MAPPING SCIENTIFIC KNOWLEDGE IN THE PRODUCTION CHAIN OF BLACKBERRIES (RUBUS GLAUCUS) IN COLOMBIA

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Abstract

This article is the result of the research project called surveillance and strategic intelligence for the strengthening of the competitiveness of the promising fruit agribusiness, whose objective was to determine the state of scientific knowledge on the production chain of blackberries (Rubus glaucus) in Colombia in the period 2010 to the first half of 2025, to see its potentialities and gaps, through a systematic mapping of the production of scientific knowledge, carried out using the PRISMA methodology with consultation in Scopus, ScienceDirect, PubMed and Google Scholar databases. 155 scientific products were analyzed, classified according to the links of the production chain: such as production, transformation, logistics, marketing and consumption or use of the fruit. The results show a marked concentration of research in the primary or production link, with 73 publications mainly oriented to the study of fungi, pests, diseases and genetic aspects. Likewise, the transformation link registers 46 products, focused on the development of by-products and the evaluation of the nutritional properties of the fruit. In contrast, there is a limited scientific production in the logistics and marketing links, with six publications in each, and a minimal presence of research related to the consumption or use of the product, with only one publication. This distribution shows important knowledge gaps in strategic areas for the consolidation and strengthening of the blackberry value chain in Castile, particularly in those related to its marketing, distribution and consumer behavior, in order to respond assertively to the R+D+i needs detected in the Strategic Plan for Science, Technology and Innovation, as well as reindustrialization for the Colombian agricultural sector

KEYWORDS: development, links, research, innovation, systematic review

INTRODUCTION

The blackberry is a fruit tree of the genus Rubus and is found in most of the world, while the blackberry (Rubus glaucus) is grown mainly in the high tropical areas of America between 1,200 and 3,200 meters above sea level, in countries such as Ecuador, Panama, Salvador, Guatemala, Honduras, Mexico, Colombia, even the United States. In the world it is estimated that there are around 127,000 hectares dedicated to cultivation with a production of 920,000 tons per year, where Mexico ranks first in production reaching 215,923 tons with a national average yield between 15 and 22 tons per hectare, which represents great potential for the economies of the families that live from this product and the respective countries. (Zamora, Baez, & Marin , 2023)

Blackberries are a desired product for their varied food and medicinal uses. Among its nutritional properties are the low caloric value, rich in vitamin C, fiber, iron and calcium, as well as tannins, organic acids, anthocyanins, phenolic compounds considered responsible for health benefits due to their ability to prevent cardiovascular diseases. In the same way, other attributes for health stand out for their antioxidant content that help strengthen the immune system reducing risks to different pathologies. Its fruit is (Martins, Goncalves, Alves, & Silva, 2023)(Verma, Grangade, Punasiya , & Ghulaxe, 2020)considered potential with a favorable market by the industries that transform it into different by-products, without neglecting its importance as a Export product in frozen or fresh form for industrial diversification (Franco & Bernal, 2020).

In this order of ideas, blackberries turn out to be a product of interest for food and agriculture, consequently, for the conservation of its genetic biodiversity, which constitutes one of the most important resources of the earth, with potential to contribute to the solution of different problems, such as poverty, hunger, unemployment, inequality, health and human well-being in general. To address these situations, it is necessary to reach consensus and agreements as agreed in the 2030 Agenda with the Sustainable Development Goals, the World Food Programme, as well as the Action Plan for Plant Genetic Resources. (Naciones Unidas, Fao, 2020)(Fao, 2012)This responds to the urgency of conserving and sustainably using the planet's plant biodiversity in the face of the aforementioned challenges, added to climate change.

The blackberry (Rubus glaucus) is a representative fruit in Colombia and plays a crucial role in the economy, standing out in national and international markets (Roldan et al. 2024). It is a generator of income, employment and strategic agro-industrial alternative in some areas of the country, given that around 6,000 families live from activities derived from this product (Franco et al. 2020) and it has a presence in 19 of the 32 departments of Colombia. Table 1 shows figures for planting, harvesting and crop yield areas for the last five years, noting that in 2022 the best yield was obtained in tons per hectare. By departments, Meta presents the best yield with 17.8 tons per hectare, followed by Caldas 16.59 tons per hectare, Cundinamarca 11.69 tons per hectare and Boyacá with 11.46 tons per hectare (Agronet, 2025)

Table 1: Production and yield of blackberries in Colombia from 2021 to 2025

Item	2021	2022	2023	2024	2025 *

Sowing area (ha)	17.904,9	17.488,5	17.511,2	16.539,8	15.951,9
Harvested area (ha)	16.741,1	16.462,6	16.965,8	15.717,6	15.436,6
Production (t)	170.477,3	175.804,5	170.069,4	156.019,3	153.988,0
Yield (t/ha)	10,18	10,68	10,02	9,93	9,98

Source: Agronet statistics, 2025. Note *first half 2025

In Colombia, the blackberry production chain was consolidated in 2015 under the competitiveness agreement. The chain is structured and formalized in five regions: regional 1 the departments of Cundinamarca, Boyacá and Tolima; regional 2, Santander and Norte de Santander; regional 3, Antioquia; regional 4, Risaralda, Caldas and Quindío and regional 5, Valle, Cauca, Nariño and Huila. Blackberries are considered a fruit with a favorable market by industries that transform them into various by-products, such as jellies, jams, desserts and soft drinks, among others; therefore, it seeks to increase the productivity of crops to guarantee demand in the markets. . (Ministerio de Agricultura y Desarrollo Rural, 2015)(Franco & Bernal, 2020)

On the other hand, as described In the Strategic Plan for Science, Technology and Innovation for the agricultural sector – Pecticia – 2017-2027 in Colombia there is great difficulty in consolidating an innovation system that promotes and encourages the flow of knowledge between the different actors for its management, especially due to the weak link between the knowledge-generating entities and the productive apparatus. This document also identified 88 research, development and innovation (R+D+i) demands for the blackberry production chain, in eight departments, referring to issues such as harvesting, post-harvest, transformation and marketing management, which represents 15.9% (528) of the total, followed by the area of socioeconomics, competitive intelligence and business development with 11.5% (381), planting material and genetic improvement with 10.7% (354) and management of the production system with 10.2% (337). It is worth clarifying that it is one of the production chains with the highest demands in R+D+i, surpassed only by the rubber and aloe chains. (Minagricultura, Colciencias, Corpoica, 2016)

In terms of scientific publications worldwide, China, the United States, and Indonesia top the list in terms of functional beverages. In 2020, the highest scientific productivity was observed in terms of probiotics, functional drinks, and antioxidant activity; showing the economic potential that the product under analysis may have (Roldan et al. 2024). The authors also show a vigilance in regulations from the codex alimentarius, standards and technical guides, on the blackberry production chain, referring to fruit handling, transformation, and packaging. Regarding the international market, they mention that the United States is the main target with a share of 71% and annual growth of 6.2% for the period 2022 to 2027; in Europe and Asia Pacific, Germany and the United Kingdom appear as leaders (Roldan et al. 2024).

With the above described, it is evident the urgent need to make a much more

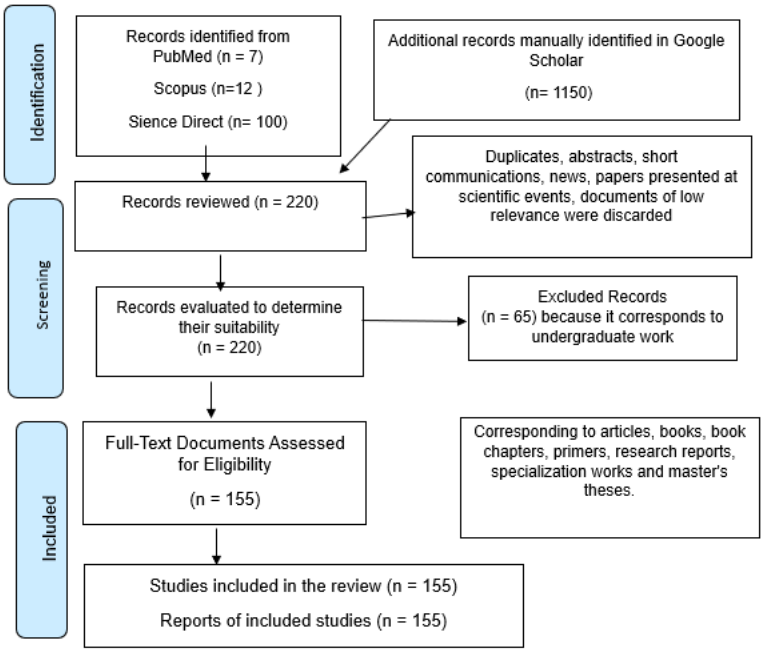
robust mapping of the production of scientific knowledge about this product, to know in detail its strengths, as well as its opportunities for improvement in this regard; as well as to have useful information and knowledge to strengthen agri-food systems, as well as to see possibilities for solid investments to improve food security, nutritional aspects and reduce hunger, among other relevant aspects. In addition, it is important to highlight the importance of consolidating this information that can be used by the different actors in the production chain and academia to project research, analyze strategies to enhance what has already been done, see options for greater support and coordination, such as the possibility of organizing and formalizing a knowledge management network on this product, as proposed by Cuspoca(Melo Torres, Ortíz Melo, & Fonseca Pinto, 2025), Melo and Mesa (2024) for the gulupa.

METHODOLOGY

Scientific mapping is a bibliometric analysis technique that facilitates the collection, classification, and organization of information for the study and visualization of knowledge, observing its evolution over time, from a perspective of intellectual structure in a field of scientific discipline, a field of research, or thematic areas related to specific research questions, which is evidenced through an aggregate of contributions from members of a scientific community or specialties registered in documentary databases (Lévano, 2023; Chen, 2017). For the development of this research, the PRISMA guide was used, which ranges from the identification, selection, extraction and registration of data, evaluation, synthesis, to the presentation of results in systematic reviews (Page et al. 2021), as shown in Figure 1. Literature was searched in the specialized databases Scopus, ScienceDirect, PubMed and in Google Scholar, using equations composed of keywords "mora", "moral", "rubus glaucus bentham", "Rubus glaucus", "Colombia" and operators "and" and "or"; for the period 2010 to 2025 first semester.

With a rigorous review , duplicates, abstracts, short communications, news, works presented at events, as well as undergraduate degree works were discarded, as they were considered more of a formative nature than of the generation of scientific knowledge; in such a way that 155 scientific products were left to analyze, corresponding to articles in scientific journals, books and book chapters, primers and guides, research reports, specialization degree projects and master's theses. They were coded and organized by links in the production chain: production, transformation, logistics, marketing, consumption and use. Within these, leading institutions in scientific production were identified according to the affiliation of their authors, language of publication, type of document, in the same way thematic areas associated with the field of knowledge of the R+D+i demands determined in the Pecticia 2016 were determined.

Figure 1: Methodological process of the research



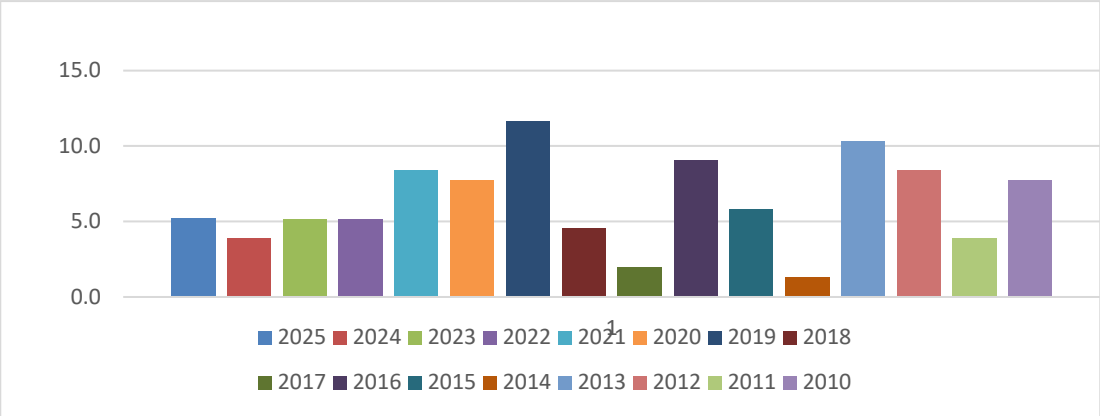
Source: authors

RESEARCH RESULTS

In general, the beginning of the production of scientific knowledge about blackberries in Colombia dates back to 1952 with a publication referring to arthropods in the journal Acta Agronómica of the National University of Colombia, adding around 20 publications until the year 2000, with varied topics such as transformation into by-products and methodologies for invitro propagation (Chadan & Larrea, 2000)(Hernández et al. 1999). In the period from 2000 to 2009, another 20 works were registered that cover the links of production and transformation, with topics on genetics, pests and diseases, as well as the elaboration of some by-products.

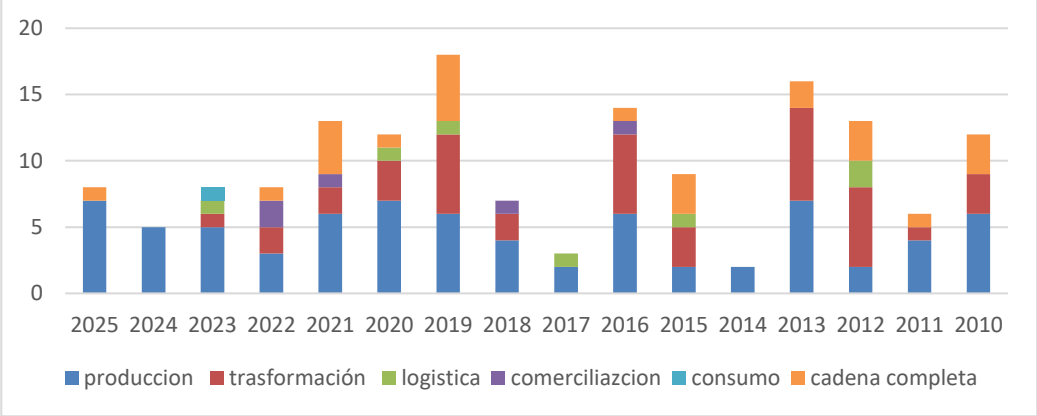
The period of analysis of this research begins in 2010 and covers until the first months of 2025, as can be seen in figure 2, with a total of 155 scientific publications, in the years 2019 and 2013 the largest number is appreciated. In terms of scientific production by links in the production chain, Figure 3 shows that the production link achieved the highest participation with 73 products, followed by the transformation link with 46, in third place, the complete chain with 26 and the others with the least representation.

Figure 2: Scientific production on the blackberry production chain from Castile 2010 to 2025



Source. Authors

Figure 3: Productivity of scientific knowledge by links in the production chain



Source. Authors

Mapping scientific knowledge for the primary or production link

This link includes all the primary activities and issues inherent to the crop until the harvest of the product, with activities such as provision of inputs and equipment, planting, propagation, genetic improvement; pest, disease and fungal management, soils, fertilization, irrigation, pruning, good agricultural practices and socioeconomic studies, among others. Table 2 shows that 57.5% of the publications correspond to articles in scientific journals, highlighting that a high percentage of the abstract and keywords of these publications are in Spanish, English and Portuguese; while 21.43% are published entirely in English, which can give them greater visibility. (Nieto, 2020)

Table 2: Production of scientific knowledge: production link

Knowledge Product Type	No	%
Article	42	57,5
Book	8	11,0
Book chapter	7	9,6

Newsletter, booklet, manual	4	5,5
Research report	5	6,8
Master's thesis	5	6,8
Resolution	1	1,4
Specialization degree work	1	1,4
Total	**73**	100,0

Source. The authors

As for the outstanding topics in this link, they are shown in table 3, where 28.8% corresponds to fungi, pests and diseases, in correspondence with the R+D+i demands of Pecticia, which undoubtedly the contributions and publications represent significant advances for growers, given the number of families that depend on it, and that advocate achieving the best yields without being affected by severe problems. The topics on genetics, fruits and integral studies represent 11% each.

Table 3: Research topics in the production link

Research topic	No	%	Research topic	No	%
Costs	2	2,7	Propagation	7	4,1
Comprehensive study - value chain	8	11,0	Pruning and watering - pruning by-products	3	9,6
Fertilization	6	8,2	Human talent	3	4,1
Ergonomics	2	2,7	Soil	1	1,4
Fruits	8	11,0	Pollination	1	1,4
Genetics	8	11,0	Technology	2	2,7
Fungi - pests diseases	21	28,8	Culture medium	1	1,4
Total				73	100

Source. Authors

The institutions are affiliated with authors with studies and publications corresponding to this link, firstly, the Colombian Research Corporation – Agrosavia (formerly Corpoica) – attached to the Ministry of Agriculture and Rural Development, which due to its own functions responds to a large part of the R+D+i demands, registered in Pecticia 2016. It contributes 23 publications, three co-authored with other institutions, where the main topics addressed were fungi, pests and diseases; then fertilization and to a lesser extent genetics and propagation. As mentioned by Saldarriaga et al. (2017), one of the main problems faced by producers is phytosanitary, which has led to a decrease in production without obtaining the yields and quality demanded by the industry, which leads to the loss of business opportunities. The University of Pamplona follows with an outstanding participation of 11 publications and the topics addressed are diseases, genetics, fruits and invitro propagation of planting materials that allows to have selected material available in favor of improvements in cultivars (Cancino et al. 2015)

From the Technological University of Pereira they contribute with 10 publications, where they cover topics of pest, disease and fungal treatment, with significant achievements as mentioned by Lopez et al. (2021). The National University of Colombia appears with 7

publications referring to diseases, fertilization, genetics and comprehensive studies; it is followed by the Pedagogical and Technological University of Colombia and the Industrial University of Santander, with three publications each, and from then on there is a large number of institutions mostly with only one product.

Mapping scientific knowledge for the transformation or industrialization link

The transformation or industrialization link covers the processing of products and their derivatives of the fruit or other component, as well as its related activities in the supply of equipment, processing methods, technology and socioeconomic studies. This link ranks second in the production of scientific knowledge with 43 publications; by type of product in Table 4 it is observed that 67.4% are articles in scientific journals, of which 5 are in English; the other contributions correspond to master's theses and specialization degree projects and a book.(Nieto, 2020)

Table 4: Production of scientific knowledge: a link of transformation

Knowledge Product Type	No	%
Article	29	67,4
Book	1	2,3
Specialization degree work	5	11,6
Master's thesis	8	18,6
Total	**43**	100,0

Source. The authors

The main research topics for this link (table 5), firstly, the production of by-products, from obtaining and evaluating pulps, acids, oils, liquors, prebiotic drinks and design of functional foods, considered innovative alternatives for the agro-industrial sector, as mentioned. Regarding the properties of the fruit, the chemical properties, yield, antioxidant activity, prebiotic and probiotic properties are investigated, as well as evaluation of fruit quality in order to (Jurado, Ceron, & Davila, 2023)determine their potential in berry markets, as well as serve as a genetic source for inclusion in breeding programs. In fruit conservation, various types of edible coatings are relevant, and finally technology related to the uses of ultrasound, microwaves and technological packages.

Table 5: Research topics in the transformation link

Research topic	No	%
Fruit preservation	7	16,3
Properties of the fruit	10	23,3
By-products	21	48,8
Technology	4	9,3
Business viability	1	2,3

Total	**43**	**100,0**

Source. Authors

Regarding the institutions with contributions to scientific research in this link, it is very dispersed from various institutions, but with participation reduced to one product. The National University of Colombia is the one with the greatest contribution, with five articles, six master's theses, a book and a specialization work, on topics for the conservation of the fruit and obtaining by-products. In their order, the universities of Nariño, Tecnológica de Pereira, Jorge Tadeo Lozano and Tolima, with three contributions each. Therefore, it is difficult to establish relationships between institutions, affiliation of authors and topics of study, which shows that there is a lot of work to be done to respond to the demands of R+D+i shown in the Pecticia 2016, especially in this link that, according to national guidelines, wants to promote reindustrialization to move from an economy based on extraction to a productive economy based on knowledge, technology and sustainability, and to respond in a better way to different problems of the country. (Conpes, 2023)

Mapping Scientific Knowledge for the Logistics Link

This link, according to Cardona et al. encompasses strategies, tactics and activities for the proper functioning of the supply chain, as well as adding value and contributing to competitiveness. It integrates packaging, cold chain, coatings for product preservation and shelf life extension. In the present case, the scientific productivity found was really low, only three master's theses, two specialization degree projects and one article (table 6)(2019). As for the topics, three are allusive to cold chains, the other three refer to packaging, coating and business viability. Noticing large gaps in the number of publications, topics of study, and therefore contributions to one of the critical situations in the logistics chain of the product due to its characteristics as a perishable product and contain a high percentage of water.

Table 6: Production of scientific knowledge logistics link

Knowledge Product Type	No.	%
Article	1	16,7
Specialization degree work	2	33,3
Master's thesis	3	50
total	**6**	100

Source. Authors

In institutions affiliated with authors with publications for this link, the National University of Colombia leads with three publications on the cold chain, where they sought to evaluate critical points with a view to contributing to the productivity and competitiveness of the production chain, in accordance with (Egea Hernández, 2015)Andrade (2023) recognizes the importance of providing solutions to reduce product losses and waste, and considers that edible coatings can be a viable option.

Mapping Scientific Knowledge for the Commercialization Link

This link, normally associated with competitive intelligence, encompasses the collection and analysis of information on competitors, customers, trends, opportunities, and challenges for the distribution and supply of the product and its derivatives to different destinations, either fresh or processed in national and international markets, as well as socioeconomic studies and business viability. The results in Table 7 show a low scientific productivity for this link, despite the multiple possibilities of topics to investigate and contribute, the amount of product produced in the country merits greater strategic vigilance for informed decision-making regarding the marketing alternatives of the product and its derivatives as mentioned (Díaz et al. 2022), in addition the few works found were developed for specific regions, which further limits the consolidation of global results or analysis.

Table 7: Production of scientific knowledge commercialization link

Knowledge Product Type	No.	%
Book	1	16,7
Book chapter	1	16,7
Specialization degree work	2	33,3
Master's thesis	1	16,7
Research Report	1	16,7
Total	**6**	100

Source: authors

Mapping of Scientific Knowledge for the Consumption Link and Product Uses

This link is attributed to topics such as preparations, recipe books, uses attributed to its nutritional benefits, health and well-being, the use of by-products derived from the fruit, leaves, seeds and other parts of the plant. For this link, only one research report was found alluding to the analysis of blackberry consumption in a municipality in Colombia, derived from the price of the product. Despite the benefits of the product, its great potential and the high number of families that depend on it, the management of knowledge about it is still very limited.

Mapping scientific knowledge for the entire chain

This grouping includes publications that cover the entire chain from initial production to the final destination, with the use or consumption of the different derived products. 26 scientific products were analyzed (table 8), among these eight articles, where what Suárez et al. (2021) did stands out, using the Delphi method and with the participation of experts from Spain, Mexico and Brazil, in order to offer decision-making tools to the actors in the chain, in science, technology and innovation for the strengthening of the chain in all links, this is how they identified the future bets of the

blackberry chain that can become direct bets for actors related to R+D+i activities for the acquisition, adoption and generation of product, process, marketing and business model innovations, as well as possible training and research activities from universities with an agro-industrial approach. Similarly, the book by García et al. (2021), who identified technological gaps and built a research and development plan in which research topics are defined that respond to the existing demands in the production chain, which, although it was projected for one department, what is stated there can be replicated or extended to other territories.

Regarding institutions affiliation of authors with contributions to the complete chain, Agrosavia with five participations between primers, book chapters and research reports, the University of Caldas with an article, a book and a master's thesis, all focused on the productive chain in the department of Caldas, in correspondence with areas of planting and product yield in that department. Then minority participations of a publication of 14 university institutions are registered, given the dispersion it is not possible to generate notorious patterns of relationship of research, themes and institutions.

Table 8: Producing scientific knowledge for the entire chain

Knowledge Product Type	**No.**	%
Article	8	30,8
Agreement	1	3,8
Newsletter, booklet, manual	5	19,2
Book chapter	2	7,7
Book	4	15,4
Research Report	4	15,4
Master's thesis	2	7,7
Total	**26**	100,0

Source. Authors

CONCLUSIONS

The mapping of knowledge about the blackberry production chain in Colombia for the period 2010 to 2025, made it possible to identify topics addressed by links, gaps, development and innovation and potentialities of this product, as well as the evolution of knowledge about this agri-food system, in order to interpret, use, transmit, replicate and cooperatively take advantage of experiences, formalize knowledge networks and project new studies, in order to encourage the visibility of the impact of the productive ecosystem on the development of the regions, reduction of disparities, as well as on the benefits to health and nutrition, especially in developing countries with the greatest impact of poverty and where the product is consumed less.

Despite the socioeconomic relevance of blackberries in Colombia, mapping shows imbalances in scientific production between the different links in the production chain, which can limit their overall competitiveness. In this sense, and in view of the weak

articulation between research centers and the productive apparatus indicated in the PECTIA, the ideal is to direct research and innovation efforts towards more links, in items such as packaging systems, market intelligence and the dissemination of the nutritional and functional properties of blackberries and their derivatives in their forms of consumption and integral use of blackberries, specifically in preparations, recipe books and potential uses of the leaves, seeds and other by-products for purposes associated with health, well-being, beauty, etc. Likewise, to strengthen a strategic knowledge management network that articulates academia, research centers and the agro-industrial sector, benefiting the transfer and appropriation of results, the closing of technological gaps and the generation of solutions that contribute to the competitiveness, sustainability and food security of the country.

This undoubtedly leads to changes in production with a greater incursion of knowledge and implementation of agriculture with contribution to the SDGs, technical assistance and agricultural extension, biotechnology, circular economy, mitigation and adaptation to climate change and sustainability. Likewise, this work is an important input useful to different stakeholders, such as decision-makers in policies, academia and members of the blackberry production chain, by gathering relevant scientific knowledge for the Colombian report of information to the World Food Programs, the Global Action Plan for Plant Genetic Resources for Food and Agriculture, as well as advances in the indicators of the 2030 Agenda and the needs of R+D+i, as well as reindustrialization policies in Colombia.

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