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Surveillance and strategic intelligence for natural ingredients in Valle del Cauca

Vigilancia e inteligencia estratégica para ingredientes naturales del Valle del Cauca

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Abstract

Through surveillance and strategic intelligence, the purpose of this research is to explore the scientific, technological and commercial trends of 10 natural ingredients prioritized in the framework of the project "Strengthening R&D capabilities for the production of Natural Ingredients (NI) from residual biomass in Palmira, Valle del Cauca, West" developed by Universidad del Valle, Corporación Biotec, and the Valle del Cauca's Government. This is consistent with Valle del Cauca's recognition and leading position in the agricultural sector domestically and internationally, making it an attractive territory for investments with an impact on the region's growth, well-being and competitiveness. The use of agribusiness residual biomass could enhance these fruit sector's advantages in developing NI that generate added value to the chain, positively impacting public health, the food industry, and cosmetics. This research's methodology is based on strategic surveillance and intelligence applied to 10 NI. From these, the relevant information is explored and knowledge generated to support the selection of three potential NI from the residual biomass of tropical fruit trees in the department, which will be produced at prototype scale at a later stage of the project framework. The NI prioritized in this research come from the residual biomass of fruit trees such as pineapple, soursop, and peach palm fruit.

Keywords: Technological surveillance, Strategic intelligence, Natural ingredients, Valle del Cauca Fruit trees, Residual biomass.

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Resumen

El propósito de esta investigación es explorar por medio de vigilancia e inteligencia estratégica las tendencias científicas, tecnológicas y comerciales de 10 ingredientes naturales priorizados en el marco del proyecto "Fortalecimiento de las capacidades de I+D+i para la producción de ingredientes naturales (IN) a partir de biomasa residual, Palmira, Valle del Cauca, Occidente" desarrollado por la Universidad del Valle, Corporación Biotec y la Gobernación del Valle. Esto en concordancia con el reconocimiento y liderazgo que tiene el Valle del Cauca en el sector agrícola a nivel nacional e internacional, que lo convierte en un territorio atractivo para la inversión con impacto en el crecimiento, el bienestar y la competitividad de la región. Estas ventajas se podrían potenciar con el aprovechamiento de la biomasa residual de la agroindustria del sector frutícola en el desarrollo de IN que generen valor agregado en la cadena, impactando positivamente en la salud pública, en la industria de alimentos y la cosmética. La metodología de esta investigación se fundamenta en el desarrollo de una vigilancia e inteligencia estratégica de 10 IN, sobre los cuales se explora información pertinente y se genera conocimiento para apoyar la selección de tres IN potenciales a partir de la biomasa residual de frutales tropicales del departamento, que en el marco del proyecto se producirán a escala de prototipo en una fase posterior. Estos IN priorizados en este ejercicio provienen de biomasa residual de frutales tales como la piña, la guanábana y el chontaduro.

Palabras clave: Vigilancia tecnológica, Inteligencia estratégica, Ingredientes naturales, Frutales del Valle del Cauca, Biomasa residual.

1. Introduction

Corporación Biotec (Biotec Corporation — CB[1]), supported by the Universidad del Valle, the Government of the Valle del Cauca and a group of companies and entities belonging to from the Valle del Cauca's agricultural, agribusiness and bio-industry sectors, set forth the initiative "Strengthening R&D capabilities for the production of natural ingredients from residual biomass[2], in Palmira, Valle del Cauca, West"[3]in 2016.

Subsequently, the Governorate of Valle del Cauca prioritized this project for the Science, Technology, and Innovation Fund of the General System of Royalties for Science, Technology, and Innovation with resources amounting to 3 billion pesos to achieve the objectives set out therein. The project has also seen support from partnerships and contributions from the productive sector and entities related to natural ingredients and regional development.

The framework of this project develops three components related to:

the characterization of the supply of residual biomass from tropical fruit trees in Valle del Cauca, the development of an inclusive and sustainable model for the production of NI, and the development of stakeholders' technical and scientific abilities in an R&D program. These components seek to address the following research question: *How to support the development of a regional strategy to align agro-industrial and residual biomass resources, especially in crops and fruit processing, and dispersed research and innovation capabilities, to seize the window of opportunity of global and domestic demands for natural ingredients?*

In response to this research question, the project's general objective was "*to strengthen and consolidate research and innovation capabilities and the use of agro-industrial resources to promote and generate a supply of differentiated and innovative world-class natural ingredients (NI) from residual biomass in Valle del Cauca*."

The following studies were developed to identify and characterize the supply of applicable-and-useful-in-natural-ingredients residual biomass in Valle del Cauca: a) An inventory and directory of Natural Ingredients' stakeholders in Valle del Cauca;

[1] Biotecis, a Research Center attached to Colombia's National STR System established in 1995 and promoted by the Universidad del Valle through the academic, research, government, and business sectors' participation. It has been recognized as a Research Center by the Administrative Department of Science, Technology, and Innovation (Colciencias), and renewed by Resolution No. 369-19 of April 2018. Based on a special agreement, CB has been headquartered at CIAT since 1999 Corporación Biotec (2016).

[2] It is emphasized that for this project that the terms residual biomass and agroindustrial resources will focus on crop biomass and tropical fruit trees agroindustrial processes.

[3] The Governorate of Valle and Colciencias prioritized this project in Valle del Cauca's Departmental Strategic Plans and Accords in 2016 as a project idea under the name of "Research and innovation for the development of natural ingredients for food and nutrition security, public health and cosmetics and cleaning - Valle del Cauca."

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b) Mapping the current status of residual biomass with potential for production of Natural Ingredients (NI) in Valle del Cauca; and c) Ten (10) surveillance and strategic intelligence exercises to identify scientific, technological and commercial opportunities for Natural Ingredients (NI) from tropical fruit trees' residual biomass the department of Valle del Cauca. Three (3) NI were selected and prioritized from these studies and will be prototyped in the execution of the second stage of the project.

According to the above, this paper's interest lies in showing the methodological process, and main results of surveillance and strategic intelligence applied to 10 natural ingredients from Valle del Cauca, which allowed to prioritize three NI for the framework project.

2. Methodology

The methodological process that allowed to develop the surveillance and strategic intelligence exercises (SSIE) for 10 NI from tropical fruit trees' residual biomass in Valle del Cauca observed three major stages. The first stage prioritized the 10 NI on which the SSIEs exercises were conducted, based on secondary and primary information. The second stage was concerned with each NI's monitoring cycle to explore scientific, technological, and commercial opportunities. Lastly, three NI were selected in the third stage based on the SSIEs' reports and participation by strategic stakeholders (Figure 1).

2.1. Stage I. Prioritization of 10 natural ingredients from tropical fruit trees' residual biomass in Valle del Cauca

The first phase of stage I of the process started by identifying 53 types of tropical fruit trees in Valle del Cauca from the information systematized in the document "*Mapping the current status of residual biomass with potential for the production of Natural Ingredients (NI) in the department of Valle del Cauca. Strategic overview of NI.*" In turn, secondary information (technical reports, books, studies, newspapers, etc.) and primary information from interviews with the project's strategic stakeholders complemented the above-mentioned search. Subsequently, based on a set of criteria defined by the project team, the 53 fruit trees identified in the first phase were assessed to select 21 fruit trees. Finally, the criteria matrix used previously was adjusted in this phase. After such modification, we proceeded to evaluate the 21 fruit trees through collaborative work by the work team members. This effort resulted in selecting ten tropical fruit trees with potential for extraction of natural ingredients from their residual biomass, namely, soursop, pineapple, cocoa, papaya, mango, pitahaya, and Hass avocado, açaí palm fruit, guava, and peach palm fruit.

From the ten fruit trees mentioned above, phase two identified 35 natural ingredients with development potential within the project framework. Based on this set of NI, the third stage identified the strategic stakeholders' interests through 10 interviews applied in the Valle del Cauca, and nine visits nationwide. The participants in this phase of the process were Levapan, Agnes de Colombia, Professor Jaime Restrepo (Universidad del Valle), Professor Hugo Martínez (Universidad Nacional), Proterra Food, Amiure, Ingredion, Jaquin de Francia S.A, Laboratories QF.A LTDA, San Jorge, *Business Laboratory* S.A.S., Neyber, Corpocampo, Green Andina, Naturales Casvior S.A., Funat, Prebel, *Bioingred Tech*, and Herbaplant Laboratories.

During the fourth phase of stage I, 35 NI were assessed internally (by members of the work team from the three stages) through 4 factors and 14 criteria placed in Cartesian-plane importance and probability of successful assessment. This was done to identify ten potential NI on which technological surveillance and strategic intelligence would be developed (Table 1).

The fifth phase assessed the 35 NI based on expert workshops and using the interviews and internal assessment results as inputs. The preceding to choose the 10 NI that would be the subject of further in-depth analysis through technological surveillance and strategic intelligence.

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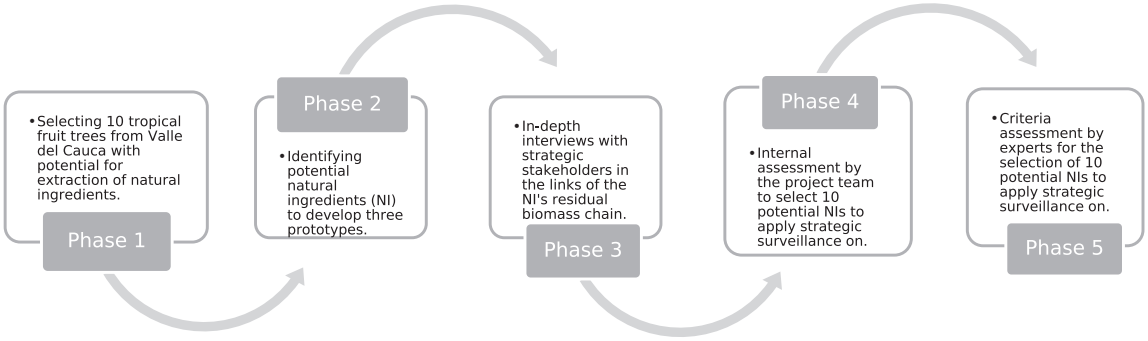
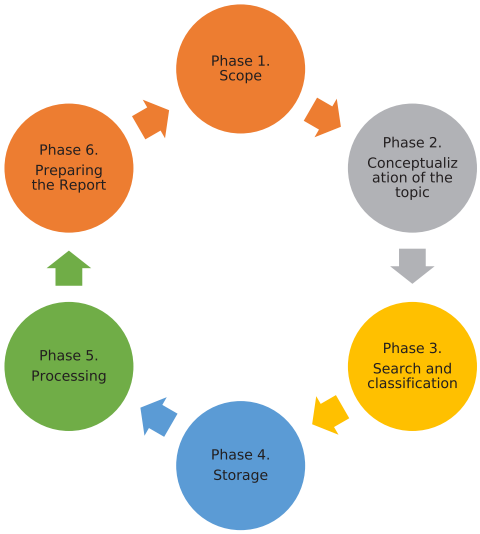
Figure 1. Methodological process

Stage I. Prioritization of 10 natural ingredients from tropical fruit trees' residual biomass in Valle del Cauca



Stage II. Exploring scientific, technological and commercial trends for the prioritized natural ingredients



Stage III. Selection of 3 natural ingredients with the highest potential for the Valle del Cauca

Source: Authors' own elaboration.

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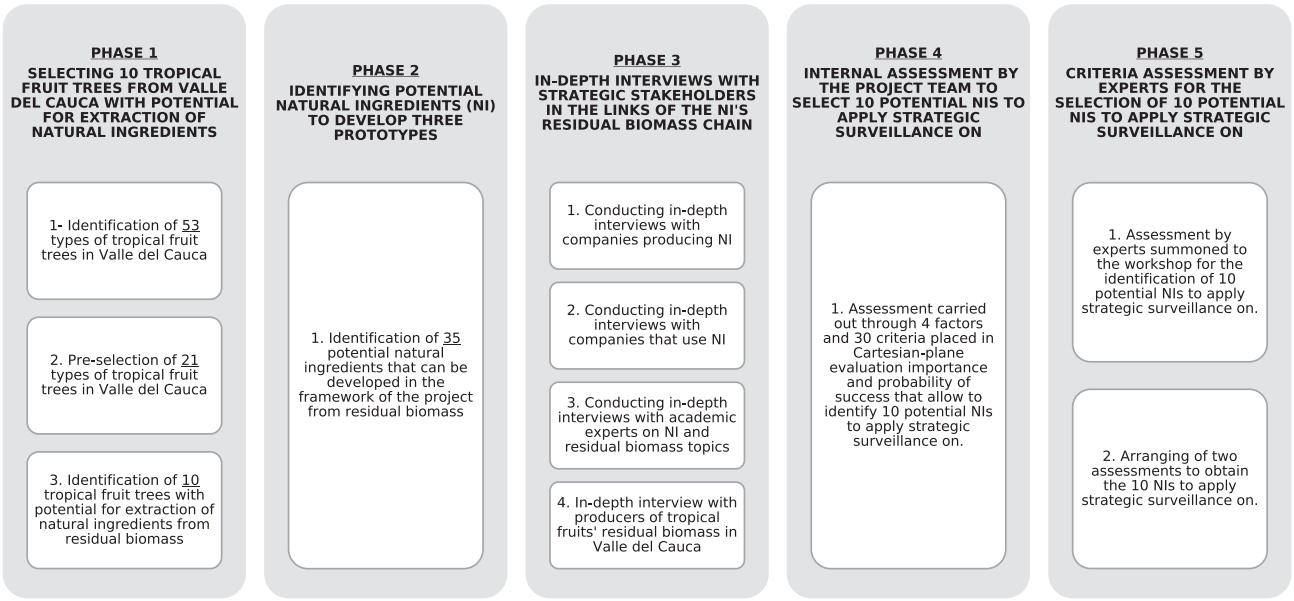
Table 1. Breakdown of assessment factors and variables for 35 natural ingredients

Relevance	Probability of success
Market status: Domestic and international market opportunities Standardized Colombian NI producing companies User Industry/sector	**Scientific and technological advancement:** Innovation/differentiation Global and domestic patents Research projects at the domestic level, and scientific papers at a global and domestic level Grey literature and ancestral knowledge
Impact: Economic impact Environmental impact Social impact	**Feasibility:** TRL (Technology Readiness Levels) in Colombia Technology intensity (TI) Articulation with strategic stakeholders Business sustainability Business sustainability

Source: Ortiz, *et al.* (2019a).

Figure 2. Phases developed to prioritize the natural ingredients



Source: Ortiz, *et al.* (2019a).

Figure 2 shows the five phases developed to prioritize the ten natural ingredients.

2.2. Stage II. Exploring scientific, technological and commercial trends for the prioritized natural ingredients

2.2.1. Concepts of surveillance and strategic intelligence. Technology surveillance (TS) is an organized, selective and permanent system that collects various kinds of information from abroad and the organization itself (economic, competitive, technological, among others) in order to select, analyze and disseminate it and turn it into less-risk decision-making knowledge capable of foreseeing change (UNE 166006, 2018).

On the other hand, strategic intelligence (SI) is a set of coordinated actions for search, processing (filtering, classification, analysis), distribution, understanding, exploitation, and

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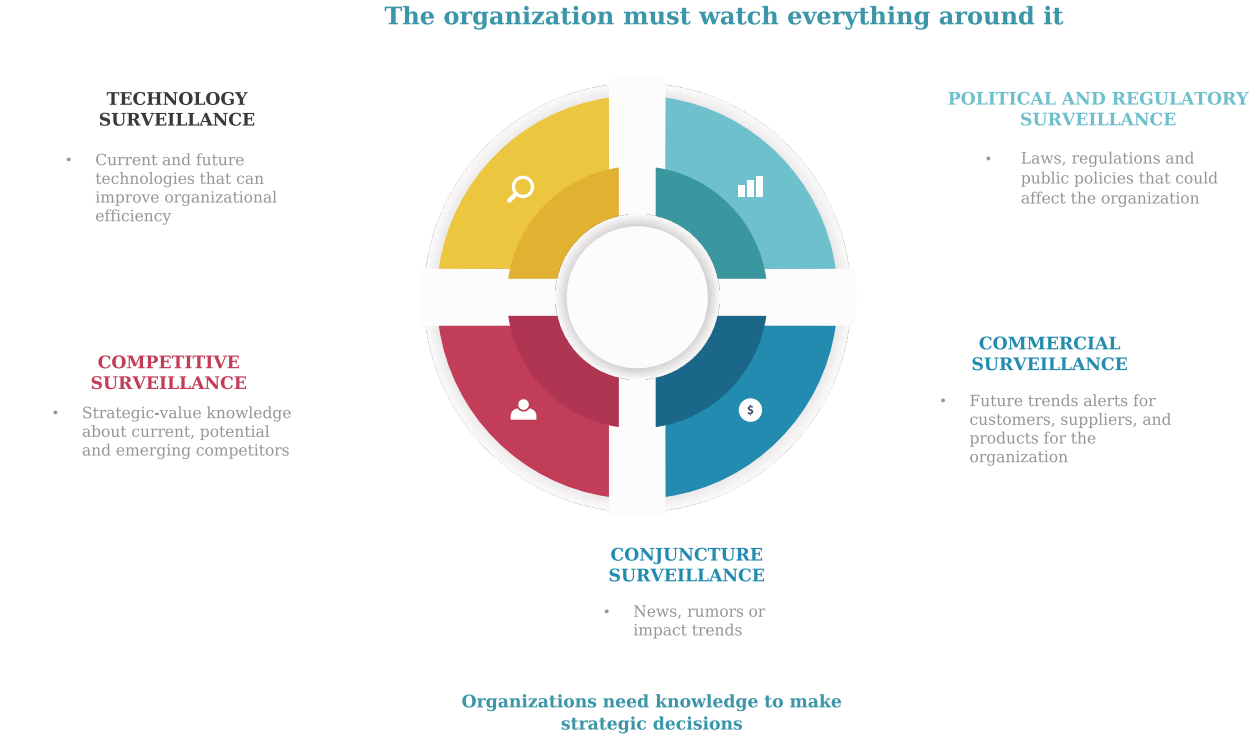
Figure 3. Types of surveillance



Source: Ortiz (2018).

protection of legally obtained information, useful for an organization's economic stakeholders in the development of their individual and collective strategies (UNE 166006, 2018)

A coordinated and continuous SSIE process enables the development of skills in the field of innovation. As a result, organizations can offer a set of services and products that are competitive domestically and internationally. Moreover, innovation processes based on TS and SI makes it easy for companies, universities, and government institutions to respond to the global environment, thus encouraging productive development (Sánchez, Medina, and León, 2007).

Sánchez and Palop (2002) provide another definition by understanding TS and SI as constituting a systematic process that collects economic, technological, political, social, cultural, and legislative information, and analyzes and disseminates it through legal means. This is in the spirit of identifying and anticipating opportunities or risks to improve the organization's strategy formulation and implementation.

Thus, SSIE is a methodology applied to obtaining and analyzing information to generate knowledge as a decision-making input (Ramírez, Rojas, and López, 2013).

2.2.2. Types of Surveillance. There are currently five types of surveillance: technological surveillance, political-regulatory surveillance, commercial surveillance, short-term surveillance, and competitive surveillance. These typologies are described in Figure 3.

2.2.3. The cycle of technological surveillance and strategic intelligence. This process is supported by Palop and Vicente's (1999) scientific and technological surveillance adaptation methodology, which pursues qualified information about the environment through legal means, in order to structure new knowledge. This discipline provides information and state-of-the-art knowledge inputs to strategically direct decisions. Figures 4 and 5 below describe each phase of the methodology.

The specialized databases used in the exercise are the following (Table 2).

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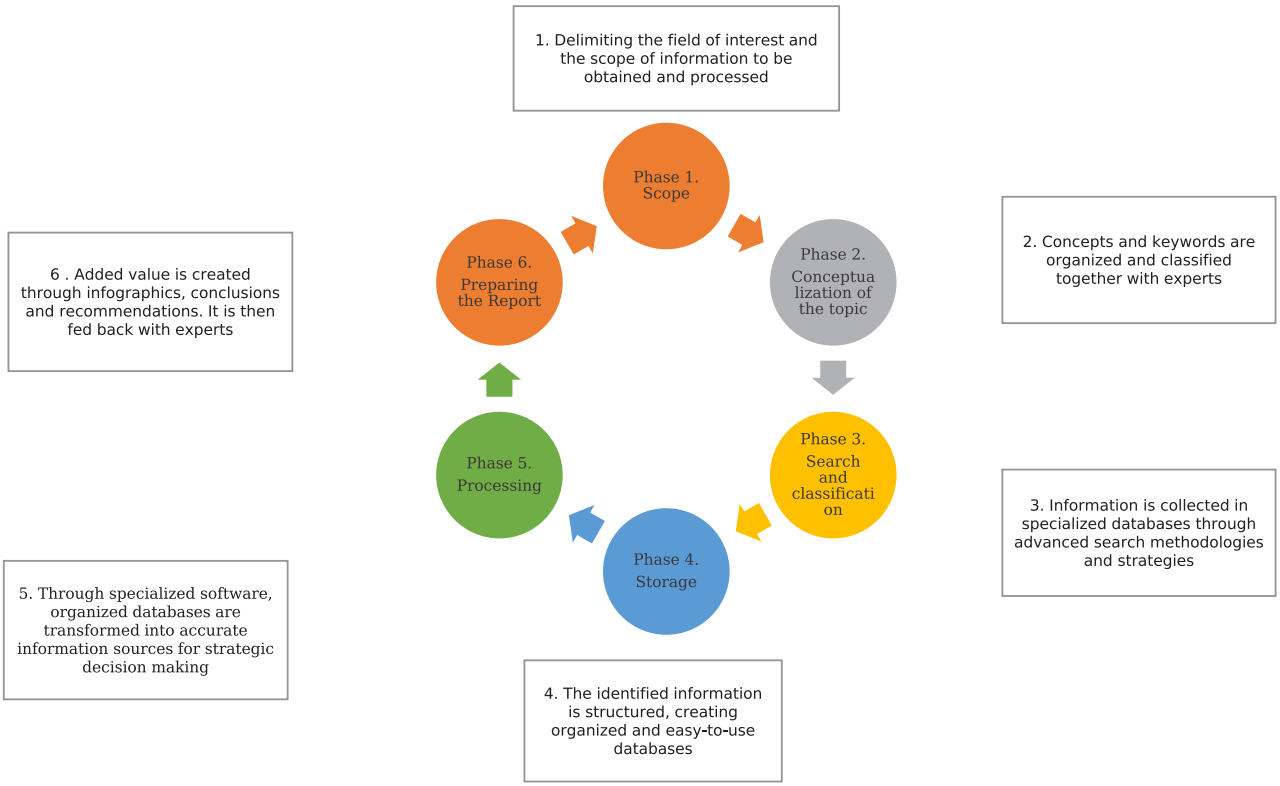
Figure 4. Structure of the surveillance cycle and strategic intelligence



Source: Authors' own elaboration.

Table 2. Specialized databases
ORBIT PATENTSCOP GOOGLE PATENT ESPACENT
SCOPUS SCIENCE OF DIRECT GOOGLE ACADEMIC
TRADE MAP EUROMONITOR LEGISCOMEX INCI IN-COSMETICS AGRONET DANE ALIBABA MADE IN CHINA

Source: Authors' own elaboration.

2.3. Stage III. Selection of 3 natural ingredients with the highest potential for the Valle del Cauca

Based on the results of the surveillance and strategic intelligence exercises on the 10 NI, an expert workshop was held, which prioritized three NI from Valle del Cauca's fruit trees' residual biomass. These will be subjected to a prototype scale development process within the framework of the project. These three NI are listed below:

- Standardized soursop leaf extract (rich in acetogenins)
- Pineapple peel Essential oil
- Powder from Peach palm fruit's husk and pulp

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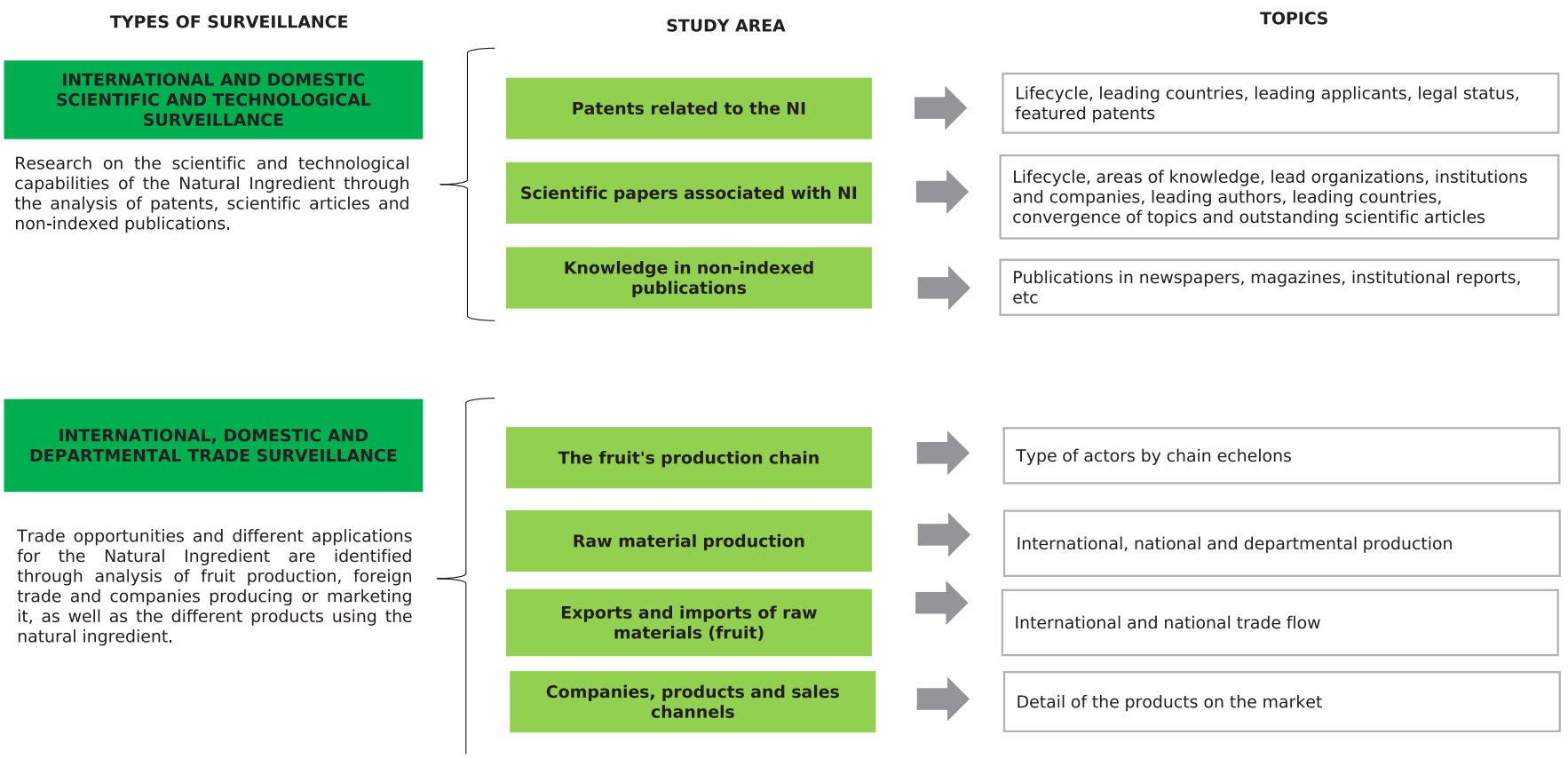
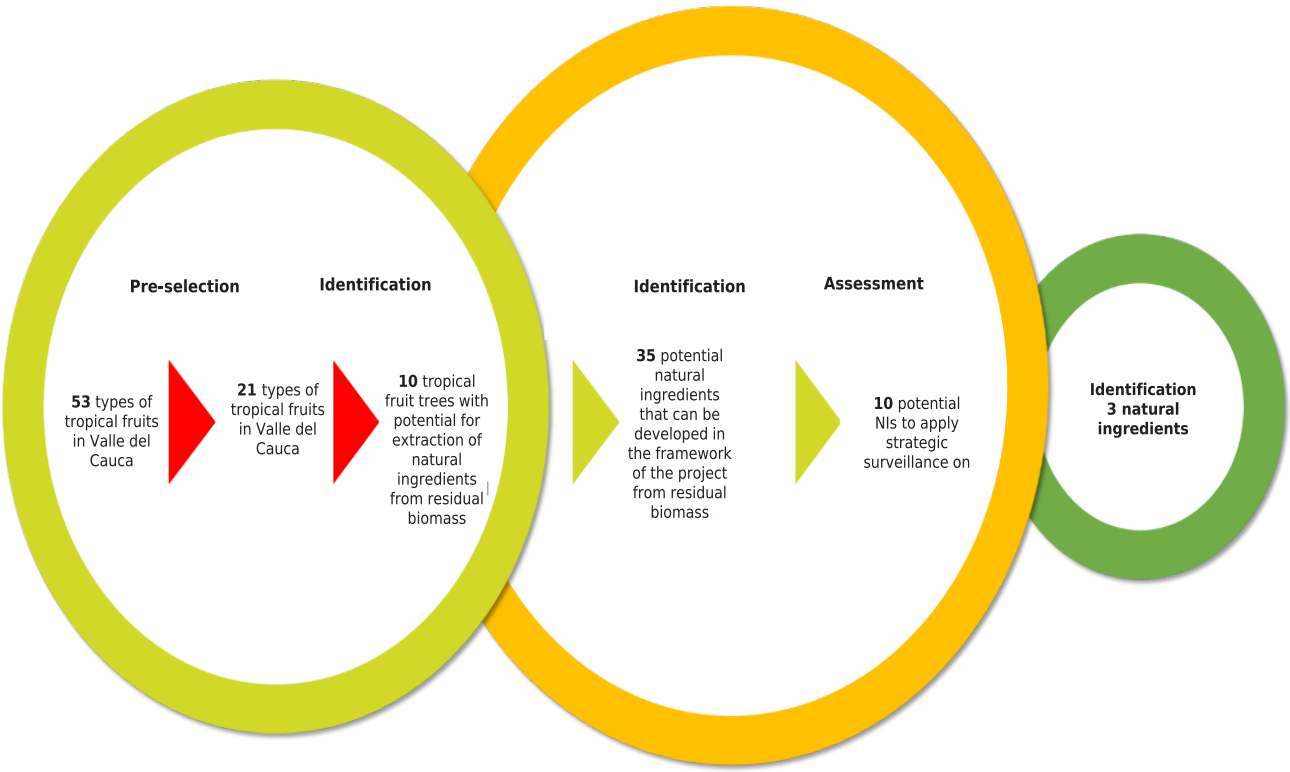
Figure 5. Content of the exercises to explore scientific, technological and commercial trends



Source: Authors' own elaboration.

Figure 6. Synthesized process to select three natural ingredients



Source: Authors' own elaboration.

Figure 6 succinctly illustrates the prioritization from a broad set of tropical fruit trees (53) from the Valle del Cauca to select three natural ingredients.

3. Results and discussion

Table 3 summarizes the main findings of the surveillance and strategic intelligence exercises carried out on the ten natural ingredients selected during the implementation of phase I of the project.

Surveillance and strategic intelligence on the 10 NI selected allowed to recognize the three main natural ingredients on which a prototyping process will be carried out as a demonstration of the framework research project, which appears below: a) standardized soursop leaf extract (rich in acetogenins), b) Essential pineapple peel oil, and c) Peach palm fruit's peel and pulp powder.

This demonstrated that the methodological process undertaken allowed to integrate qualitative and quantitative information from secondary and primary sources, which underwent an exhaustive analysis to produce knowledge that supported strategic stakeholders' decision-making to harness resources and capabilities from the framework research project.

Likewise, the surveillance and strategic intelligence processes became a fundamental input for the model to be developed in the project to produce world-class natural ingredients (NI) from (tropical fruit trees') residual biomass in Valle del Cauca.

4. Conclusions

The surveillance and strategic intelligence processes identified several scientific, technological, and commercial trends in the three selected NI described below.

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Table 3. Main findings from the 10 NIs prioritized

Natural Ingredient	No. of patents	No. Scientific papers	Non-indexed publications	Production in Valle del Cauca (ton/ year)	Harvested area in Valle del Cauca ha/year	Productivity in Valle del Cauca ton/ha	No. Commercial products
Yellow pitahaya seed oil	1.027	13	10	977	114	8.5	1
Pineapple peel Essential oil	672	116	11	161,070	2.542	63.4	5
Hass Avocado seed oil	1.352	10	16	27.865	2.077	13.4	14
Guava Pulp Powder	1.027	61	7	10.278	1.000	10.3	11
Mango peel extract	3.659	208	9	2.000	190	10.5	20
Açaí palm fruit extract	1.086	203	13	0	0	0	25
Standardized soursop leaves extract (rich in acetogenins)	117	181	9	2.463	296.2	8.3	16
Peach palm fruit's peel and pulp powder	36	33	10	8.864	1.762	5	10
Yellow pitahaya pulp powder	25	25	10	977	114	8.5	2
Freeze-dried soursop pulp powder	135	22	10	2.463	296.2	8.3	9

Source: Authors' own elaboration.

Standardized soursop leaf extract (rich in acetogenins)

- Over the last ten years, 117 patent families have been found concerning soursop leaf extracts, mainly for use in anticancer, antispasmodic, sedative, antimalarial treatments, and a vasodilator and antidiabetic drug. There are also records of use in foodstuffs components such as dietary foods and tea and cosmetic skincare products (Ortiz *et al.,* 2019a).
- The United States is leading the worldwide research and development with 51 patents, of which 28% relate to food chemistry, and 22% to pharmaceuticals (Ortiz, *et al.,* 2019b).
- USA is among the top 10 buyers of soursop leaf with an estimated value of USD$272.48 million, followed by Japan with USD$198.51 million, and Germany USD$224.55 million. It should be noted that the United States is an avid consumer of medicinal plants for various purposes (Mendez Encalada, 2016).
- According to scientific articles, the leading organizations producing knowledge on the subject are mainly universities in Asia, Putra University Malaysia, and the University of Indonesia. Though at the national level, and specifically at the regional level, the Biotec Corporation is a Center for Research, Development, and Technological Innovation for Agriculture, Agribusiness and the Bio-Industry that has impacted on the topic of Natural Ingredients for Food and Nutrition security, public health, and added-value industries. Among such impacts, it has developed research, technological development, and innovation strategies in the soursop production chain (*Annona muricata L.*)
- In Colombia, the production of soursop during the last decade increased by 128%. By 2017, Valle del Cauca was the fifth

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producer of this fruit with 2,463 tons, with the municipality of Bugalagrande leading production in the region, followed by Pradera with 300 tons and Caicedonia 292 tons (Ortiz, *et al.,* 2019a).

- It is noteworthy that Colombia enacted the Green Growth Policy -CONPES 3934- in 2018, to transition towards a more sustainable economic model (DNP, 2018). One of its strategic axes is developing a market for bio-products, and the improvement of competitiveness in sectors related to the bio-economy, where strategic projects concerning natural ingredients are to be implemented between 2018 and 2030.
- The market for herbal tea products is quite broad and versatile. This application is of particular interest because it would allow commercially moving the ingredient in formulations of this type.

Pineapple peel Essential oil

- Regarding research, the 21st century a growing number of patent families directly and indirectly related to pineapple peal essential oils, concerning extraction methods and final product use on account of its aroma-related properties. Concerning the essential oil extraction processes, those applied to other fruit trees stood out because they can be held as a reference for the NI being studied. Given that they are easy to perform, low-cost, good-quality, and easy to extract, and patented in Asian countries, and therefore not protected in Colombia (Ortiz *et al.,* 2019c).
- Regarding the number of scientific publications directly or indirectly related to product peel essential oil worldwide during the 21st century, the figure has moved upward, with Brazilian universities playing a leading role in producing such scientific knowledge. Similarly, it should be noted that there are publications (mostly Latin American) related to the NI and unindexed in databases such as Scopus or Science Direct. Nevertheless, they are relevant in guiding research on the characterization of physicochemical properties (volatile components/aromas), functionals, and antioxidants of essential oil extracted from the pineapple peel (Ortiz *et al.,* 2019c).
- It is emphasized that in terms of uses, essential oils have applications mainly in the cosmetics industry, toilet products, and the food industry, given the physicochemical properties of their intense aroma and flavor. In this way, they are used as raw material to manufacture perfumes, soaps, shampoo, toiletries, detergents, among others, and as flavorings in drinks and foodstuffs.
- Furthermore, new applications for essential oils as an ingredient have been found in phytocosmetics, where their content can reach 1%, as well as in the so-called cosmeceuticals that harness not only the oils' sensory properties, but also its biological, antioxidant, and antimicrobial abilities (CENIVAM, 2009).
- It should be noted that in terms of products available on the market, we found that essential oil from pineapple peel is used mainly for fragrance in the preparation of perfumes, bath lotions, cleaning products, candles, incenses, shampoo, oils for body massage. The offer mainly comes from abroad, where the United States stands out. It should be noted that there is a wide variety of essential citrus fruits' oils and medicinal plants in the market. However, for those from pineapple, specifically from the peel, there is little supply. Therefore, orientation towards the extraction of this type of oil could be novel to some degree in domestic and international markets, which would be in line with the firm and growing global trend to prefer, buy, and use natural products rather than synthetic ones.

Powder from Peach palm fruit's husk and pulp

- Peach palm fruit is rich in oils and carbohydrates and low in proteins. It also contains all essential amino acids for human nutrition, carotenes (natural orange dye), omega oils 3, 6, and 9. It does not contain gluten, making it beneficial for people with celiac diseases and the like.
- There are several uses for peach palm fruit, both in the food industry and in cosmetics. Some of the market products

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include styling cream, shampoo, peach palm fruit, and maca syrup and jam, dietary supplements, energy drinks, and flour used as raw material for diverse food preparations such as arepas, empanadas, cakes, among others.

- According to the companies visited in the project framework, we found that peach palm fruit is widely used in nutritional supplements. Companies and laboratories' interest in gaining knowledge on cosmetic uses for this fruit and introducing it to their research and products also came to light.
- According to the technological surveillance carried out, it is evident that the leading countries in patenting this fruit are Brazil and the United States. Their core developments are in the field of food chemistry. For its part, Colombia has only one patent for snacks made of a thin slice of the fruit, which is fried until crispy. The said patent was applied for 2010, and its current is abandoned (Ortiz *et al.,* 2019d).
- According to the articles analyzed, the main research topics on this fruit are plant extracts, pigments, and active compounds such as antioxidants and carotenoids, animal feed, diet fiber, metabolism, weight gain, and the like. The most recent research on this fruit is from the Universidad Nacional and Universidad de Nariño (Ortiz *et al.,* 2019d).
- It is of great importance for the region, the country, and the world, to develop further research on the nutritional, medicinal and cosmetic properties of this fruit. Although there is research from several years ago, it could either several ways in or face barriers because it is such an exotic product. Further scientific explorations will shed light on its benefits in-depth for different fields and industries.

5. Conflict of interest

The authors declare no conflict of interest.

6. Source of Financing

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