Production and trends of scientific research on cactus pear in mainstream journals

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ABSTRACT

To identify production and trends on publications of cactus pear from 1900 to 2015 at an international level, a review of qualitatively and quantitatively indexed bibliographic records from Science Citation Index Expanded (SCIE) and Social Sciences Citation Index (SCIE) was conducted. The analyses included the concepts or key words 'opuntia' as well as the common names of cactus pear and its variants. It was found that there were 1,472 documents regarding cactus pear, from which 50% were published during the last ten years, and more than 81% after 1990; these data show the relevance and dynamism of cactus pear research during the last years. The most indexed type of document was the article with 86.1%. The preferred language of publication was English with 92.7%. The Institutions with more indexed documents were the university system of the University of California and the National Autonomous University of Mexico with 99 (6.7%) and 84 (5.7%) respectively. The Journal of the Professional Association for Cactus Development (JPACD) had the highest number of scientific articles (92). The impact factor (IF) of JPACD is 0.22, and is ranked 30 among 33 in the "Horticulture" category of the Journal of Citation Reports (JCR). Plant Physiology the journal with the highest IF (6.28) published 29 of the indexed documents. The main research areas where scientists publish according to SCIE and SCCI are: Plant Sciences, Food Science Technology, Environmental Sciences, Horticulture, Ecology, Applied Chemistry, and Biochemistry and Molecular Biology. Mexico and the United States published 50% of all production, but Tunisia, Brazil, France and South Korea had an important number of contributions on *Opuntia*. The main native English authors speaking with more published documents in mainstream journals are Nobel and Felker, while Saenz and Murillo-Amador are the main native Spanish speaking authors. The trending research in the last ten years are the functional properties and biological activity of active ingredients on *Opuntia*. The identified trends would allow setting strategies, synergies and scientific and technologic policies for research and decision making in those countries where the species is considered as important.

Keywords: *Opuntia*, Scientific production evaluation, Scientometrics, Bibliometrics.

INTRODUCTION

Mexico has a cultural wealth and flower diversity that has fascinated explorers and researchers (Heinrich *et al.* 2014). Because of its abundance and diversity since Pre-Hispanic times, one of the plant species of greatest social and economic relevance is cactus pear (*Opuntia* spp), in the regions where it is distributed (Realini *et al*. 2015). Although the center of origin of the species is still a subject of research (Majure *et al*. 2012), its domestication process is concentrated in the central part of Mexico (Griffith, 2014). Currently, because of its long history of use, *O. ficus-indica* (L.) Miller is one of the most important species at the global level (Irvin, 2012). FAO (2006), as a result of various studies, has highlighted the importance of this species as a natural resource and as a potential source of income, employment and nutrients; likewise, considering the recrudescence of desertification and the decline of water resources, it is gaining increasingly more importance as an effective element in the food production system (Stintzing and Carle, 2005).

This has motivated great dynamism and interest in the international scientific community to carry out basic and applied research about the species. However, despite its nutraceutical potential and its wealth in nutrients, it is still not considered an important source of food, due particularly to its localized production and its high perishability (Patel, 2015); therefore, its use is restricted mainly to its center of origin.

The quantitative and qualitative analysis of international scientific production, from the indexed bibliographical records in different databases, allows analyzing the production of research, as well as inferring its trends, providing tools for research planning and decision making.

Given the importance of the analysis of scientific production using bibliometric indicators, studies have been performed that address diverse themes such as: dental (Garrison *et al*. 1992), health (Pellegrini *et al*. 1997), climate change (Li Wang and Ho, 2011), biotechnology (Amaro and Robles, 2013), and regional development (Valenzo-Jiménez *et al*. 2016), among others.

Concerning *Opuntia*, three studies were registered where bibliometric techniques were used. In one of them, carried out by Inglese and Liguri (2010) aspects of biology and ecophysiology were addressed; another one deals with the effect of cactus pear in relation to body weight and cardiovascular risks (Onakpoya *et al*. 2015); and the third contemplates studies about cactus pear used as fodder and its validation in animals (Grünwaldt *et al*. 2015).

The Science Citation Index Expanded (SCIE) from the Core Collection of the Web of Science (WOS) of the Thomson Reuters Company is the most important database and is used frequently to elaborate analysis of scientific literature in all scientific fields (Li *et al*. 2009). The bibliometric indicators are numerical data extracted from the documents that scientists publish, that allow understanding the different stages of the scientific activity (Sanz and Moreno, 1997), which presents advantages compared to other methods used in the evaluation of science, since it is an objective method susceptible to analysis (Bellavista *et al*. 1997). In the evaluation, in addition to the unidimensional bibliometric

indicators: number of documents published, types of documents, language of the publications, institutions of origin of the authors, journals where the documents were published, study area of the journals, countries of origin of the indexed documents, and authors with highest number of contributions, the themes dealt with in the documents can be identified through the analysis of Keywords of the authors and Keywords Plus, using the option of cloud of tags from the tool of social marking of academic documents CiteUlike (Hammond *et al*. 2005) since in the WOS it is not possible to perform this task.

This study analyzes the production and trends of research related to *Opuntia* through unidimensional bibliometric indicators, with the aim of allowing researchers and decision makers to focus, plan and direct research in those countries where the species is important, based on the results.

MATERIALS AND METHODS

The study was based on the quantitative bibliometric analysis of the bibliographical records indexed in the databases of the Science Citation Index Expanded (SCIE) and Social Sciences Citation Index (SSCI) during the 1900-2015 period, in order to register the distinctive production and research trends of the international scientific communities related to cactus pear through bibliometric indicators. The CAB abstracts database was used to find the keywords of the documents published during the 1900-1990 period due to the SCIE and SSCI databases does not include these words. The SCIE and SSCI databases index the so-called “mainstream” journals (Salager-Zeyer, 2015). In the search strategy, it was indicated that only the concepts or keywords ‘*opuntia*’ and common names of the plant should be included, as well as their main products to guarantee that the main theme addressed by the documents is cactus pear (Figure 1).

It is worth highlighting that there is a high number of records that still include the denomination “prickly pear”, which must be taken into account when the search is done with the current name of “cactus pear”.

The words *Halimeda opuntia*, nopaline, and Nopal-1 were filtered; the first is the name of a marine algae that is distributed in the coral reefs and lagoons of tropical and sub-tropical regions (Hofmann *et al*. 2013); the second is a chemical compound unrelated to the plant, described in https://pubchem.ncbi.nlm.nih.gov/compound/108012; and the third, an uranium deposit in Sierra Blanca Sonora (Schindler *et al*. 2010) whose records were filtered with the words “nopal I” and Uranium, respectively (Figure 1).

TI=("prickly pear" cact* OR cladodes OR opuntia OR "Cactus pear" cladode* OR nopal* OR "cactus pad*" OR "cactus cladod*" OR "nopal slime" OR "cactus fruit" OR "prickly fruit" OR "Prickly-pear*") NOT TI=(nopaline OR "*Halimedia opuntia*" OR "nopal I" OR uranium)

Figure 1. Descriptors and syntaxes of the search strategy about cactus pear in the databases of Science Citation Index Expanded (SCIE) and Social Sciences Citation Index (SSCI) from the Core Collection of the Web of Science (WOS).

Of the resulting bibliographical records, the quantitative bibliometric indicators mentioned before were obtained, using the facilities that the WOS provides. The indicators

"publication journals" and "authors" were complemented with data that allow having a better perspective of the value of such information. In the case of journals, the Impact Factor (IF) of the journals was added, which results from the division between the number of cites received by a journal in a specific year, and the number of citable documents published in that journal during the two years immediately before (Garfield, 2006); and the position of the journal in the category Journal of Citation Reports (JCR) which has the best position and its corresponding quartile (InCitesTM Journal of Citation Reports® 2015).

For authors, the Hirsch Index was added, better known as Index H, which was proposed by Jorge Hirsch to evaluate qualitatively researchers of the area of physics, and which he defined as "the number of articles published by a researcher that shows more or equal number of cites", with the aim of estimating the importance, significance, and impact of the accumulative research contributions of a scientist (Hirsch, 2005).

To identify the themes on cactus pear addressed by documents that result from the search, they were divided into three databases by time periods (1900-1990, 1991-2005 and 2006-2015) using the keywords by authors and those assigned by the SCIE, SSCI (KeyWord Plus) databases. Keywords by authors (Ugolini *et al*. 2001) and KeyWord Plus (Qin, 2000) have been used in previous studies, although using different methodologies than the one used in this study to analyze the keywords.

The three databases were analyzed through the tool of social marking of academic documents, CiteUlike, created by Richard Cameron of the University of Manchester (Hammond *et al*. 2005), which allows importing bibliographical information from the databases and conserving, managing, storing and sharing the references. With this information, the most common index terms or 'tags' were identified, as well as how these have evolved throughout the study periods. The indexed documents in the 1900-1990 period do not include keywords by authors, or those assigned by the databases, so that in order to identify the themes, 180 records obtained from the CAB Abstracts databases were used, employing the same search strategy than in the SCIE and SSCI, and identifying the theme with the tools that such a database provides.

RESULTS AND DISCUSSION

Given their inherent limitations, the results obtained in this study can be considered as a first approach to understand the current state and the large trends in research related to cactus pear during recent years.

Bibliometric indicators

Number of documents published

International scientific production of documents related to cactus pear published in mainstream journals, reached a total of 1,472 products, during the study period. For 91 years (1900-1990), only 288 documents were indexed (19%); from 1991 to 2015, 81%, where it can be highlighted that 451 (31%) were indexed from 1991 to 2005, and 733 (50%) documents were indexed from 2006 to 2015 (Figure 2). The low number of records observed in this study is lower than the 5,723 detected by Grünwaldt *et al*. (2015), since the SCIE and SSCI databases did not incorporate documents such as articles from peer-

reviewed journals that are not considered mainstream: congress abstracts, thesis and patents, among others.

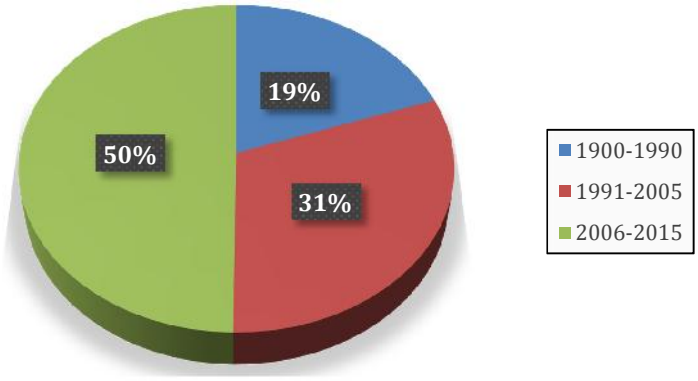

Figure 2. Rate of indexed documents published in mainstream journals about cactus pear (1900-1990, 1996-2005, and 2006-2015).

Regarding the number of records per year, the trend has increased constantly from 1990 to 2015 (R^2= 0.8494), so that during 2015, the number of indexed documents produced was higher, with 123.1% more than in 2010. This brings to light the technical and scientific importance, and the dynamism that research about this species has acquired during the last 25 years at the international level (Figure 3). However, it is necessary to consider that the small number of publications until before the 1980s can be related to the low indexation of scientific journals, as well as to scarce divulging of those publications before the digital era, not only of this species but in general in all sciences.

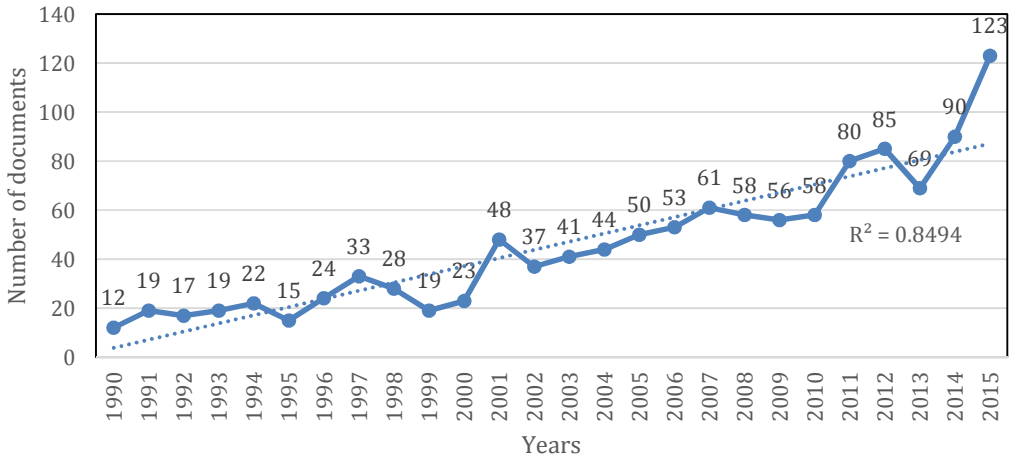

Figure 3. Increase in the number of indexed documents in the Science Citation Index Expanded (SCIE) and Social Sciences Citation Index (SSCI) about cactus pear from 1990 to 2015.

Types of documents published

The type of document that was most frequently published was articles with 1,268 records (86.1%). In decreasing order, the following are next: meeting abstract (108), scientific note

(42), book review (31), and congress proceedings (20). Other types of documents present rates lower than 0.5%, including: editorial material which is as note or announcement from the journal´s editor to the readers; corrections that are considered as a published note, where the author corrects some errors founded in a previous published documents; and Book Review which is a descriptive notice about a published book with a potential interest to the journal readers (Table 1). The predominance of articles is because the SCIE and SSCI index mainly scientific journals, and these, in turn, publish mostly scientific articles.

Table 1. Documents types about cactus pear (as indicated in Figure 1) indexed in Science Citation Index Expanded and Social Sciences Citation Index, during 1900 to 2015.

Document types	Number of records	% of 1,472
Article	1,268	86.141
Meeting Abstract	108	7.337
Note	42	2.853
Review	31	2.106
Proceedings articles	20	1.359
Letter	6	0.408
Editorial material	6	0.408
Correction	4	0.272
Book review	4	0.272
News item	3	0.204

Language of the publications

Without a doubt, an aspect of vital importance is related to the language of the publications. Six languages were used primarily: English, Spanish, Portuguese, French, German and Italian, but a high percentage of the records, 1,365 (93%) are in English, 64 (4%) in Spanish, and 1.5% in Portuguese. The languages French, German and Italian together represent less than 1.5% of the documents indexed (Table 2). It is important to consider that although Mexico contributes an important scientific production, a high percentage of it is in English, demonstrating the importance of this language to achieve higher international visibility and impact.

Table 2. Language of the indexed publications about cactus pear (as indicated in Figure 1) in the Science Citation Index Expanded and Social Sciences Citation Index (1900-2015).

Language	Number of records	% of 1472
English	1,365	92.731
Spanish	64	4.448
Portuguese	23	1.563
French	11	0.747
German	5	0.340
Italian	4	0.272

Institutions of origin of the authors

Concerning the institutions that participate in the generation of knowledge related to *Opuntia*, a total of 1,036 teaching and research institutions participated worldwide, although 83 (5.6%) records do not have data for institutions. The University of California as a whole predominates, since it presented the highest number of studies generated, with 99, of which the University of California at Los Angeles contributed with 70. Following Mexican education institutions, such as: Universidad Nacional Autónoma de México (84 documents), Universidad Autónoma Chapingo (48), Instituto Politécnico Nacional (42), Universidad Autónoma de San Luis Potosí (36), and Colegio de Postgraduados (35); then, universities from Chile, Italy and France. It should be highlighted that of the 15 institutions that published 20 or more documents in mainstream journals, eight are Mexican; likewise, individually, Universidad Autónoma de México is the institution that contributes the greatest scientific production for this specie (Table 3).

Table 3. Institutions of origin of the documents' authors about cactus pear (as indicated in Figure 1) with 20 or more indexed records in the Science Citation Index Expanded and Social Sciences Citation Index (1900-2015).

Institutions	**Number of records**	**% of 1,472**
University of California System, USA (including University of California Los Angeles, USA)	99	6.726
Universidad Nacional Autónoma de México	84	5.707
University of California Los Angeles, USA	70	4.755
Universidad Autónoma Chapingo, México	48	3.261
Instituto Politécnico Nacional, México	42	2.853
Universidad Autónoma de San Luis Potosí, México	36	2.446
Colegio de Postgraduados, México	35	2.378
Universidad de Chile	33	2.242
University of Palermo, Italy	32	2.174
Centre National de la Recherche Scientifique (CNRS), France	28	1.902
Universidad Autónoma de Querétaro, México	24	1.630
Texas A & M University System, EUA	23	1.563
United States Department of Agriculture (USDA)	22	1.495
Universidad Autónoma Metropolitana, México	21	1.427
Centro de Investigación y de Estudios Avanzados, México	20	1.359

It is worth highlighting that there are too many institutions involved, based on the number of documents; however, it should be considered that various institutions participate in a single publication, which indicates the high inter-institutional and inter-disciplinary collaboration.

Publication journals

The documents about *Opuntia* indexed in the SCIE and SSCI during the period of study show a high variability given that they were indexed in 528 journals, of which 16 published more than 15 documents: 9 (60%) are positioned in the first quartile (Q1) in the JRC categories according to their IF; of these, three are categorized in Plant Sciences: American Journal of Botany, Plant Physiology and Phytochemistry; two in Food Science and Technology: Food Chemistry and Plant Foods for Human Nutrition, and one each in multidisciplinary agriculture: Journal of Agricultural and Food Chemistry, Applied Chemistry (Carbohydrate Polymers), Horticulture (Scientia Horticulturae), and Biology (FASEB Journal). There are two journals categorized in Ecology, Oecology positioned in the second quartile (Q2) and Journal of Arid Environments im the third quartile (Q3); four journals (26.66%) are positioned in the fourth quartile (Q4) in the categories of Horticulture: Journal of the Professional Association for Cactus Development, Plant Science (Haseltonia), Food Science and Technology (Food Science and Biotechnology), and Multidisciplinary Agriculture: Agrociencia (Table 4).

The journal with most documents about the species indexed in the SCIE and SSCI is the Journal of the Professional Association for Cactus Development (JCPAD), and is the only one that has neither page charges nor a cost to download the articles. The objective of the founders of the JPACD was to put the grey literature on cactus from developing country scientists into an electronic format free without charge to all scientists (without pages charges and costs to download). Page charges for a major international journal are often of the same magnitude as the annual research budget of scientists in developing countries. For more than 20 years, the second most frequently cited US author exclusively published in journals without page charges for this reason (Felker, pers comm). However, it is the one that presents the lowest IF of the 16 journals with most indexed documents, maybe because the site does not have a software for online journal publishing, which has several consequences as the delay of appearance of the published articles in indexing databases.

The second journal with the most articles is the Journal of Arid Environment (JAE) which has no page charge but there is a cost to download papers from the journal. There are listed five journal that are published by Elsevier, including (JAE) with a cost per article downloaded of USD $35.95.

Three journals are published by Springer with a cost per article downloaded of USD $39.95. Agrociencia, a multidisciplinary journal is free to download articles, the same as JCPAD, however, it charges a cost for annual subscription (USD $50.00) to the correspondence author; it is edited in Mexico by Colegio de Postgraduados and has the particularity of publishing bilingually, which increases its impact and diffusion.

All the journals with cost to download articles has the option to publish in open access, charging the cost to the authors or to grant institutions, the cost range from USD $700 to $4,000, with preferential costs to members of the associations or if the institution of the correspondence author is subscribed to the journal. It is important to say that since the implementation of the Consorcio Nacional de Recursos de Información Científica y Tecnológica (Mexican Consortium of the Scientific and Technological Information Resourses) the access to scientific articles for academic institutions is not a problem.

Table 4. Titles of journals that published 15 or more documents about cactus pears (as indicated in Figure 1) indexed in the Science Citation Index Expanded (SCIE) and Social Sciences Citation Index (SSCI), 1900-2015.

Journal title	Number of records	FI 2015 / Position / quartile	JCR Category	Page charges To publish (USD)	Cost to download an article (USD)
Journal of the Professional Association for Cactus Development	94	0.222 / 30 of 34 / Q4	Horticulture	No charge	Free
Journal of Arid Environments	38	1.623 / 89 of 149 / Q3	Ecology	No charge	35.95
American Journal of Botany	36	2.811 / 43 of 209 / Q1	Plant Sciences	Voluntary. Mandatory if have five or more errors	8 for seven days
Plant Physiology	29	6.280 / 8 of 209 / Q1	Plant Sciences	1,900, or 1,600	20 for two days access
Food Chemistry	24	4.052 / 7 of 124 / Q1	Food Science & Technology	No charge	35.95
Journal of Agricultural and Food Chemistry	22	2.857 / 3 of 57 / Q1	Agriculture, multidisciplinary	No charge	40 for two days access
Phytochemistry	19	2.779 / 44 of 209 / Q1	Plant sciences	No charge	35.95
Oecologia	19	2.902 / 44 of 149 / Q2	Ecology		39.95
Carbohydrate Polymers	19	4.219 / 5 of 71 / Q1	Chemistry applied	No charge	35.95
Haseltonia	18	0.5 / 171 of 209 / Q4	Plant sciences	No charge	35.95
Scientia Horticulturae	17	1.538 / 8 of 34 / Q1	Horticulture	No charge	35.95
FASEB Journal	16	5.299 / 7 of 86 / Q1	Biology	50, processing, 199 per printed page	20 for one day access
Plant Foods for Human Nutrition	15	2.276 / 30 of 124 / Q1	Food Science & Technology	No charge	39.95
Food Science and Biotechnology	15	0.699 / 96 of 124 / Q4	Food Science & Technology	No charge	39.95
Botanical Gazette	15	No data*	No data	No data	No data
Agrociencia	15	0.305 / 48 of 57 / Q4	Agriculture, multidisciplinary	50, Annual subscription	Free

Journals are ordered by number of records. Impact Factor (IF), position in the Journal of Citation Reports (JCR); corresponding quartile, JCR category, cost of page charges and cost to download an article. *Botanical Gazette ceased to be indexed in the SCIE, in 1991 changed name to International Journal of Plant Sciences, which has an IF of 1.536, position 88 out of 209 in the JCR Plant Science category.

It is also important to highlight that Acta Horticulturae is not included, it publishes selected articles that are presented in the International Congress on Cactus Pear and Cochineal, and which incorporates a high number of articles related to the subject (Table 4).

In the developed countries the standard metric for judging the quality of the journal is the number of times papers in that journal are cited in other journals. The more funding in that field, the greater will be the number of scientists and journals, and the greater will be the number of citations for journals in that field. For research that has its major focus on poor developing countries, the funding will be less, the number of researchers less, the number of papers in those fields will be less and the number of citations less. This will inherently result in lower citations for journals focused on issues of the rural poor and their ecosystems in developing countries especially those of arid zones. In developing countries journals that facilitate the transfer of information to the global scientific electronic literature from resource poor scientists provides a value that is above and beyond traditional metrics of journal citations (Felker, pers comm).

Research areas of the journals

The research areas in which the journals that published documents about *Opuntia* are grouped, indexed in the Core Collection of the WOS, which were reviewed, are numerous (75 in total); however, the publication of these documents was focused mainly on six areas with more than 100 documents are: Plant Science with 404 (27.45%) records, in Food Science and Technology, 227 (15.42%), in Horticulture, 152 (10.33%), in Ecology, 142 (9.65%), in Applied Chemistry, 122 (8.3%), and in Biochemical and Molecular Biology, 110 (7.47%). The areas of Pharmacology and Pharmacy, Nutrition Dietetics, Agronomy, Medicinal Chemistry, Multidisciplinary Agriculture, and Agriculture, Animal and Dairy Science, concentrated between 100 and 50 indexed documents (Table 5).

Table 5. Categories of the Web of Science with more than 50 records about cactus pear (as indicated in Figure 1) published in mainstream journals (1900-2015).

Categories of the Web of Science	Number of records	% of 1,472
Plant sciences	404	27.45
Food Science Technology	227	15.42
Horticulture	152	10.33
Ecology	142	9.65
Chemistry Applied	122	8.30
Biochemistry Molecular Biology	110	7.47
Pharmacology Pharmacy	81	5.53
Environmental Sciences	75	5.10
Nutrition Dietetics	71	4.82
Agronomy	68	4.62
Chemistry Medicinal	65	4.42
Agriculture Multidisciplinary	64	4.35
Agriculture Dairy Animal Science	54	3.67

Source: Science Citation Index Expanded and Social Sciences Citation Index.

It is necessary to consider that the same journal may be classified within two or more research areas, so that a publication may be counted in one or more areas. For example, the Journal of Arid Environments is categorized both in Ecology and in Environmental Sciences, which in Table 4 appears in the area of Environmental Sciences, since it is better positioned there.

Countries of origin of the indexed documents

In the research generated around the specie, a high number of countries (64) participated; however, it is concentrated in only two countries, which each participated with more than 23%. Mexico is the main producer of scientific knowledge worldwide, since it contributed with 367 records (25%), the second is United States of America with 344 records (23.3%) of the total (Table 6).

Mexico stands out because of its contribution to knowledge of the specie, since it is considered one of its centers of origin and diversification (Griffith, 2004), as well as due to the social and economic importance that it represents for Mexicans and the high number of inhabitants of Hispanic and Latin origin who reside in the United States (Hernández, 2013). Among the countries that currently participate actively in the scientific production related to the specie, is Italy with 5.7% of the documents indexed, and Tunisia, Brazil, South Korea, Spain, South Africa and France, with rates between 4.69 and 4.0%.

Table 6. Countries of origin of the authors who published documents about cactus pear (as indicated in Figure 1) indexed in mainstream journals (1900-2015).

Countries	Number of records	% of 1,472
Mexico	367	24.93
USA	344	23.37
Italiy	84	5.71
Tunisia	69	4.69
Brazil	68	4.62
South Korea	65	4.42
Spain	63	4.28
South Africa	61	4.14
France	59	4.01
Germany	48	3.26
India	43	2.92
Argentina	39	2.65
Chile	38	2.58
Canada	34	2.31
Morocco	27	1.83
England	25	1.70

Source: Science Citation Index Expanded and Social Sciences Citation Index.

Authors with highest number of contributions

The SCIE and SSCI databases indicate that there are 3,624 authors who participated in the publication of 1,472 indexed documents about cactus pear between 1990 and 2015.

This indicates that for each document published, 2.46 authors participated, mean that is known as co-authoring coefficient (Sanz and Moreno, 1997). Among the authors with highest number of products focused on the study of *Opuntia*, Park S. Nobel stands out, a former professor of the University of California at Los Angeles, who published 67 documents, most of them scientific articles.

Another researcher who stands out because of his prolific work is Peter Felker, former professor from University of Texas A&M and current researcher in D'Arrigo Bros. Co. of New York Inc., with 27 collaborations. Then, M. Mahrouz and Paolo Inglese (Italy) appear with 19 and 18 records, respectively.

With less than 16 documents, six authors of Latin America origin appear: Carmen Luisa Sáenz Hernández, Associate Professor at the Agronomic Sciences School in Universidad de Chile; Bernardo Murillo-Amador from Centro Investigaciones Biológicas del Noreste (CIBNOR), Mexico; Juan Carlos Guevara from Instituto Argentino de Investigaciones de Zonas Áridas (IADIZA) from Argentina's Consejo Nacional de Investigaciones Científicas y Técnicas; Nimbe Torres y Torres, researcher from Instituto Nacional de Ciencias Médicas y Nutrición "Salvador Zubirán", Mexico; Juan Antonio Reyes-Agüero from Instituto de Investigaciones en Zonas Desérticas at Universidad Autónoma de San Luis Potosí, Mexico; and José Luis García-Hernández, who works at the Facultad de Agricultura y Zootecnia de la Universidad Juárez del Estado de Durango, Mexico (Table 7).

Table 7. Authors with 14 or more contributions on cactus pear (as indicated in Figure 1) in mainstream journals (1900-2015). Ordered by number of indexed documents, including citations received up until July 20th, 2016, average of citations per document and Hirsch Index (h-Index).

Authors	Number of records	Number of citations / Average citations per document	h-Index
Nobel, P.S.	67	1562 / 23.31	24
Felker, P.	27	819 / 30.33	16
Mahrouz, M.	19	691 /33.37	16
Inglese, P.	18	316 / 16.63	10
Saenz, C.	16	436 / 27.25	8
Murillo-Amador, B.	16	56 / 3.5	5
Guevara, J.C.	15	121 / 8.07	6
Reyes-Agüero, J.A.	14	143/ 10.21	6
Torres, N.	14	50 /3.57	4
García-Hernández, J.L	14	39 / 2.79	4

Source: Science Citation Index Expanded and Social Sciences Citation Index.

Themes of the documents

The detailed analysis of keywords from registry keys shows that the themes of the documents have shown evolution through the time. Table 8 highlights that during the 1900-1990 period the main themes were directed towards the importance of cactus pear as fruit and its management as invading weed, where numerous studies were included

about phytosanitary containment agents. In addition, the first studies to understand basic aspects of physiology and metabolism are included, as well as to determine the chemical compounds present. In contrast, during 1991-2005, the main trend was focused on understanding its ecophysiological aspects, its metabolism, characterizing its components and its productivity under different scenarios. Finally, during 2006-2015, they are focused on determining properties and applications of its functional compounds and on its biological activity in health, its function as bioremedial plant, and the important role that it may have to reduce the effects on globbal climate change.

Table 8. Themes of the documents about cactus pear (as indicated in Figure 1) indexed and CAB abstracts (1900-1990), and in Science Citation Index Expanded and Social Sciences Citation Index (1996-2015).

1900-1990 (180 records)	**1991-2005 (451 records)**	**2006-2015 (733 records)**
Fruit crops (59)	Opuntia (182)	Opuntia (324)
Subtropical crops (51)	Cactus (117)	Cactus (199)
Weeds (46)	Pears (109	Pears (174)
Exotic species (32)	Ficus indica (86)	Ficus indica (165)
Introduced species (32)	Prickly (69)	Antioxidants (136)
Natural enemies (29)	Acids (51)	Cactaceae (106)
Biological control (29)	Fruits (47)	Cladoes (84)
Invasive species (28)	Growth (42)	Acids (76)
Ornamental plants (25)	Cladodes (41)	Betalains (56)
Control (24)	Metabolism (36)	Extracts (56)
Arid regions (23)	CO2 (29)	Seeds (53)
Agricultural entomology (20)	Desert (29)	Stress (52)
Weed control (18)	Water (29)	Water (51)
Phytopatology (11)	Crassulacean (25)	Foods (48)
Plant growth regulators (11)	Temperature (25)	Mucilage (44)
Ecology (11)	Seeds (24)	Quality (43)
Growth susbstances (10)	Fibers (23)	Proteins (42)
Responses (10)	Proteins (23	Growth (41)
Chemical constituents of plants (9)	Cacti (22)	Polisaccharides (38)
Opuntia amyclaea (9)	Productivity (21)	Metabolism (37)
Plant composition (9)	Prickly-pear (19)	Flavonoids (33)
Carbon assimilation (8)	Relationship (19)	Phenolics (32)
Carbon dioxide fixation (8)	Roots (19)	Pigments (24)
Common pricly pear (8)	Storage (19)	Polyphenols (23)
Cultural methods (8)	Stress (19)	Glycosides (23)
Giberellic acid (8)	Cells (18)	Diabetes (17)
Metabolism (8)	Pectins (18)	Cancer (16)
Photosyntesis (8)	CAM (17)	Phenolic compounds (16)

CONCLUSIONS

The analysis of the bibliographical records indexed in the Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SCIE) databases, complemented with the keywords of CAB abstracts for the documents published from 1900-1990, allowed identifying the productivity and tendencies of scientific activity about *Opuntia* in mainstream journals.

The highest publication period of years were 1990 to 2015, but during 2015, the number of indexed documents produced was more than two times higher than in 2010.

The research published during the latest ten years are focused on determining properties and applications of its functional compounds and on its biological activity on health.

The results obtained will allow the researcher to make decisions regarding from where and in which journals to publish, what researchers to interact with, as well as the recommended language based on the research area of the contribution.

REFERENCES

Amaro R., M. Robles B., E. 2013. Producción de conocimiento científico y patrones de colaboración en la biotecnología mexicana. Entreciencias 1 (2): 183-195.

Bellavista, J., Guardiola, E., Méndez, A., Bardons G., M. 1997. Evaluación de la investigación. Centro de Investigaciones Sociológicas, Madrid. Cuadernos Metodológicos No. 23.

Food and Agriculture Organization (FAO). 2006. Utilización agroindustrial del nopal. Boletín de Servicios Agrícolas de la FAO. 162. Roma, Italia. ISBN 978-92-5-305518-0. p. xi.

Garfield, E. 2006. The history and meaning of the journal impact factor. [In line] Jama 295:90-93. Available in: http://garfield.library.upenn.edu/papers/jamajif2006.pdf (Accessed 25 July 2016).

Garrison, H. H., Herman, S. S., Lipton, J. A. 1992. Measuring characteristics of scientific research: a comparison of bibliographic and survey data. Scientometrics 24(2): 359-370

Griffith, P. M. 2004. The origins of an important cactus crop, *Opuntia ficus-indica* (Cactaceae): New molecular evidence. American Journal of Botany 9(11):1915-1921.

Grünwaldt, J. M., Guevara, J.C., Grünwaldt, E. G. 2015. Review of scientific and technical bibliography on the use of *Opuntia* spp. as forage and its animal validation. Journal of the Professional Association for Cactus Development 17:13–32.

Hammond, T., Hannay, T., Lund. B., Scott. J. 2005. Social Bookmarking Tools (I): A General Review [In line]. D-Lib Magazine, 11(4). Available in: http://www.dlib.org/dlib/april05/hammond/04hammond.html [Accessed 16 June 2016].

Heinrich, M., Haller, F. B., Leont, M. 2014. A perspective on natural products research and ethnopharmacology in Mexico: The eagle and the serpent on the prickly pear cactus. Journal of Natural Products 77:678-689.

Hernández F., A. D. 2013. El nopal verdura en México y en el mundo. *In*: Guevara, A. J. C., Ornelas P., J. de J. (eds). Tecnología Postcosecha y efectos Biofuncionales del Nopal y la Tuna. Ed. Trillas. México. pp:11-49.

Hirsch, J. E. 2005. An index to quantify an individual's scientific research output. Proceedings of the National Academy of Sciences of the United States of America 102(46):16569–16572.

Hofmann, L. C., Heiden, J., Bischof, K., Teichberg, M. 2013. Nutrient availability affects the response of the calcifying chlorophyte *Halimeda opuntia* (L.) J.V. Lamouroux to low pH. Planta 239(1):231–242. http://doi.org/10.1007/s00425-013-1982-1

Inglese, P., Liguori, G. 2010. Growing cactus pear *O. ficus-indica* (L.) Mill. The contribution of the scientific research on plant ecophysiology and biology [On line]. *In*: International Congress on cactus pear and cochineal (7: 2010: Agadir, Maroc). Association Marocaine de Développement du Cactus (ANADEC). Available in: http://www.agrimaroc.net/cactuscongress/s21%20Growing%20cactus%20pear.pdf . Accessed 13 June 2016.

Irvin, G. N. 2012. Indian fig cactus (*Opuntia ficus-indica* (L.) Miller) in the Americas: an uncertain history. Haseoltonia 17: 70-81.

InCitesTM Journal of Citation Reports® 2015- Thomson Reuters [In line]. Consultado en Julio de 2016. Available in: https://jcr.incites.thomsonreuters.com. Accessed 10 June 2016.

Li, L.-L., Ding, G., Feng, N., Wang, M-H., Ho, Y-S. 2009. Global stem cell research trend: Bibliometric analysis as a tool for mapping of trends from 1991 to 2006. Scientometrics 80(1):39–58.

Li, J., Wang, M.-H., Ho, Y.-S. 2011. Trends in research on global climate change: A Science Citation Index Expanded-based analysis. Global and Planetary Change 77(1–2):13–20. http://doi.org/10.1016/j.gloplacha.2011.02.005

Majure, L. C., Puente, R., Griffith, P.M., Judd, W. S., Soltis, P. S., Soltis, D. E. 2012. Phylogeny of *Opuntia* s. s. (Cactaceae): clade delineation, geographic origins, and reticulate evolution. American Journal of Botany 99(5):847-864.

Onakpoya, I. J., O'Sullivan, J., Henegahn, C. J. 2015. The effect of cactus pear (*Opuntia ficus-indica*) on body weight and cardiovascular risk factors: a systematic review and meta-analysis of randomized clinical trials. Nutrition 31(5): 640-645.

Patel, S. 2015. *Opuntia* fruits a source of inexpensive functional food. *In*: Emerging Bioresources with Nutraceutical and Pharmaceutical Prospects. Chapter 3. 15-30. Springer International Publishing Switzerland. ISBN 978-3-319-12847-4.

Pellegrini F., A., Goldbaum, M., Silvi, J. 1997. Producción de artículos científicos sobre salud en seis países de América Latina, 1973 a 1992. Rev Panam Salud Púbica/Pan Am J Public Health 1(1):23-34.

Qin, J. 2000. Semantic similarities between a keyword database and a controlled vocabulary database: An investigation in the antibiotic resistance literature. Journal of the American Society for Information Science 51(2):166–180.

Realini, M. F., González, E. G., Font, F., Picca, P .I., Poggio, L., Gottlieb, A. M. 2015. Phylogenetic relationships in *Opuntia* (Cactaceae, Opuntioideae) from southern South America. Plant Syst Evol. 301:1123-1134.

Salager-Zeyer, F. 2015. Peripheral scholarly journals: From locality to globality. Ibérica 30:15–36.

Sanz Casado, E., y Moreno C., M. 1997. Técnicas bibliométricas aplicadas a los estudios de usuarios. Revista General de Información y Documentación 7(2):41-68.

Schindler, M., Fayek, M., Hawthorne, F. C. 2010. Uranium-rich opal from the Nopal I uranium deposit, Peña Blanca, Mexico: Evidence for the uptake and retardation of radionuclides. Geochimica et Cosmochimica Acta *74*(1):187–202. http://doi.org/10.1016/j.gca.2009.09.017

Stintzing, F. C., Carle, R. 2005. Cactus stems (*Opuntia* spp.): A review on their chemistry, technology, and uses. Mol. Nutr. Food Res. 49:175-194.

Ugolini, D., Cimmino, M. A., Casilli, C. and G. S. Mela. 2001. How the European Union writes about ophthalmology. Scientometrics 52(1):45–58.

Valenzo-Jiménez M. A., Rodríguez M. R., Martínez A., J. A. 2016. Estudio bibliométrico del desarrollo regional en México. Revista de la Facultad de Contaduría y Ciencias Administrativas 1(1):15 – 42.