provisions are issued

Additionally, there are regulations on the quality of beehive products and bee health, this is regulated by the National Ministry of Health (MINSALUD), the Colombian Agricultural Institute (GBP), in terms of technical regulations for honey bees, good beekeeping practices (BPA) and the beekeepers registration (Ministry of Agriculture and Rural Development - MADR (Colombia), 2023). In general, the regulations in Colombia are directed specifically to beekeeping, and bees have few regulations, however, bees are classified as wild animals due to their swarming behavior, and they are associated with another group of species. Then, the beekeeping regulatory framework is grouped into a general regulatory block where bees are related to the environment, health, care, and protection of wild animals, as well as to bee products within packaged or packaged foods for human consumption, and one that is focused on the importance of beekeeping at the socioeconomic, environmental and health level of the country.

b. Development of value-added products from beehive products

The development of value-added products from bee products has been increasing in the last decade, mainly due to the nutritional and medicinal characteristics of their bioactive components. **Napaka! Vira sklicevanja ni bilo mogoče najti.** shows the latest value-added products developed from the beehive products.

Table 2 shows the value-added products, those made with honey are found mostly in the scientific literature. The development of beverages with honey was evidenced mainly by its use as a sweetener and antioxidant properties (Berg & McCarthy, 2022). Biodegradable food films and packaging are also developing with great boom, the antimicrobial properties and malleability of beeswax have significant importance in the physical and mechanical characteristics of the films (Joseph-leenose-helen et al., 2022). For its part, the characteristics of propolis as a preservative and sealant make it an excellent additive to prevent food degradation (Pu et al., 2023). The products obtained from royal jelly are widely applicable in the field of medicine and in food to improve probiotic characteristics (Moriyama et al., 2017).

In Colombia, the development of honey-based products has been a poorly explored field, the production of mead has been reported in different areas of the country, especially in the Andean region (Quicazán et al., 2018).

Table 2: Value-added products from hive products

Beehive products	Value-added products	Characteristics/Properties	References
	Drink or "shake" based on soy yogurt and honey	Its consumption is effective in improving cardiovascular diseases, weight control, and its adverse effects. Promotes a healthy lifestyle.	(Berg & McCarthy, 2022)

Honey and/or pollen	Green tea enriched with honey and bee pollen	Product to increase the number of polyphenols reflected in its antioxidant activity in human health	(Yildiz & Maskan, 2022)
	Honey powder with phytochemicals	The product is obtained from medicinal plants, used as a natural sweetener with antioxidant properties	(Yildiz & Maskan, 2022)
	Honey wine	Productos con mayor contenido de alcohol, menores desechos y buena actividad fisicoquímica y antioxidante	(Wang et al., 2023; Yildiz & Maskan, 2022)
	K-carrageenan edible films	Film with physical, antioxidant, and antibacterial properties. Among its components, it has bee pollen and honey extracts.	(Velásquez et al., 2022)
	Fermented beverages	Drink obtained from sesame seeds, pollen, and honey, with probiotic characteristics and good acceptability	(Leones-Cerpa et al., 2024)
Bee wax	Bee wax edible packaging	The quality of the container was corroborated by the good texture and appearance. In addition, it presented antioxidant and antibacterial properties.	(Joseph-leenose-helen et al., 2022)
	Edible films based on biopolymers	The product is applied to the coating of fruits and vegetables. Good mechanical practices and low dehydration	(Joseph-leenose-helen et al., 2022; Velásquez et al., 2022)
Propolis	Propolis nanoemulsion – natural preservative	The nanoemulsion prevents food degradation and has antimicrobial and antioxidant activity	(Seibert et al., 2019)
	Propolis functionalized coatings and films	Propolis mixed with other products has better antimicrobial and preservative properties	(Pu et al., 2023; Seibert et al., 2019)
Royal jelly	Functional probiotic yogurt with royal jelly	Generation of probiotics with the addition of royal jelly. Innovative functional food	(Kavas, 2022)
	Energy Drinks with Royal Jelly Medicinal to Functional	Medicinal and functional product. Health benefits	(Moriyama et al., 2017)

Mead is a wine-like fermented beverage that contains alcohol concentrations between 8 % and 18%. For its fermentation, a dilution of honey in water is required, as well as the presence of a fermenting microorganism, it is probably one of the beverages oldest in the world, and is a craft product that has been expanding (Starowicz & Granvogl, 2020). In the Caribbean region, computer-assisted evaluations have been

carried out on a pilot scale of mead production processes in the Bolívar department (Gonzalez-Delgado et al., 2021), but this process has not yet been implemented. Scientifically, no official reports of value-added products developed in the Colombian Caribbean region whose main raw material is some of the bee products were found.

The CPAA has information on companies in the beekeeping sector in Colombia, among which they distribute products with bee honey such as artisan granola, with propolis such as cough syrups, hand and body creams based on Royal Jelly, pollen, propolis, and honey. bees, wax and propolis creams, and honey vinegar (Production Chain of Bees and Beekeepers (CPAA), 2020). The CPAA reports products made in the Caribbean region by the *Apisierra company*. Initially, they offered a variety of honey such as orange blossom honey, rosemary honey, chocolate honey, eucalyptus honey, thyme honey, also honey liqueur, honey candies, and propolis (Production Chain of Bees and Beekeepers (CPAA), 2020).

Although the development of some value-added products in the Caribbean region is evident, the wealth of natural resources allows bees to settle easily when finding a good source of nectar, thereby increasing a positive impact on the production chain, and it is possible to increase the variety and novelty of products, as well as capture other market segments, taking into account that a higher added value is generated, which can represent a higher income for beekeepers.

c. *Beekeeping practices: technical equipment and honey bee genetic improvement*

In beekeeping, beekeeping management practices (BPM) are essential to managing hives, identifying their status, achieving objectives, and defining specific risk actions (El Agrebi et al., 2021). The beekeeping practice depends on the care and constant observations of the beekeeper. However, all the activities and follow-ups that must be carried out are not clear, although there is abundant information on management practices (Steinhauer et al., 2021), there are still areas to address. The hives management also requires the use of instruments and technical equipment for the development of the beekeeping activity. In the hives, the boxes and frames are made of wood. However studies have been carried out to determine the hive resistance of the according to the type of wood used and what is its useful life depending on the climatic conditions to which it is exposed (Dupleix et al., 2020). Also, studies have been carried out on the development of equipment for the collection of apitoxin (bee venom) in the upper-interior part of the hive, among whose novel characteristics stand out the change in position, in this case, it is vertical, the collector will have electrical filaments on the sides, and an energy flow control (Serrinha et al., 2019).

Another important part of the new beekeeping developments is to consider the health of the beekeeper, since some tasks hinder their mobility, actions such as transportation, constant exposure to stings, and high temperatures represent risks on which investigations should focus. In some studies, technological recommendations have been made to improve the ergonomics of beekeepers, such as the construction of lighter boxes for hives with materials resistant to weather conditions, the use of pole systems for the transfer of hives, the design of chemical-type smokers or electric with which the smoke is suspended (Fels et al., 2019). On the other hand, the inspection and surveillance of hive behavior is the main tool for detecting alterations in its environment. Bees are constantly attacked by insects, fungi, viruses, and mites, among others, natural enemies of their survival, which is why strengthening the hive is the main defense mechanism against external invasions. Research has been carried out in beekeeping genetic improvement, carrying out crosses between bees of two hybrid genotypes, considering characteristics such as honey production, queen posture model, size of the forewing of worker bees, and defensive behavior, the results obtained with the crossed bees showed better production, low aggressiveness, and good average wing length (Arechavaleta-Velasco et al., 2021; Mondet et al., 2020).

In the Caribbean region, specifically in Montes de María, the Multiactive Cooperative of Organic Beekeepers Montes de María "COOAPOMIEL", from Carmen de Bolívar, adopted genetic improvement processes in queen bees to be placed in the brood chambers of hives, through systemic observation and evaluating traits such as hygiene, health, and honey production, as well as the high productivity of fruit trees (Ministry of Agriculture and Rural Development -MADR (Colombia), 2021).

d. *Beekeeping in the Colombian Caribbean region - initial survey of beekeepers*

The Colombian Caribbean region is made up of seven departments, in most of them beekeeping is practiced, however, the largest amount of production is concentrated in the Sierra Nevada de Santa Marta (Magdalena department), Sincelejo (Sucre department), and the Montes de María subregion (Bolívar department).

The results of the survey indicated that of the 31 beekeepers who responded to the survey, 96.6 % are beekeepers from the Caribbean region and 3.4 % are not from the Caribbean region, therefore, the sample is representative. The results related to the knowledge of the regulations and protocols for the management of the hive and its products, also evidenced the need for beekeepers to be trained in regulations that benefit their activity and promote the development of sustainable productive practices. Figure 1 shows the results of the survey for question number 3.

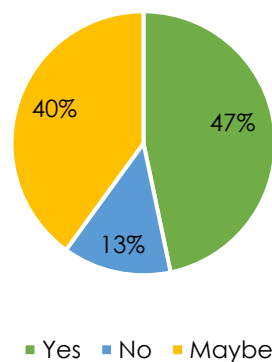


Figure 1: Knowledge about beekeeping regulations in Colombia

According to the results shown in Figure 1, only 46.7 % of the 31 beekeepers consider that they know the legal framework of their productive activity and products, while another 40 % indicate that they have information on this topic, but not enough, and 13.3 % of them have no knowledge of this item, in this case, the majority of beekeepers (53.3 %) may not know about the current regulations for the exercise of beekeeping. Ignorance of these regulations greatly affects beekeeping in the region, the main consequence is that standardized procedures are not followed for production processes in apiaries, and the conservation of bees is not considered as a predominant activity in the pollination of endemic crops.

In question number 4, where one or several response options could be chosen, related to aspects to improve beekeeping in the region. Figure 2 shows the results, where it is highlighted that the "None" option was not selected by the beekeepers, which shows that there are still areas to be studied in beekeeping. The option with the greatest selection was the "Generation of value-added products" which 71 % of the beekeepers favored. This result is justified by the opportunities that beekeepers see with beehive products to improve their product portfolios and generate higher income, with functional foods, cosmetics, and bioactive compounds, among others, whose contribution impacts on human and animal health, and the environment. The second most selected option was "honey bee genetic improvement", mainly justified because *Apis mellifera* is an aggressive wild species, but its behavior goes hand in hand with the production of honey and generating offspring, sufficient reasons for beekeepers to consider this option that could help them increase their productive objectives.

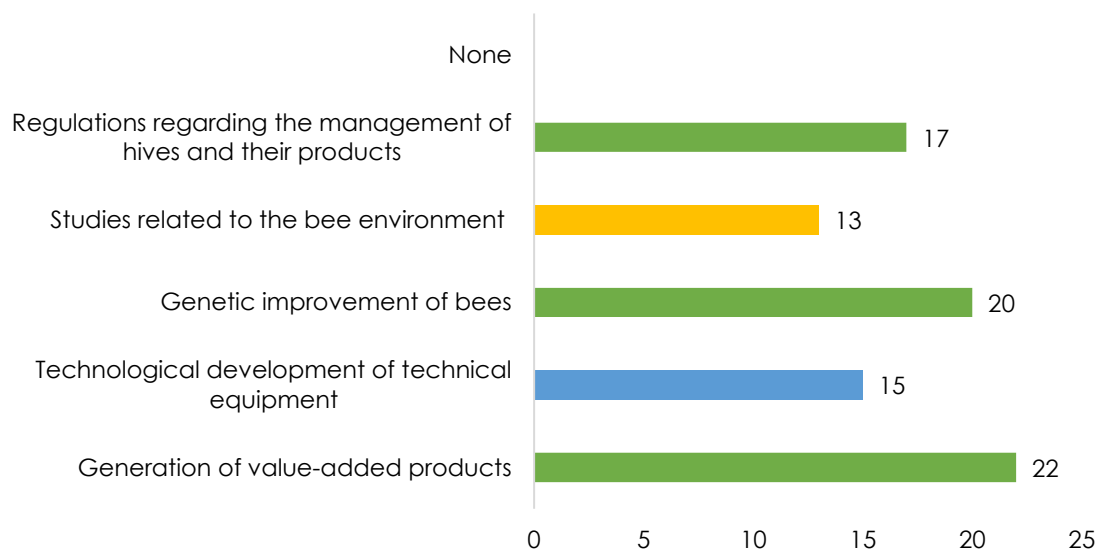


Figure 2: Possible aspects to improve in the Caribbean region beekeeping chain

The third option with the highest selection was "Regulations regarding the management of hives and their products" with 54.8 % because although beekeeping has current regulations, there are still opportunities for improvement in laws that prevent adulteration of the honey, and the management of the market by the collectors, who obtain the greatest rewards from the beekeeping activity.

The two options with the least selection were "Technological development of technical equipment" and "Studies related to the environment of bees" with 48.4 % and 41.9 %, respectively. Beekeepers are accustomed to using materials and equipment within the environment of the apiaries and during the extraction seasons. Some studies have been carried out where it is evident that beekeepers are reluctant to implement new technologies in apiaries (Arechavaleta-Velasco et al., 2021), however, their use could optimize production processes, for example, honey extraction, attack monitoring in the hives and their transfer. On the other hand, the honey of bees from the Colombian Caribbean is generally multifloral due to the little development of monocultures (Gonzalez et al., 2021), so beekeepers consider having full knowledge of their environment, although the various contaminants present in the environment are not evaluated as pesticides that are applied to nearby crops or the state of contamination of water sources and soil.

The results of the review of research at the international level, in Colombia and the region, showed, first, the few Colombian regulations, only five in force and under debate, that exist for beekeeping and derived products. It is worth noting the vigilance of government institutions such as the Colombian Agricultural Institute (ICA), Ministry of Agriculture and Rural Development (MADR), and the Production Chain of Bees and Beekeepers (CPAA), on issues such as apiary management, registration, and control of good beekeeping practices. In the development of value-added products, some recently published products were related, in which the antioxidant properties and bioactive components of bee products are used. Beverages with honey, propolis and royal jelly predominate as multifunctional foods, as well as films and packaging with beeswax and pollen for food applications. In a company in the Caribbean region, varieties of honey, honey sweets, and propolis are offered, however, product development is low and has little impact. The technological development of beekeeping in the region is almost non-existent, traditional equipment for honey extraction, hive inspection, feeding and handling of bees, and control of external factors continue to be used. Restructured hives and materials resistant to environmental conditions (Fels et al., 2019) would become a great contribution to beekeeping in the region and the country.

VI. CONCLUSION

National beekeeping has been strengthening considerably in recent years. Different beekeeper associations in Colombia have extensive experience in managing bees. The Colombian Caribbean region is characterized by having great biodiversity, a warm climate, and a high economic dependence on agricultural activities. This region is also characterized by its high social vulnerability, high rates of unsatisfied basic needs, large families displaced by violence, inefficient health, and education services, etc., all these aspects have been associated with the limited economic development of the region. Beekeeping is a growing activity that can be developed in the area because it does not require land ownership. Beekeeping is becoming one of the most relevant economic sectors in some municipalities of the Colombian Caribbean region. However, its importance as a productive dynamic sustainable where bee products are obtained due to the work of farmers and the pollination of hectares of fruit crops that induce their productivity, seeds availability, and food security for humanity is still ignored. There is a need to increase and promote beekeeping in this region. Beekeepers in the Colombian Caribbean region have abundant empirical knowledge of the production process, but there are no process standardization protocols, and limited information about beekeeping regulations, and hive products.

Beekeeping practices require the development of technical equipment that optimizes beekeeping production processes and constantly monitors hives to prevent possible attacks and early detection of food requirements. The genetic improvement of bees also influences production, aggressiveness, and resistance to diseases, viruses, and fungi. The surveys applied to beekeepers provided a general vision of the improvements that the Colombian beekeeping chain needs, the results showed a greater affinity of beekeepers for the development of new products, specific regulations for beekeeping and its products, and the genetic improvement of bees. This research becomes a starting point for several studies in different academic and industrial fields to provide new contributions to the beekeeping chain generating employment and progress in the participating communities.

Bees play a fundamental role as one of the pollinators of the Forest, which is why beekeeping contributes to preserving this resource with all the ecosystem services it generates. This study highlighted the importance of beekeeping as a sustainable practice and how beekeepers view the sector to improve beekeeping quality and its products. In the research, a limitation was found in the survey application to beekeepers. Some had problems with the internet connection, and others with the tool. For future surveys, platforms with a practical guide are suggested. From this study, future research with great potential emerges, such as the development of value-added products from bee products, ergonomic equipment for the development of beekeeping activity, and studies on the genetic improvement of bees (queens and workers) to reduce their aggressiveness and facilitate the work of beekeepers.

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AUTHORS

A. Karina A. Ojeda is a Doctor in Chemical Engineering, Industrial University of Santander, Colombia. Full Professor of the Chemical Engineering program at the University of Cartagena, Colombia (e-mail: kojedad@unicartagena.edu.co).

ORCID ID: [0000-0001-5360-4711](https://orcid.org/0000-0001-5360-4711)

B. Jalelys L. Leones-Cerpa is a Chemical engineer, University of Cartagena. PhD student in Engineering, University of Cartagena. Colombia (e-mail: jleonesc@unicartagena.edu.co).

ORCID ID: [0000-0002-2205-7388](https://orcid.org/0000-0002-2205-7388)

C. Martha Cuenca Quicazán is a Doctor in Chemical Engineering, National University of Colombia. Master in chemical engineering, National University of Colombia. Full Professor of the Chemical Engineering program at the University of Cartagena, Colombia (e-mail: mcuencaq@unicartagena.edu.co).

ORCID ID: [0000-0003-4243-7625](https://orcid.org/0000-0003-4243-7625)

D. Juan F. Restrepo is a Master in Administration, at EAFIT University, Colombia. Specialist in Management of Educational Institutions, Technological University of Bolívar, Colombia. Head of Knowledge Management, Montessori School of Cartagena, Colombia (e-mail: jrestrepo@montessoricartagena.edu.co).

ORCID ID: [0000-0002-4544-9851](https://orcid.org/0000-0002-4544-9851)

E. Katherine Velandia is a Master in e-Learning, Autonomous University of Bucaramanga (UNAB) in agreement with the Open University of Catalonia (UOC). Specialist in International Development Cooperation, Latin American School of Cooperation and Development ELACID; San Buenaventura University in agreement with the University of Pavia, IT. Teacher of Natural Sciences and English, Montessori School of Cartagena, Colombia (e-mail: kvelandia@montessoricartagena.edu.co).

ORCID ID: [0000-0002-4891-2004](https://orcid.org/0000-0002-4891-2004)

F. Eduardo Sanchez-Tuiran is a Doctor in Chemical Engineering, Industrial University of Santander, Colombia. Full Professor of the Chemical Engineering program at the University of Cartagena, Colombia (e-mail: esanchezt2@unicartagena.edu.co).

ORCID ID: [0000-0001-7540-3961](https://orcid.org/0000-0001-7540-3961)

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Perspektive v čebelarški vrednostni verigi: inovacije in razvoj v severni regiji Kolumbije

Povzetek – Kolumbija in njene regije imajo bogato botanično bogastvo in podnebne razmere, primerne za razvoj čebelarstva. Karibska regija spodbuja čebelarjenje kot dejavnost, ki koristi ekosistemom, zdravju ljudi in socialno-ekonomskemu položaju. Cilj te raziskave je ugotoviti stanje čebelarstva v kolumbijski karibski regiji in področja, na katerih je treba sprejeti ukrepe za izboljšanje. Metodologija je bila izvedena po bibliografskih podatkih in vladnih poročilih, za ankete pa so bili uporabljeni Google vprašalniki. Glavni rezultati so pokazali potrebo po več predpisih na področju čebelarstva in pridobljenih proizvodov, majhen razvoj proizvodov z dodano vrednostjo ter malo tehnologij za upravljanje čebelnjakov in gensko manipulacijo čebel. Ankete med čebelarji so potrdile njihovo mnenje o nekaterih področjih, na katerih čebelarški sektor potrebuje raziskave in razvoj.

Ključne besede – kolumbijska karibska regija, gensko izboljšanje, med, izdelki z dodano vrednostjo