TECHNOLOGICAL SURVEILLANCE AS A METHODOLOGY TO ESTABLISH A STRATEGIC ROUTE OF RESEARCH: CASE OF CHILI CHAIN IN COLOMBIA

BLADIMIR GUAITERO
Universidad Jorge Tadeo Lozano, Bogotá, Colombia, lenisb.guaiterod@utadeo.edu.co

DIANA SAAVEDRA
Universidad Jorge Tadeo Lozano, Bogotá, Colombia, dianap.saavedrac@utadeo.edu.co

LAURA RUGELES
Universidad Jorge Tadeo Lozano, Bogotá, Colombia, laura.rugeles@utadeo.edu.co

Abstract

Technological surveillance is a methodology that helps to strategically address the processes of research and technological development (R&D) in different productive sectors; it is based on the fact that technology is a key factor in the competitiveness of enterprises, therefore, knowledge of technological advances, in all its components, is a sine qua non for progress with more certainty in the identification of gaps and challenges. In Colombia, technologicalsurveillance was one of the tools widely implementedby the Ministry of Agriculture and Rural Development (MARD); it was used in the definition of prospective R&D agendas for 24 agricultural chains, among these, chili´s chain. These agendas are considered as an appropriate mechanism to identify and prioritize the issues of technology and non-technology sectors as a key step in targeting and allocation of resources for R&D.

This article discusses the role of technology surveillance in the construction of the prospective agenda for R&D in pepper chain. This tool was basically oriented towards the identification first of the state of art and trends in R&D in Colombia and around the world and second national research capabilities and gaps and technological challenges. Analysis is done in two ways: one based on the results from the applied methodology for surveillance, and the other from the results expressed by the experience and subsequent process. Main intention is to contribute in the understanding that processes and outcomes are among actors; a good process and relevance of results of research depends on the nature of actors and coordination achieved.This technological surveillance allowedus a structured analysis of developments and trends in R&D in eight key subject areas within the chain of chili. From this, there were gaps and challenges in R&D for the chain in Colombia. However, several obstacles are evident for the massive appropriation of surveillance in organizations. Representativeness, capacities and flow of trust between actors are determining factors; it is needed that the process continues, especially where results effectively articulates the future with today through politics that materialize strategies and allocation of resources to overcome the factors that limit the competitiveness of the chain. The possibility to establish and strengthen vicious cycles instead of virtuouscycles is a likely risk in the field of

agricultural chains, especially when it comes to science, technology and innovation, a system component that is still under construction.

*Keywords:*technological surveillance; chili; research and development; ICT, prospective.

Introduction

Within the broad portfolio of vegetables grown in Colombia, chili becomes a product of importance to the countrybecause it has a good performance on socio-economic indicators, exports, development prospects within chain and betsthat have madegovernment entitiesthrough strategic planning exercises. Particularly for chili sauce, positive aspects are highlighted as a growing national and international consumption, high potential for adding value, rising exports and the existence of growing areas and industries that support domestic production (Rugeles et al., 2009). However, there are problems and obstacles that are affecting performance of chili chain in different ways, knowing them it´s an important input to address decision making, strategies and implementation of research and innovation activities in order improve the competitiveness of the chain in the country.

In order to help improve the competitiveness of the horticultural sector, and more specifically, prioritized chain (pepper), in 2009 the Ministry of Agriculture and Rural Development (MARD) of Colombia, commissioned us (research group Agribusiness Networks and Territory from Faculty of Economics and Administration at the University Jorge Tadeo Lozano) for the construction of Prospective Agenda for Technological Research and Development for Horticultural Chain. These agendas are considered as an appropriate mechanism to identify and prioritize the technological and non-technological issues of economic sectors as a key step in targeting and allocation of resources for research and technological development (R&D). This article discusses the role of technology surveillance in the construction of the prospective agenda for R&D for Chili Sauce chain. This tool was basically oriented towards the identification of both the state of the art and trends in R&D in Colombia and around the world as national research capabilities and technological gaps and challenges. The analysis is done in two ways: one based on the results from the surveillance methodology applied and the other oneexpressed from the results by the experience obtained in the process and subsequent process, wish is basically contained in the field memory of researchers and actors. This types of results are presented, however, the main intention is to contribute in the understanding that processes and outcomes are among actors;a good process and relevance of research results depends on the nature of actors and coordination achieved.

Why use technology surveillance methodology?

Economic and current global innovation environment is based on the continuous flow of information, its main characteristics can be summarized in big systemic changes, temporary competitive advantages rather than continuous, rapid decision-making, development of products

and services with short life cycles and new ways to compete framed in globalization (Hitt, Ireland, Camp and Sexton, 2002, cited in Johannessen and Olsen, 2010). Similarly, the progress made in the Information and Communication Technology (ICT) has enabled greater availability and faster access to information generated and distributed widely throughout the world. Saavedra (2000 and 2002) argues that existing information now doubles every five years and that 50% of technology changes every decade. It further provides that in future the information will double more often. These characteristics of the competitive environment of firms, based on the management information for decision-making, can be considered a threat to organizations, especially in emerging economies, as they have to adapt and develop capabilities to respond and compete under these global market conditions, primarily in sectors or chains whose products are destined for export market.

Growing availability of information, opens the question: how to investigate, taking into account that it´s needed in a short time and with optimized resources, while ensuring consistent and understandable results. In this regard, Castellanos et al. (2003) argues that in this context of growth in information availability, conventional analysis methods may be less effective (in the short term) and that the collection, selection and analysis of information flowsthrough greater contact with environment. Vargas and Castellanos (2005) studies known as "state of art" are widely used to characterize the technological and / or scientific context in a particular theme, however, they show several limitations because of its static character and only shows precise technologies but do not find trends that provide information that help to generate strategies for the medium and long term. Similarly, in current market conditions, organizations must go beyond activities like talking with customers and suppliers, consulting technical journals or market research or attending technological fairs and congresses, because this process is not continuous and systemic (Castellanos et al., 2008).

Contrary to the above, the surveillance is emerging as a systemic and organized tool for observation, collection, analysis, dissemination and retrieval of accurate factual information about the real situation that enable the organization or company to make decisions with less risk and to being able to anticipate changes (Palop and Vincent, 1999).

AccordingEscorsaandMaspons(2001), PalopandVicente(1999) andTyndale(2001):

"The importance of technological surveillancein the contextof emerging economiesisincreasinglyunderstoodasthe systematic effortby an organizationfor search,analysis and dissemination ofscientific and technological information, allowingidentification ofemergingand decadent trendsin technological development, which in turnpreparescompanies toanticipate changesin the environment "(Cited by Castellanosetal.2006).

In otherwords, technologicalsurveillanceis seen asa strategic tool, which takes as its starting pointthe identification ofresearch needsand endswith the knowledge of gapsand challengestobeundertaken bythe organization. This process requiresa careful analysisof theenvironment, taking into account thevastamount ofinformation that can befound, followed by aproper circulationanduse of informationin productive organizations(Vargas andCastellanos,

2005). Inthat sense, technologicalsurveillanceis conceived asa system ofinformation managementthatallows you to adjustandmake room forinvestigative processesin order to achieveorganizational goalsand more so in a context where resources for R&D are scarce. This means that results of technological surveillance can become sources of innovation for companies. According to Cunningham et al. (2008:11):

"With this kind of exercisesit is possible to make a systematic and continuing analysis with the following objectives: a) to establish the state of art of technology, b) seeking solutions to technological problems, c) identify technology partners, technology trends and purchasable technologies; d) develop technology profiles, and e) assist decision makers in science and technology programs in identifying emerging sectors."

In Colombia, this technological surveillance methodology was widely used by the MARD through a prospective work developed during the period 2006 - 2010 in 24 agricultural chains, including the prospective agenda for vegetable chain. Similarly, the Institute for the Promotion of Science and Technology –Colciencias, through this tool, carried out the strategic direction of biotechnology for the next 10 years (Carrizosa et al., 2005).

The articulation and coordination between actors.

Triple helix model of Etzkowitz (2000) is the more applied scheme in a trilateral space: State-University-Industry; for its usefulness in analytical and policy inissues related to collaboration and cooperation. For this author, progress depends on this three actors working articulated on the path of research, development and innovation (R + D + i). While the university is approaching to business world involved in innovation processes, the State has to intervene encouraging, facilitating and financing the link. Meanwhile governance perspective, Jessop (2002) and Williamson (1991.1996), among others, highlights the problems of coordination between actors, when they are autonomous but interdependent in the development of processes of common interest, whether in the public sphere, the private or the public-private partnership at a time.

Performance capability of the actors, including the state in its capacity as Jessop of *primus inter pares*, to putin a good place their own interests and minimize opportunism, appears as a determinant in the performance and results of this triangle of interactions, especially in national and local contexts, sometimes complex and turbulent as Colombia and other Latin American countries. Etzkowitz´sjoint and Jessop´scoordination are certainly two problems of the same process that contribute to look critically the results ofprospective research agendas in agroindustrial chains.

Methodology

Technological surveillance was used to identify trends and capabilities in research and technological development for technologies in chain of chili, both in Colombia and the rest of the

world. According to Guzman and Sotolongo (2000) cited by Castellanos et al. (2009), patents represent an economic and scientific value and have a special proximity to industrial development, meanwhile, scientific articles, sometimes first published than patents, permit the disclosure of knowledge that can be used later in the developing a patentable innovation. Therefore, the dynamics of publishing and patenting are considered indicators of the trend in research and technological development, respectively, in topics of interest.

The national and international technological surveillance process followed the phases proposed by Vargas and Castellanos (2005). It should be clarified that these phases are flexible and allow feedback to each other. Below are details of each methodological phase.

Phase I: Planning

It should be clear that this application of technological surveillance was conducted under a governmental project that aims to define the Prospective Agenda for Research and Technological Development for Colombia Vegetable Chain, specifically for Chili Sauce. This allowed a broad knowledge of the characteristics of this agribusiness and the performance of the chain, which was very important to addressing the surveillance process.

National and international technological surveillance was used to identify the capabilities and trends in research and technological development in relation to the chain of chili sauce. Particularly, we defined eight thematic areas to watch, these are: 1) genetic resources and breeding, 2) eco-physiology, 3) controlled conditions (cultivation under cover), 4) management of pests and diseases, 5) agronomic management, 6) agro-industrial processes, 7) new product development and 8) models of business organization and territory. The definition of these subject areas was the result of the grouping of records about publications and research projects related with chili chain in Colombia, up to date, and also socialization and validation with experts, researchers and actors (agricultural and industrial) during meetings and field visits. Similarly, for each area, were agreed problematic issues that negatively impact the performance of the chain, allowing an objective analysis of contributions of international technological surveillanceand the possible solution of the problems of the chain in the country.

Phase II: Preparation and database search

For identification of research trends in Colombia, we used as indicator the dynamics of publications (books, book chapters, articles, and reports, theses undergraduate and graduate) and research projects. Moreover, for trends in technological development, patents were compiled for the period covered by the history of research in chili inColombia. On the other hand, to identify research capabilities were searched institutions and research groups that have done work related to the chain. In international technological surveillance, we used dynamics of published articles as indicator of trends in research and patents as indicator of technological development trend, this for the period 2000-2008.

Methodology considereddatabases search forstructured and unstructured information. Table 1shows databases, keywords used and number of records downloaded in the process of searching for publications, projects, patents, research institutions and groups. It is important to note that the keywords and / or search equations were designed to find the largest number of records relating to the chain of chili, also they were socialized, refined and validated with chain-related researchers.

Phase III: Depuration, validation, processing and analysis of results

From the records downloaded, we constructed a database in Microsoft Office Excel ® for each indicator. These databases were subjected to a depuration process that consisted in exclusively extract records related to the hot pepper. Since somehot peppersand sweet or bell pepper are con-specific (*Capsicum annuum*), searching is difficult to have a keyword that allows us to separate them, except for common names like chili, chili pepper and hot pepper. In the case of publications that do not use these common names, it was made an initial depuration through the Reference Manager 11®, using common names of sweet peppers, which very likely were present in the title, keywords or abstract of some of these publications. Then result was a database of publications referring to cultivars of sweet pepper.

On the other hand and to make sure that the remaining publications were related to hot peppers, a second depuration was performed through the same program (Reference Manager 11®) in which each record was reviewed in the title, abstract and some casesin the full text of each publication. Simultaneously according to their content, records were grouped into one of the eight subject areas to be monitored, previously identified and validated. In this way, analysisof the leadingauthorswasconducted and the contribution of research to each of the subject areas defined.

After depurating the database, it was performed the analysis of the dynamics of publications and patents using tools like Microsoft Office Excel®. Through Microsoft Office Excel®. We were able to learn the dynamics in publication and patents through the years, by country, by institutions, authors, etc. The result of these analyzes allowed us to know the progress and trends in research and technological development associated with chili in the world.

Phase IV: Design strategies and impacts.

After reviewing the records, we identified gaps and challenges for Colombia chili chain in each subject area to be monitored. These gaps and challenges are the product of deep comparative analysis of findings in international technological surveillance against national under detailed knowledge of context. They provide important guidelines for strategic direction of research in chili chain.

Table 1.Databases,keywords anddownloadedrecordsin the process ofnational and internationaltechnological surveillance.

	Indicator	Database	Keywords and/or search equation	Downloaded records
National technological surveillance	Publications	METASERCHING, National System of libraries, UNC.	ají, capsicum, frutescens, chinense, pubescens, baccatum	38
		ScienTi Xacta COLCIENCIAS	ají, capsicum, frutescens, chinense, pubescens, baccatum	33
		Scientific Electronic Library Online - SCIELO	capsicum or ají or pepper	5
		Google	ají, capsicum, frutescens, chinense, pubescens, baccatum	3
	Projects	ScienTi Xacta COLCIENCIAS	ají, capsicum, frutescens, chinense, pubescens, baccatum	20
		Google andPersonal communications	ají, capsicum, frutescens, chinense, pubescens, baccatum	5
		Sistema Integral de Gestión de Proyectos (National System for project management)- SIGP	ají, capsicum, frutescens, chinense, pubescens, baccatum	0
	Patents	Superintendencia de Industria y Comercio - SIC	ají, capsicum, jalapeño, habanero, tabasco, cayena, cayenne	3
	Institutions	From publications		5
	Research gruops	ScienTi Xacta COLCIENCIAS	ají, capsicum, frutescens, chinense, pubescens, baccatum	11
		Google and Personal communications	ají, capsicum, jalapeño, habanero, tabasco, cayena, cayenne	2
International technological surveillance	Papers	CAB Abtracts	(capsicum OR "hot pepper" OR "chili pepper" OR "chile pepper"):ti OR (capsicum OR "hot pepper" OR "chili pepper" OR "chile pepper"):ab	3.813
		ISI Web of Knowledge	(capsicum OR "hot pepper" OR "chili pepper" OR "chile pepper")	2.382
		EBSCO-Academic Source Complete y Fuente académica	(capsicum OR "hot pepper" OR "chili pepper" OR "chile pepper")	1.456
		Engineering Village 2	(capsicum OR "hot pepper" OR "chili pepper" OR "chile pepper")	444
		Science Direct	(capsicum OR "hot pepper" OR "chili pepper" OR "chile pepper")	401
		OmniFile Full Text Mega – Wilson Web	(capsicum OR "hot pepper" OR "chili pepper" OR "chile pepper")	231
	Patents	Goldfire®	Capsicum <in> ET <Or> capsicum	220

Results

Results of the exercise of technological surveillance, in the context of definition of the prospective R&D agenda for chili chain in Colombia can be classified into two groups: the results of a technical nature in a general sense, and the results of coordination of actors and chain processes.

Technical results

Trends in research related to the chili sauce chain in the world

The dynamics of publications allows detecting the development of research and the behavior in the world in a given period. In this case, 1583items were found for the period 2001-2008, during which there is a growing trend in the number of publication. These articles were published in 597 journals. Of this total, 16 journals grouped 24% of total publications, among which we highlight: Hortscience American magazines, Scientia Horticulturae, Plant Disease and Vegetable Science.

During the period 2001-2008 were 4066 authors have advanced research - individually or in groups - on issues related to the chili. Featured Researchers are primarily linked to institutions in the Republic of Korea, United States, India, Israel and Mexico. At the top are the Korean researchers Kim, BD (Seoul National University, Korea) and Choi, D. (Korea Research Institute of Bioscience and Biotechnology) with 21 items each. U.S. researchers: Sanogo, S. (New Mexico State University) who has worked in the management of diseases in pepper, Bosland, PW (New Mexico State University) and Jahn, MM (Cornell University) that have focused on plant breeding processes. It is important to highlight, the eight main researchers are associated with institutions of the Republic of Korea and their research topic is breeding and genetic resources.

The review of the literature was performed in accordance with the problematic issues identified in the chain of chili sauce. Table 2 provides overview of the number of journals, authors and publications in each of the thematic areas.

Table 2.List of journals, authors and articles recorded during the period 2001-2008 in the subject areas related to the chili.

Subjectarea	Number of journals	Number of authors	Number of papers	% participation in the total papers
Genetic resourcesand breeding	207	1.341	533	33,6%
Pest anddiseases	178	1.049	370	23,3%
Agronomic management	154	811	282	17,8%
New Product Development	175	788	237	15,0%
Ecophysiology	58	224	76	4,8%
Agroindustrial processes	47	215	76	4,8%
Modelsof business organization	6	20	6	0,4%
Controlled conditions	5	22	5	0,3%
Total	830	4.066	1.583	100,0%

i. Breeding and genetic resources

During the period 2001-2008, around the world were published 533 articles (33.6%) related to plant breeding and genetic resources. Fluctuating dynamics is observed with increasing trend in the number of publications. Given the institution to which belong the principal investigators, We

could confirm that Korean institutions such as Korea Research Institute Bioscience and Biotechnology, Seoul National University and Korea University and American universities as State University of New Mexico and Cornell University are obligatory references regarding the breeding of pepper.

In particular, research by Choi, D. relates developments aimed at improving the response of pepper plants to the presence of different pathogens (resistant plants). Similarly, Kim, B. D. works in the analysis of proteins and genes involved in the biosynthesis of carotenoids and capsaicinoids, suppression of male sterility (cytoplasmic),resistance topathogen typevirus (tobamovirus, Potato virus X), fungus (*Phytophthora capsici*) and bacteria (*Xanthomonas campestris*). Overall, the work framed within this subject area enclosing the analysis of gene banks, with the aim of finding agronomic characteristics (yield, resistance to pathogens, pungency, etc.) to improve the conditions culture and market.

ii. Pest and diseases

During the period 2001-2008, around the world were published 370 articles related to pest and diseases in pepper, whose behavior has experienced slight declines in the past two years. Within the main researchers is Sanogo, S. belonging to the New Mexico State University. His publications include the description of symptoms and evaluation of management measures of the major diseases of pepper (*P. capsici*, *Verticillium dahliae*, *V. albo-atrum*, *Fusarium oxysporum* and *Rhizoctonia solani*) in growing areas of New Mexico (USA).

Publications of Mexican researchers, Velásquez-Valle, R., Amador-Ramirez, MD associated with the National Institute for Forestry, Agriculture and Livestock (INIFAP) and Medina-Aguilar, MM Regional Center of Studies and phytosanitary diagnostics, are mostly related to research in critical time of weed control, effectiveness and feasibility of chemical control of weeds in crops of pepper, and research on recognition of viral and pathogenicity and symptoms of diseases caused by fungi.

In general, we can say that research in management of pests and diseases of pepper cultivation shows a slight positive growth. Likewise can be referenced leading players in this field, as in the case of researchers from institutions in United States, Mexico, Spain and India, advances in managing diseases caused by fungi and pepper virus, particularly diseases caused by *P. capsici* and complex viruses, which are particularly important pathogens in pepper production in Colombian systems.

iii. Agronomic management

It is the third thematic area gathering 17.8% (282 items) of all publications in the world related to chili. In this area, researchers in India excel in the research process, mainly those belonging to the Central Research Institute of Food Technology (Ravishankar, GA, Giridhar, P., Gururaj, HB and Sharma, A.) and the University of Agriculture and Technology Orissa (Mohanty, BK), who have advanced in researchrelated tooptimization,evaluation and use of protocols and propagation techniques and plant micropropagation in *Capsicum annuum* and *C. frutescens*.

In second place are Mexican researchers from the Center for Scientific Research of Yucatan, who have conducted research on issues similar to those treated by Indian researchers, with the difference that they have focused on defining and optimizing plant propagation protocols for C .chinense (habanero variety).

iv. Development of new products.

During the period 2001-2008, around the world were published 237 articles related to the development of new products from the chili and its derivatives. As such, it is not observed a researcher who is leading, differentially, research in the development of new products based on chili. It is observed that most of the publications of the principal authors in this subject were made in recent years of the analysis period (2006-2008), confirming the importance that development of new products has taken in the chili industry.

Japanese researchers (Kobata, K., Morita, A., Watanabe, T. and Iwasaki, Y.), afilliated to Shisuoka University, have advanced in research related mainly with the use of capsaicin (active component which allows the pungency ofchili) in improving the production of human body heat, stimulating nervous system and inducing the secretion of adrenaline, which allows the reduction of body fat.

In other hand, U.S. researchers belonging to the University of Utah (Reilly, CA and Crouch, DJ), have reviewed the effect of pepper-based products such as "spray" on the skin of humans. Similarly, they have assessed the effect of these "spray" in the inflammation and cell death airway epithelial animals. In this same country, researchers from Regional Research Center of South (De Lucca, AJ and others), have conducted research related to the extraction of saponins from C. frutescens, which have shown strong fungicidal control allowing control Candida albicans, Pneumocystis carinii and Aspergillusspp, including fungal pathogens.

v. The remaining research areas related

The remaining four areas grouped for 10.3% of total publications related to the chili. In ecophysiology 76 publications were made during the period 2001-2008. It is noted that authors from Kyoto University in Japan have published articles on the effect of heat stress and photoperiod on growth, flowering and fruiting on varieties of C. frutescens and C. annuum. They also examined the characteristics of germination of seed C. frutescens under conditions of Southeast Asia. On the other hand, researchers at the National University of Colombia, have evaluated the growth, physiological changes and determination of the pepper crop accessions of the Amazon region.

In agroindustrial processes 76 articles were published, presenting anupward dynamic since 2004. In general, each year between 5 and 13 published articles on this subject area. As researchers, we highlight the contribution of Canadians from McGill University (Shivhare, U.S. and Ahmed, J.), who have investigated the effect of heat treatment on the color and pungency of fresh chili and pepper pasta, and also characteristics and effect of drying on the color and pungency.

During the period 2001-2008, were published 6 articles related to business organization models in chili. These items were economic evaluations of the implementation of irrigation and crop production costs in capsicum, the analysis of the importance, seasonality of consumption and marketing of vegetables (among these, C. frutescens) in Burkina Faso. Regarding controlled conditions were published 5 articles, where they studied the behavior of different cultivars in greenhouses established in Hungary, the effect of polyethylene on the earliness and yield of pepper crops and application of technologies "polyhouse" for growing vegetable in India, among them *Capsicum*.

Advances in technological development in the chain of chili sauce in the world
Technological development in products or processes relating to chili has focused particularly on the use of oleoresins of fruits from genus *Capsicum* in various applications as well as in improving the processes of extraction and quantification. The dynamics of patenting in the world has shown fluctuations in the number of patents withtwo peaks observed in 2001 and 2006, however, presents a slightly positive growth trend. In the study period (2001 - 2008) it was reached a total of 183 patents related to the chili.

Between years 2000-2008, Japan had 76 patents (41% of total) and U.S. 71 (38%). The remaining 21% of records (36 patents) have been made by countries like the Netherlands, United Kingdom, Republic of Korea, India, etc.

According to the International Patent Classification (IPC), patent registration is carried out according to different areas of technology to which they belong (WIPO, 2009). Of the 183 records found, 92% (162) are classified in category A (human needs) 38 patents are grouped in category C (chemistry and metallurgy) and only 8 patents are grouped in categories B (operations or transport of materials), D (textiles and paper), H (electricity) and G (physics). Similarly, patents are distributed in 41 subcategories, 21 in category A, 12 in category C, 3 to Category B, 3 to D and 1 to G, H and A. Below, we will briefly described developed patents and grouped into major IPC subcategories.

In sub-category A61K, we found 64 patents developed by 40 institutions from 9 countries. Developed patents involving medicinal products as poultices, a preventive treatment against cervical cancer (tampons plant extracts), migraine treatments, analgesicpatches and anti-inflammatory, anti-bacterial products (Salmonella typhimurium and Escherichia coli) and products for hair care. Countries and institutions leaders in this subcategoryare: Japan (Teikoku Seiyaky Co. Ltd. and Pola Chem Ind Inc) and United States (New Mexico Technical Research Foundation and Purdue Research Foundation).

In the subcategory A23L, we found 31 patents that involve development of food products with improved nutritional qualities (high carotenoid content), spicy food coloring, optimization methods for producing soy sauce with chili, methods to improve cold storage postharvest using pepper extracts and optimization of the extraction process that seeks to improve the color and pungency of pepper oleoresin. The country and the leading institutions in this subcategory is Japan (Asama Kasei KK, Ajinomoto Co. Inc., Enkaku Iryo Kenkyusho yFanclKK Corp.).

Subcategory A61P relates new destinations using chili and its derivatives, in particular pepper oleoresins. We highlight work in developing cancer treatments (chili as a suppressant agent for proliferation of cancer cells), also in the development of patches and poultices with anti-inflammatory and analgesic power. Besides, cosmetic products that include chili have been developed, such as treatments for the scalp (hair growth promoters) and hair (dyes). Countries and institutions that are leaders in this subcategory: Japan (Kao Corp., Teikoku Seiyaku Co. Ltd., Pola Chem Ind Inc and Fancl Corp.) and the United States, Germany and Australia.

In the subcategory A01N, patents (21) refer to development of repellents (insects, sharks, etc.), antibacterial products, such as tear gas and biological control for fungi in plants. For subcategory C12N, it should be mentioned advances in the development of chili cultivars with resistance to stress, fungi (*Colletotrichum gloeosporioides*), bacteria (*Xanthomonas campestris*) and cultivars with improved nutritional value of fruits (higher content of carotenoids, ascorbic acid and sucrose) and also that enable longer shelf life.

As is it seen, the development of technology related to the chili has been oriented to research in products based chili for medicine, cosmetic, pest control and genetic improvement of cultivars with particular characteristics (higher content of carotenoids and vitamin C). Likewise, other works seeking to improve processes of oleoresin extraction and postharvest conservation of chili.

National capabilities and research trends in chili chain in Colombia
79 publications were identified and classified dating from 1975 to 2008, 44% of all publications were related to genetic resources and breeding, 21% to ecophysiology and 18% agroindustrial processes. The remaining 17% of the publications is distributed among the other five areas.

The area of genetic resources and breeding, with 35 publications, has focused on the characterization of chili germplasm bank from different perspectives: agronomical, morphological, physiological, biochemical and molecular. The prevalence of this research topic may correspond to the existence of great genetic diversity of chili in Colombia, which may offer interesting agronomic traits when starting a process of breeding. Publications on ecophysiology (17) correspond to analysis of plant growth and development of some promising accessions peppers and fruit postharvest physiology. In agro-industrial publications (14) it were studies on characteristics of processing and extraction methods derived from chili peppers (oleoresins) and improvement in the processes of transformation to dehydrated chili. Seven publications are related to the development of pepperchains and marketing processes.

Agronomic management has only 3 posts, 2 posts in pest and disease and one in new product development. These results contrast with the research needs of the pepper crop, as the primary information revealed, serious problems with the recognition and management of diseases, arthropod pests and virus vectors, also in evaluationof fertilization programs, seeding and site preparation.

From the information available in the sources, we detected 15 institutions and 13 research groups that recorded publications associated with chili chain. Of the 79 publications, 56% correspond to the National University of Colombia (UNC) and 19% to the Institute of Amazonian Research-SINCHI, which are concentrated in many of the publications in the area of genetic resources and breeding.

As leading researchers, Luz Marina Melgarejo has participated in 20 publications jointly or individually, being the researcher who reported the highest number of publications, followed by Maria Soledad Hernandez, a researcher belonging to SINCHI and Franco A. Vallejo and Mario A. Garcia affiliated to UNC - Palmira.

According to review of different databases and access to primary information, this study identified 25 projects developed from 1990 to 2008. As in the publications, research projects have focused almost 50% in the study of genetic resources and breeding, practically in the morphological, physiological and biochemical genebank, many of these projects have been executed by the UNC - Palmira, CORPOICA and SINCHI.

Advances in technological development in the chain of chili sauce in Colombia
According to results, we found 3 records of patents, which describe the use of pepper fruit either for the production of biopesticides or products for human consumption.

Although the low number of patents, it is clear that the chili is a promising crop for the development of several products. Some companies have already taken the first steps in the commercialization of products based on chili (biopesticides) for pest control in some flower farms in Colombia. We conclude that technological development in chili pepper sauce in Colombia has been scarce.

Gaps and technological challenges in the Colombian chili sauce chain
Chili chain in Colombia has a slow dynamic in scientific research and technological development, compared with the rest of the world. Internationally, publications and patents have significance as a contribution to the problematic issues that affect the performance of the chain in the country.

Taking as reference subject areas we monitored, it verifies the contribution of international research to the problematic issues of the chain in Colombia. In the world, development of research around these themes is increasing; there are a significant number of articles in areas of particular importance as the management of pests and diseases.

Related to genetic resources and breeding, it is considered the most advanced research in the world, including Colombia. In the rest of the world, the research aims to develop plants that resist pests and diseases, fruits with higher nutritional value and greater pungency and plants with higher harvest yields, in Colombia instead, they have focused on characterizing genebanks existing. It is necessary to evaluate the transfer of existing technology in other countries, especially high yielding varieties of crop and pest and disease tolerant, limiting issues in

Colombia. Research institutions in countries such as the Republic of Korea and the United States are required referencesfor latest advances in breeding of pepper.

Much of pepper diseases are common in pepper production systems around the world, which may allow a tangible contribution of international publications results in management of production systems in the country, but we must work on the adaptation of these results to local conditions and to continue, with the help of plant breeding processes, with research related to pest and diseases, a subject which has had very little research in the country. Similarly, leaders associated with institutions in the United States, Mexico, Spain and Indiacan be referenced.

Regarding agronomic management, we highlightleading researchers in institutions in India and Mexico, who have developed and optimized plant propagation techniques. These techniques can help research conditions for chili in Colombia if they are incorporated in the studies, such as in plant breeding programs. However it is noted that, as in Colombia, research worldwide is inadequate in areas such as fertilization and irrigation strategies, use of mycorrhizae, mulch or padding, drainage design, etc. It is therefore a challenge for research institutions in Colombia resume and develop studies related to these issues, using publications founded in other countries.

About development of new products based on chili, there are important contributions in the papers reviewed, related to the development of high value-added oleoresins, medicinal and personal defense. Regarding chili sauces, worldwide publications about this were insufficient in number but very useful in increase possibilities of developnew products with higher added value, for example sauces high in vitamin C. Research institutions in countries like the U.S., Japan and the Republic of Korea are important references to learn about the latest advances in product development based on chili.

Ecophysiology areas, agro-industrial processes, business organization models and controlled conditions have a low number of publications and their contributions to the chain of chili sauce are scarce. From these findings, the challenge for research institutions is to advance in these research processes together with actors (farmers and industrial) in order to define the research priorities in the chain.

Global technological development, in relation to patents, is led by United States and Japan. Importantly, the main pepper producing countries like Mexico and China reported no patents, which correlates with the existence of a low number of patents inprimary production processof chili, which definitely limitsthe transfer of technologyto pepperproduction systems in Colombia.

Interestingly, there have been international patents for the development of propagation techniques and plant breeding for *Capsicum* varieties with resistance to pests, viruses and stress conditions. It should arouse interest in improving the structure of research in Colombia, where private companies and research institutions could work integrated in order to build and adapt these technological advances in production processes in the chain, for this, institutions countries like the U.S., Japan, South Korea and Mexico are obligatory references.

Subsequent results

Actors

Research group that coordinated thisexercise, did a considerable effort not only to identify key stakeholders and representative segment of each link in the chain in the country (producers, industry, government, union, experts and researchers), but also to get their attention and participation in long hours and work processes; because they are not used to this. As expected, it was required, among other things: representation and leadership, information, openness to discussion and agreement, and availability of time and resources to move from their own places in compliance with the schedule. As there is not a strong chain,neitherwith a long history in the country, the group made was adjusted to such proportions, something that favored progress and consistency / relevance of the results.

Not surprisingly, the strength of the process was led by the industrial firstly and secondly by researchers and technicians; between the two were created bonds of trust and synergies. Inconsistencies in official data were adjusted, it was checked in the field and we built the future to act in the present. Entrepreneurs acted as researchers and researchers advanced as entrepreneurs. Everybody´s motivation was to achieve adequate and stable resources to investigate, help solve problems, train youth and visit peer groups in the world wherever they are. Entrepreneurs and scientists do not compete, their interests are complementary, hence the need to coordinate interest is lower, although not question the need for articulation.

Industrialists, who had not met face to face before and who arecompetitors, shared the same table and assumed with clarity and responsibility the process. Each one is located neara port area of influence, in north and southwest of the country, Each one have their own external customers and somehow they have managed to differentiate their product, but it is clear that strive hard for raw materials, especially in the territory of better crop performance.

Producers expect short-term solutions: credit, pest control and prices. This is the link of the chain that generates more jobs, about 650 days per hectare- year there. Added value depends heavily on weather patterns and the efficiency of labor, but also on the ability of space management. Of course it is the weakest link in the whole chain but with a structural importance, so that industrialists tacitly exert a protective relationship in technical and financial aspects. In fact, at this link were concentrated technological demands resulting from the agenda because it is where more knowledge is required.

The government, more distant and cautious, assisted in the exercise but ended up giving in to negative incentives. Anyway guild and Government handle the main bag of resources for research in horticultural chain.

In the exercise performed, we all dreamed about coordination and organization. To this end, wisely and carefully built scenarios and made the proper technology research projects and "strategies for the non-technical" according to the criteria and recommendations set forth by the

consultants. Everything was recorded in the respective document and the results are largely socialized through various mechanisms.

Governance failures
The first step forward was the creation in December 2009 of the National Council of Chili - CONAJI, an organization of actors that was considered essential for strengthening and implementation of strategies related to demands of public policy.

As a final activity, we structured territorial draft agendas for the two regions that were involved and it was proposed coordinators represented in each case by a university and an industrial exporter. University Jorge Tadeo Lozano was asked to continue providing support in a kind of mentoring process to come. Weall came out confident in the smooth running of the process for the future designed.

Well, the question is: what happened between December 2009 and December 2012? Few events, clearly only one, but enough to threaten the entire future designed. Appeared malicious opportunism mentioned by Williamson and governance failures stated by Jessop, theory in action. The state, which had developed a methodology taking prospective country as structuring and guiding axis for the construction of the agenda, continued exercising hierarchy and regardless of the actors of the process, designated a " coordinator "of chili chain.

So far nothing is known. Among other things: Where is the coordination? Who is the coordinator? Does he have any idea of the process? Does he understand business priorities? Will he ask explanation and guidance? Would he understand bilateral dependency problem? Did heuse surveillance for his decisions? Nobody has information, but at this time, by government policy, it is a calling for the construction of the agenda for research and technological development in the chain of vegetables (a new one); same call is made for major agricultural chains. Uncertainty reigns: Will it have any value to the current actors in government the research and development agenda, built several years ago for a horizon of eight years?

Conclusions

This article started recognizing that to strengthen innovation processes; companies require new methodologies and tools that add value from the massive amount of information available. Technological surveillance allowed structured analysis of developments and trends in R&D in eight key subject areas within the chain of chili sauce. From this, there were gaps and challenges in R&D for the chain in Colombia. Throughout this process was important the appropriation of methodology by actors involved, as this allowed the generation of endogenous capacities. Having a methodology grounded in country characteristics and production chains, constitutes a significant advance for the strategic direction of R&D. However, several obstacles are perceived to allow massive appropriation of surveillance in organizations, such as: lack of quality public information, low availability of databases, lack of mechanisms and resources to ensure both

continuity of this dynamic process and strengthening capacity for search and analysis of information.

As already mentioned, results of the technological surveillance can be a source of innovation ideas for organizations. But by itself, this tool does not ensure the competitiveness of enterprises; therefore, it is important to strengthen with prospective agendas that achieve an ideal scene to that organization or chain. At the same time it is necessary to guarantee the resources and materialize commitments of different actors in order to carry out the projects and strategies embodied in those prospective exercises and overcome the factors that limit the competitiveness of the chain.

Technological opportunities identified for chili chain in Colombia, are defined from existing research capabilities and advances in joint research centers with private sector to find solutions to their production problems and new innovation processes. In this regard, the chain of chili has researchers that have been generating technology to solve some problems, especially related to the link in the production, but is required to advance in the articulation of these researchers and increase them, especially for most deficient subjects, placing them mainly in two specialized areas where agribusiness is located, Atlantic Coast and Valle del Cauca.

Technological limitations identified in Colombia are given mainly by deficit of researchers located in territories that are specialized in this agribusiness, mostly to solve problems related to primary production: recognition and management of diseases, arthropod pests and virus vectors, evaluation of fertilization programs, irrigation, seeding and soil preparation, as these represent constraints to agronomic management and crop yields. Moreover, there is little research on crop ecophysiological components and postharvest physiology of fruit in commercial varieties. There are no consolidated research groups in the principal production territories and there is no effective coordination and agenda between the private, public and research institutions to investigate pepper in the short, medium and long term. On the other hand, research on business models has been reduced to the issue of association of small producers but not to more advanced models like vertical and horizontal integration or balanced contractual forms, increasing formality of the sector.

During planning phase of technological surveillance, active participation of key actors in the chain was a key factor, who offered their valuable contributions through meetings and field visits, to development and validation of subject areas to be monitored. This fact made it possible to establish and strengthen bonds of trust and cooperation between stakeholders, achieving a greater sense of belonging to the research and the results of it. Constant communication and willingness to work together are one of themain products of this inclusive and participatory strategy. Among other aspects, technological surveillance is a tool that enables integration and coordination of stakeholders in a common topic or problem, to find possible solutions based ontechnologytrends and advancements in the country and around the world.

As noted, prospective is a matter of actors and shared information, in this case: rural producers, industrialists and traders, researchers, technical assistants, union representatives and local and

central government. Coordination of these actors and the type of incentives for joining them in thisprocess (academic and management) as it is recorded in this article deserves enough attention to facilitate successful results from different aspects. Subsequent stages to prospective exercise also deserve equal attention, because that is where public actors concrete strategies and allocation of resources. With regard to the experience in the definition and implementation of prospective Agenda R&D for chili chain, it can be concluded that:

i. Success of this prospective exercise was based on a careful balance of actors and a sleek, coordinated and reliable process.
ii. Adjustments to local and national information of the chain were achieved by a joint effort of sincerity and agreements.
iii. Between building and development of the agenda, planned it for a period of eight years, the state regained its hierarchy imposing an unknown actor as process coordinator. The insistent balance between actors and horizontality are at risk, of course trust and the possibility of returning to similar processes.
iv. Although prospective agenda for R&D of chili chain was born with the intention to guide the formulation of agricultural policy, this purpose is distorted when rulers and decision makers change.
v. What this article wanted to reiterate is that the governance of science and technology system, on the smallest and simplest level of interactions requires a cooperating State, rather than an opportunistic State. Prospectiveagendas are opportunities to build effective public policy.

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