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Scientific and Technological Advances in the Production Chain of the Pitaya (*Hylocereus Undatus*)

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Abstract: This study presents a study of technological surveillance of the exotic fruit pitaya as an economic potential of Colombia's marginal regions. In this sense, the research was made from search equations in the Scopus and Wipo databases. The study includes eight stages: scientific production, outstanding authors in scientific production, countries with the greatest number of publications, outstanding institutions with scientific production, patents production, main applicant countries, main applicant companies and patent classes. Finally, the research shows the growing importance of economic activity during the 2010-2018 period, based on the volume of scientific and technological information available in the databases.

Key words: Technological surveillance, productive bets, search equations, surveillance, economic, scientific

INTRODUCTION

Colombia is an important fruit producer due to its environmental, hydrological and climatological conditions. According to PROCOLOMBIA, the country is the ninth supplier of exotic fruits worldwide and has the possibility of strengthening their range in international trade. In this regard, the identification of non-traditional products with potential becomes a fundamental task for the sustainable development of the agricultural sector (Madrigal, 2010), for which it becomes imperative to direct efforts in strengthening this productive region.

Several studies have been developed including some technological and prospective surveillance which seek to establish some alternatives to support the growth of these sectors and economic activities (Andrade *et al*., 2018; Navia *et al*., 2018; Mogollon *et al*., 2017). Thus, technological surveillance, henceforth TS becomes a fundamental tool to empower economic activities based on the identification of the technological and scientific trends that are being developed. A trend is understood as a pattern, dynamic or behavior in any field, perceived or identified from the processing of information (Castellanos Dominguez *et al*., 2011).

Generally, TS is defined, based on the concepts of Palop and Vicente (1999) and Callon *et al*. (1995) as a tool that facilitates the possession of scientific and technical information that is sufficiently selective, elaborated and updated to take advantage of new developments and put innovations into practice. It also, serves to identify key areas, opportunities and threats to technological development and research trends from indicators of bibliometrics, scientometrics and patentometry, among others (Hodgson *et al*., 2008; Dereli and Durmusoglu, 2009; Arman *et al*., 2009).

TS identifies trends through techniques such as bibliometrics that allow the analysis of scientific production (articles, books, memories, among others) in order to determine progress, impacts and relationships in the field or area in particular. Also, the studies include patent analysis. Patents represent one of the main information inputs towards innovation, especially because it allows to know which technology is available in the market (Castellanos Dominguez *et al*., 2011).

For the reasons cited above, this study focuses on conducting an evaluation of TS for pitaya in order to contribute to the exploitation of its economic activity in marginal regions of Colombia with great comparative advantages in its production, from the identification of alternatives in production, marketing and agro-industry.

MATERIALS AND METHODS

There are several procedures to carry out studies related to TS. The methodology used for the development of the present study is exposed below, based on the proposed by Andrade *et al*. (2018).

Construction of the search matrix: The construction of the search matrix is aimed at defining the scope of the study. This is developed jointly by experts and researchers who based on their knowledge and experience, provide key elements to take into account in its development.

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Identification of the tools to be used: For the elaboration of the article, the main databases containing information related to the research topic were identified and accessed using.

Scientifically

Scopus: The largest database of citations and abstracts of peer-reviewed literature: scientific journals, books and conference proceedings. It has intelligent tools to track, analyze and visualize research, offering an overview of global research production in the fields of science, technology, medicine, social sciences and the arts and humanities.

Technologically

WIPO: The World Intellectual Property Organization (WIPO) is a specialized agency of the United Nations System, created in 1967 with the signing of the Stockholm Convention, dedicated to promoting the use and protection of artworks of the human intellect (patents).

Research: For the exploration of the information, different logical equations were established based on thesauri and Boolean operators in order to obtain the largest amount of validated scientific, technological, commercial and conceptual data.

Construction of the equations through the use of operators: In the construction of the search equations, both the thesauri and the Bolean operators were taken into account, estimating a construction of equations for searching scientific articles and others for searching for patents. The operators allowed to focus the exploration, linking search terms and defining the relationship between them.

Construction of indicators for bibliometric analysis: The construction for each block will be as follows:

- Bibliographic production block
- Publications in time
- Keywords
- Institutions with the largest number of publications
- Countries with the highest number of publications
- Main technological and scientific advances

RESULTS AND DISCUSSION

Next, the results obtained at a scientific and technological level for the economic activity of pitaya are presented. The search for pitaya was made with the following equation:

(TITLE-ABS-KEY (pitahaya) OR
TITLE-ABS-KEY (pitaya) OR
TITLE-ABS-KEY (ask her) OR
TITLE-ABS-KEY (pita-haya) OR
TITLE-ABS-KEY (pita AND haya)
OR TITLE-ABS-KEY ("Hylocereus undatus")
OR TITLE-ABS-KEY ("dragon's fruit")) AND
PUBYEAR>2009 AND PUBYEAR<2019

Scientific production: The results obtained through the developed search equation show a total of 620 scientific documents for the period 2010-2018, of which there are 491 research articles, 88 conference papers, 13 scientific notes, 10 review articles, 9 chapters of book, 6 printed articles, 2 editorials and 1 erratum. Likewise, there is a growing trend in the number of publications during the analysis period, with a substantial increase during 2018 with 128 documents (Fig. 1).

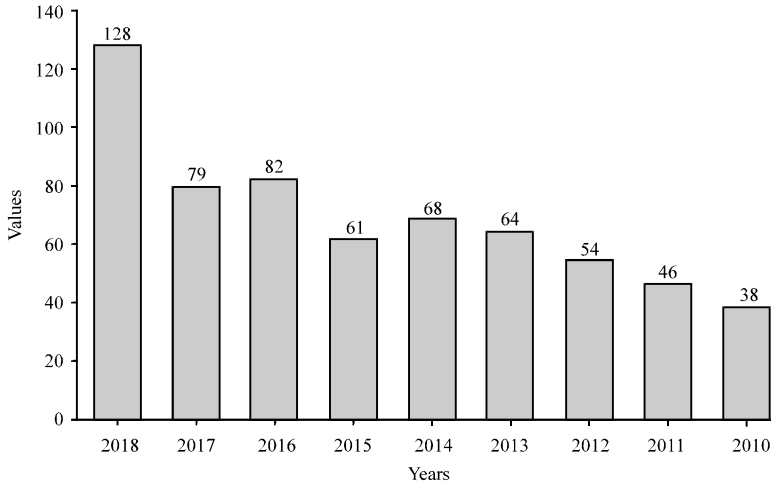

Fig. 1: Related scientific production in the period 2010-2018; Own elaboration based on scopus

Regarding the countries with the highest related scientific output, China stands out with 98 scientific documents, followed by Malaysia with 91 products. Further back, Brazil has 67 and Mexico, 51 scientific products. Finally, in the fifth place, the United States has 29 products (Fig. 2).

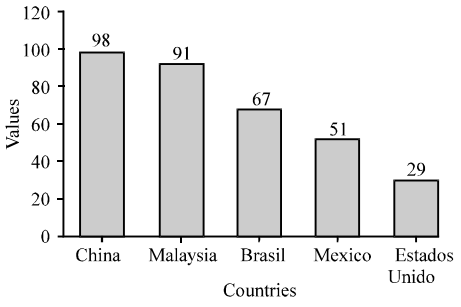

Fig. 2: Main countries with related scientific production; Own elaboration based on scopus

On the other hand, the main source of publication of products related to pitaya is the Belgian-born serial book Acta Horticulturae with 48 products, followed by the Malaysian magazine International Food Research Journal with 26 and the North American magazine Plant Disease with 19. In Latin America, the Brazilian Journal of Fruit Production stands out with 14 products (Fig. 3).

Among the most relevant researchers, Jose Darlan Ramos from the Federal University of Lavras (Brazil) stands out with 14 related documents, followed by Asgar Ali from the University of Nottingham, Malaysia campus with 11 articles. Rodrigo Amato Moreira, from the Federal University of Valles del Jequitinhonha and Mucuri (Brazil) and Noosheencon Zahid, from the University of Poonch (Pakistan) with 9 research articles each (Fig. 4).

Regarding the institutions with the highest scientific output, Putra Malaysia University is the one with the largest number of products with 80 documents. In this

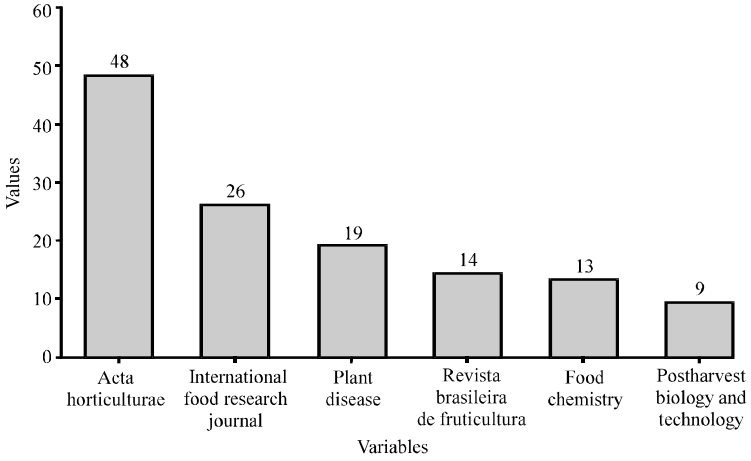

Fig. 3: Main journals with related scientific production; Own elaboration based on scopus

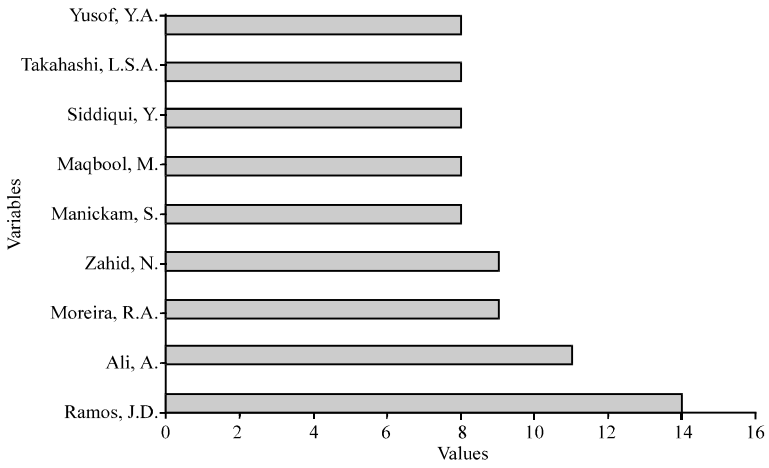

Fig. 4: Main researchers with related scientific production; Own elaboration based on scopus

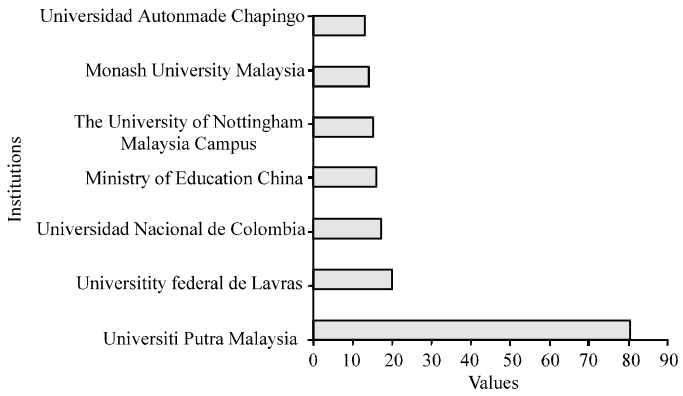

Fig. 5: Main institutions with related scientific production; Own elaboration based on scopus

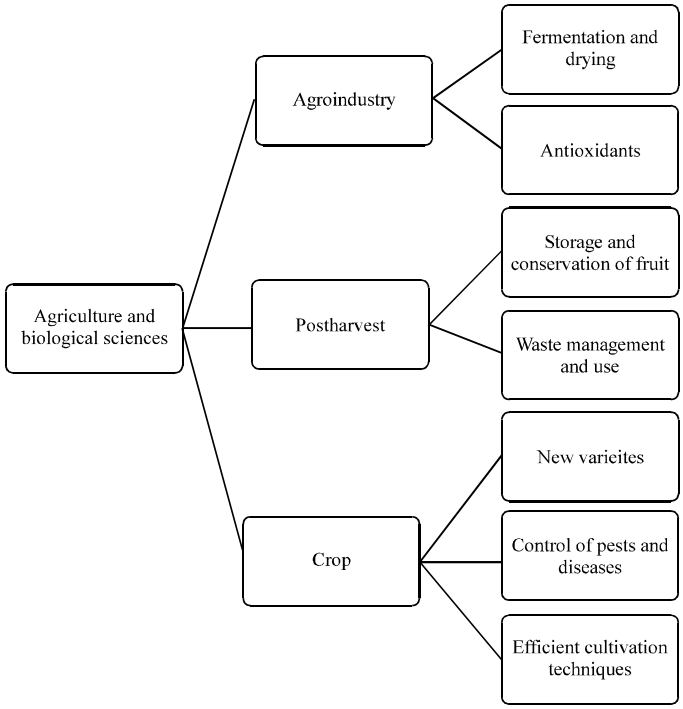

Fig. 6: Research trends for agriculture and life sciences; Own elaboration based on scopus

regard, Putra Malaysia University is one of the leading research universities in Malaysia with a focus on agricultural sciences. Second, there is the Federal University of Lavras (Brazil) with 20 research products, followed by the National University of Colombia (Colombia) with 17 products (Fig. 5).

Regarding the research advances related to pitaya, research trends for agriculture and biological sciences were analyzed, highlighting three areas of research: agro-industry, postharvest and cultivation. In the area of agri-industry, two sub-areas stand out: fermentation and drying and antioxidants. In the area of post-harvest, two sub-areas stand out which are storage and conservation of the fruit and management and use of waste. Finally, in the cultivation area there are three sub-areas that are new varieties, pest and disease control and efficient crop techniques (Fig. 6).

Faced with research trends for biochemistry and molecular genetics, three areas of research are emphasized: pharmaceutical, liquid waste management and genetic improvement. In the pharmaceutical area, there are two sub-areas that are cosmetics and medical formulation, while in the area of liquid waste management there is a sub-area called bio-coagulants. Finally, there is the area of genetic improvement with two subareas: creation of hybrids and molecular characterization (Fig. 7).

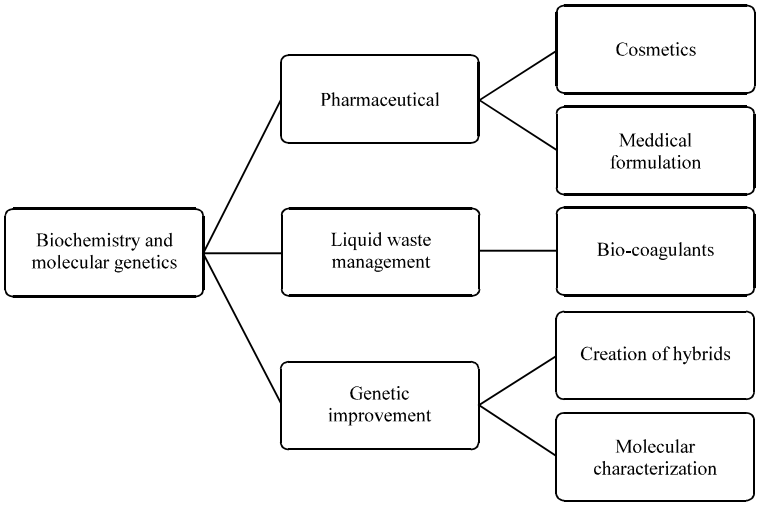

Fig. 7: Research trends for biochemistry and molecular genetics; Own elaboration based on scopus

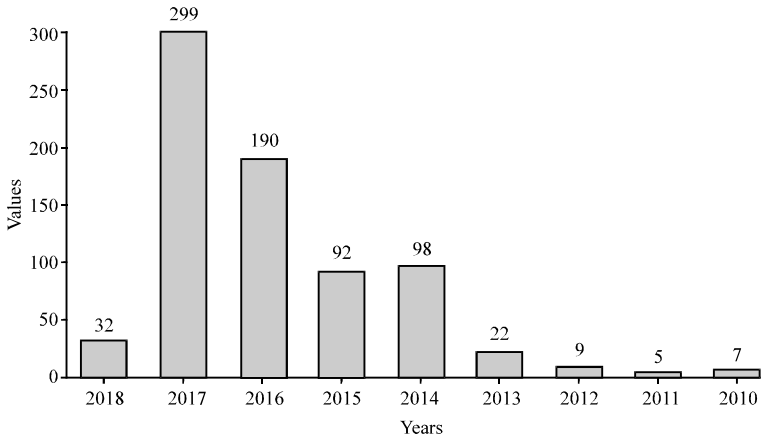

Fig. 8: Related technology production in the period 2010-2018; Own elaboration based on scopus

Technological production: The search in Wipo yielded a total of 768 patents during the period 2010-2018. There is an accelerated upward trend from 2014 with 98 records with a maximum point in 2017 with 299 records, to fall precipitously in 2018 with 32 patent registrations (Fig. 8).

During the study period, the country with the highest production of patent registrations is China with 731. By far, the United States has 10 patents, the European Patent Office and the World Patent Office register 6 each. At the Latin American level, Brazil and Mexico appear each with 2 patents (Fig. 9).

Patents related and requested worldwide are classified mainly with the code A23L with 219 patents. This means that the main advances in the matter were related to food or food products and their treatment, that is the modification of nutritional qualities, physical treatment or preservation of food. Secondly, there are the patents codified as A01G with 115 records, related to horticulture or the cultivation of plant varieties comprising aspects such as plant reproduction, grafts, cuts, growing substrates, among others. Third, code C05G appears with 78 records linked to the preparation and use of fertilizers for the crop (Fig. 10).

Next, some of the related inventions (patents) are listed according to their classification (Fig. 11 and 12). On the other hand, the main patent applicant is Xiaoping He, researcher of Chinese origin, with 14 patents, followed by the Qinzhou Pitaya Engineering Technology Research Center of China with 9 patents. The third position is held by the Guizhou Fruit Institute (China) with 7 patents (Fig. 13).

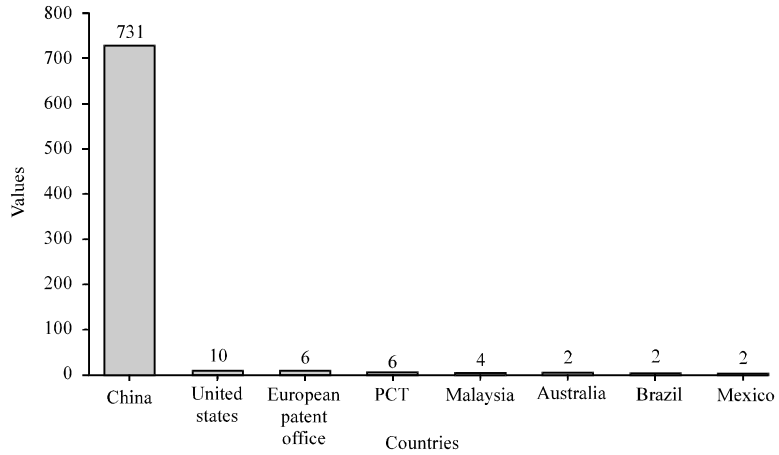

Fig. 9: Main countries with related technology production; Own elaboration based on scopus

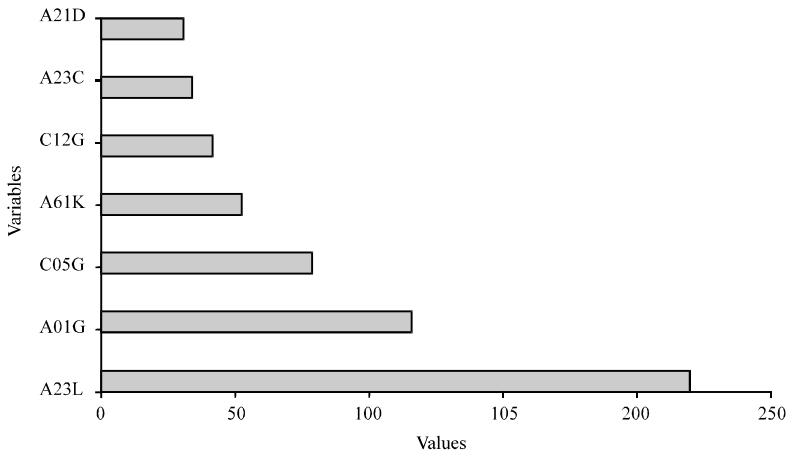

Fig. 10: Production of patents by classification; Own elaboration based on scopus

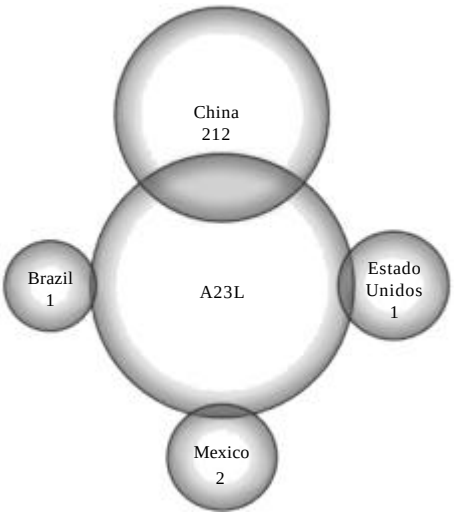

Fig. 11: Countries and patent classification A23L; Own elaboration

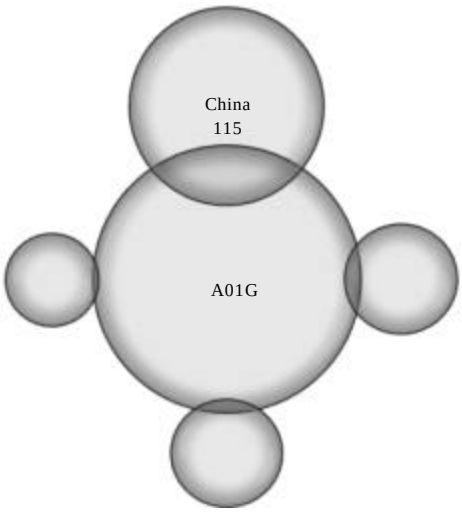

Fig. 12: Countries and patent classification A01G; Own elaboration

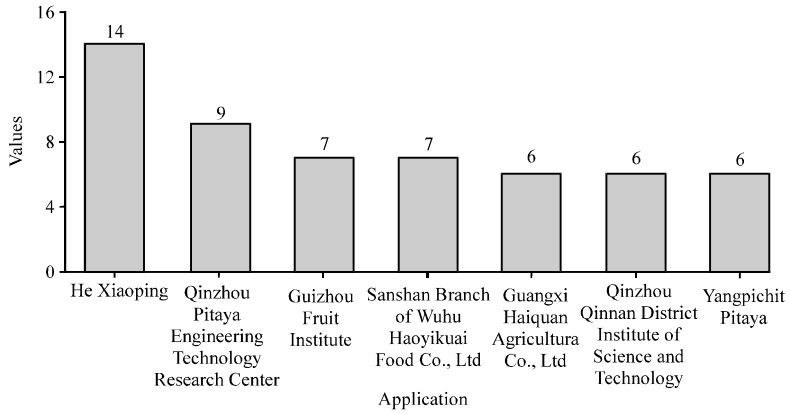

Fig. 13: Main patent applicants; Own elaboration based on scopus

CONCLUSION

The study of TS allowed to recognize the scientific and technological evolution that pitaya has had in the world. In the scientific field, it increased from 38 documents in 2010-128 documents in 2018, a substantial difference in the number of high-quality scientific publications. Likewise, in the technological field it, increased from 7 patents in 2010-299 patent registrations in 2017 with an edge of 32 patents in 2018.

On the other hand, China predominates as the country with the highest scientific production in the period of analysis, followed very closely by Malaysia, while in the technological field, China has 731 patent registrations and United States baerly 10 patents.

In the technological field, a large part of the patents registered in the study period corresponded to code A23L which means they are related to food or food products derived from pitaya and its treatment, China being the main applicant. Finally, the most prolific research areas of pitaya in research were agriculture and biological sciences and biochemistry and molecular genetics.

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