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Research Article

Application of Engineering Strategies in Food Plant Materials for the Prevention of Diseases Resulting from Oxidative Stress: A Bibliometric Analysis

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Abstract

The development of products for the prevention of diseases derived from oxidation reactions in humans is an essential contribution to the improvement of their quality of life. However, to achieve this purpose it is essential to identify scientific and technological aspects that allow to preserve the faculties that plant materials have to counteract oxidation reactions. Based on the above, the objective of this study was to perform a bibliometric analysis of the application of engineering processing strategies in food plant materials for the prevention of diseases derived from oxidative stress in humans. Methodologically, a systematic search process was carried out using a search equation in scientific and freely accessible databases. The results obtained were processed using descriptive techniques, creation of bibliographic coupling networks (Network) and analysis of association strength of bibliographic coupling (normalization).

The results were visualized through multiple correspondence analysis in qualitative variables, network mappings and identification of common concepts by K-means grouping (cluster). The results allowed to identify the contribution to the central theme from two clusters. One of them focused on engineering aspects related to the application of instrumental techniques for the analysis, design and development of products for disease prevention and the other, oriented towards the pharmaceutical area and possibly the development of medicines. It is concluded that the central topic of the study is an area of interest for many countries of the world that are making contributions from their perspectives supported by the formation of cooperation networks. Among them, the generation of knowledge in Asian countries such as China stands out, which leads the scientific production oriented towards the application of engineering and pharmaceutical strategies for the prevention of diseases based on food.

Keywords: Phytochemicals; Health; Freeze-Drying; Nutraceuticals

Introduction

At present a large number of diseases have been associated with the prevalence and generation of free radicals in humans. Free radicals are chemical-cutting molecular species that are capable of existing regardless of whether they contain one or more unpaired electrons at the orbital level [1]. They are commonly known as free radicals to the super oxide ($O_2^{\cdot -}$), nitric oxide ($NO^{\cdot}$), tiyl ($RS^{\cdot}$), tricloromethyl ($CCL_3^{\cdot}$) and others, which are radicals focused on oxygen, sulfur and carbon, respectively. Naturally, free radicals are produced by the normal use of oxygen in the body during respiration, endogenous production caused by cell-mediated immune functions and also by exogenous sources related to environmental pollution, use of agrochemicals, exposure to radiation sources, among others [2]. The high level of reaction of free radicals leads to possible interactions with cellular structures, to the point of damaging their membrane, generating mutations and causing their death [3]. Based on the above, an aspect that must be considered to avoid the development of diseases as a result of the reactions of these molecular structures, is to maintain a balance between the amount of free radicals and the content of antioxidants in the human body to have an adequate functioning at the physiological level, since antioxidants confer a blocking effect for free radicals. An excess of free radicals in the human body brings with it oxidative stress that results in cerebrovascular diseases, cardiac anomalies, formation of cancer-like cells, among others [4,5].

The consumption of foods with antioxidant activity can prevent oxidative stress and the onset of diseases. However, bioactive compounds (phenolic compounds, anthocyanins, tocopherols, carotenoids, among others) responsible for antioxidant activity in food plant materials are usually sensitive and degrade under processing and storage conditions that involve the use of high temperatures, pressure, exposure to light, oxygen, among other factors that are commonly used in transformation activities. In a certain way, these aspects compromise at the level of bioaccessibility the use at the tissue level of the components with antioxidant activity. Therefore, the food industry has increased interest in achieving methods and procedures at the processing level that lead to the development of products that meet the nutritional purpose and also contribute to health benefits [6-9].

On the other hand, during activities related to research, technological development and product design, it is common to carry out processes of inquiry and search for information for the selection of engineering strategies that make it possible to meet the nutritional requirements and contributions to health desired by current consumers. Based on this, using quantitative investigation techniques and bibliometric analysis can be useful for planning activities related to the study of the benefits offered by plant materials in disease mitigation scenarios. Since the usefulness of bibliometric analysis focuses on examining the literature with academic and scientific character to offer a description, evaluation and detailed monitoring of scientific research, it is possible to consider its use to identify possible trends framed in this area of study. Despite the importance of bibliographic analyses, in the available literature that was reviewed it was identified that there are no studies focused on conducting bibliometric analyses to study the production of foods with nutraceutical properties from plant materials and the benefits they can obtain in human health. Based on the above, the objective of this study was to perform a bibliometric analysis of the application of engineering processing strategies in food cut plant materials for the prevention of diseases in humans derived from oxidative stress [10-13].

Materials and Methods

Search design

In the present study, a bibliometric analysis was carried out using open access scientific databases as resources, mainly the PubMed database (https://pubmed.ncbi.nlm.nih.gov/). This database is the primary database for health sciences and is produced by the National Center for Biotechnology Information (NCBI) of the National Library of Medicine. It is characterized by being used by researchers, professionals and students worldwide for including more than 30 million citations, from more than 5,300 journals currently indexed in MEDLINE and almost 3,000 journals that have deposited material in PubMed Central [14]. Based on this, the documents that were considered for the realization of the study consisted of scientific articles with the "Full text" and "Free full text" modality that the database provided, in such a way that it was possible to segment the analysis only to articles in full versions, leaving aside the abstracts. As search design criteria, documents that were published in an observation spectrum from 2006 to 2022 and that met the topics of interest of the present study were analyzed quantitatively and qualitatively. For this aspect, the method used by [15].

Search strategies and tools

For the development of the study, common topics were considered as a potential strategy for the search. Based on the above, descriptors were selected from the DeCS website (https://decs.bvsalud.org/E/homepagee.htm) which is a search engine in the area of health science. Additionally, possible synonyms of selected descriptors were checked on websites such as (https://visuwords.com/sally) to expand the scope of the search. Once the descriptors were defined, a search equation was constructed to carry out the process of systematic review of the bibliographic material that was considered in the study, for this purpose the method used by [16].

According to the search strategy drawn, the descriptors used were "Microcapsule", "Microencapsulation", "Freeze drying", "Spray drying", "Coacervation", "Fruits benefits" and "Fruit health" corresponding to the respective translation into American English. For the construction of the search equation, Boléanos connectors such as "and" and "or" were selected complemented by the use of parentheses and quotation marks to ensure a structured equation that would facilitate carrying out a specific search within the database. The equation that was applied for the systematic search was: (Microcapsule OR microencapsulation OR "freeze drying" OR "Spray drying" OR coacervation) AND ("Fruits Phytochemicals" OR "fruits benefits" OR "fruit health"). The bibliographic material that was selected included the object of study, the method of processing, analysis and the approach of engineering strategies in food plant materials for the prevention of diseases derived from oxidation reactions. The results were stored in ".txt" format, for the development of subsequent processing and analysis activities.

Data analysis

For the statistical analysis of the data, in the first phase the "Bibliometrix" package of Rstudio was used, which is a complete tool for the development of quantitative bibliometric and/or scientometric research involving visualization of maps and statistical graphs. For its part, the open-source software Rstudio consists of

a set of applications for data manipulation, calculation and visualization of statistical graphs, is characterized by being powerful and flexible during information processing. Figure 1 illustrates the operational diagram that was made for the processing of the data associated with the executed bibliometric analysis [13,17,18].

Depending on the structure proposed for the processing of the data of the second phase, the process of acquiring the data was considered as the initial stage, which was carried out taking into account the criteria described in the previous subsections. The database obtained was refined and organized following the requirements requested by Bibliometrix, then the data was imported into the analysis software. In the processing of the data, initially a descriptive analysis of the framework of the bibliographic data was carried out, taking into account aspects associated with the metadata of the articles such as the case of the authors, articles by author, keywords plus, sources or other aspects. Next, we proceeded to the creation of networks to analyze the bibliographic coupling and the formation of connections or networks of co-occurrence that led to the identification of nodes of interrelations between the metadata, such as authors, countries, documents, keywords, among others. Additionally, a normalization process was carried out to identify associations moderated by the proximity index as a measure of similarity. For this process, taxonomy techniques and coupling of bibliographic sources were used to frame the use of metadata associated with the information base obtained.

Figure 1: Operational diagram for data processing.

As a last phase, the visualization of the processed data was carried out. For this aspect, a mapping of the conceptual structure was carried out by means of a principal components analysis weighted to a multiple correspondence analysis. The purpose of these analyses was to examine categorical data to narrow down the set of variables into a smaller set of components that summarized the information contained in the data. Additionally, a process of conformation of [19] *clusters* of K-means was carried out for the determination of common groups among the topics found in the documents. Finally, a factor map was made to simultaneously analyze tables of the same set of individuals that were described through several groups of variables, which was complemented by a relationship tree dendogram that provided a description of the taxonomic system of the articles [20-22].

Results and Analysis

Based on the assumption that bibliometric studies make it possible to carry out in-depth analyses about the evolution and transcendence of scientific publications on a given topic and also, considering that with this type of studies it is possible to estimate the trend of publications, authorship details, scientific categories, the most active journals and institutions, The networks of collaboration between authors, cooperation between countries and the central topics of the research, the results were processed and then the pertinent analyses are detailed following the subsections described above [23].

Contribution of countries to the area of knowledge

As initial results, a total of 368 references were obtained related to engineering strategies in food cut plant materials for the prevention of diseases derived from oxidation reactions in humans

(EDROSH) framed in the observation period between 2006 and 2022. Similarly, these results were consistent with the previously established "Full Text" and "Free full text" document typology, omitting all abstract-type documents. This aspect was relevant to achieve consistency in the information base, which has also been considered by authors such as [13]. Figure2a illustrates the production of scientific articles associated with the subject of the study by year. There is a growing trend in scientific production associated with the subject as time passed, highlighting the predominance of two maximum points in 2016 and 2021, respectively. This result indicates that in recent years in the scientific communities there has been some interest in the generation of new knowledge focused on the mitigation of EDROSH, which allows us to infer that the selected study topic is relevant in the midst of scientific communities and is a current issue that with the passage of time is taking greater boom at the scientific level. However, in the midst of this panorama, greater efforts are still demanded in the generation of knowledge about the evaluation of therapeutic interventions and nutritional recommendations to prevent functional losses associated with age, which are due to the accumulation of damage induced by oxidation reactions [24].

Figure 2b illustrates the participation of countries in scientific production associated with the thematic area. The results indicated that 21 countries have conducted research on the subject of study in recent years. China was the country with the most research, its contribution represents 19% of the total studies. In the second instance, Brazil (11%) also stands out for its scientific production related to the object of study. Then, countries such as Poland (9%), Spain (6%) and Mexico (5%), subsequently influenced the development of the theme. Similarly, the rest of the countries of the world account for 51% of total research. Part of these results can be attributed to the high investment in research and development in countries such as China, which through the creation of scientific academies has the technological infrastructure in various research institutes. This event has allowed to position the science, technology and scientific production of the Chinese territory as a new re-

Figure 2: a) Production of scientific articles associated with the theme by years; b) Participation of the countries in scientific production associated with the thematic area; c) Evolution of the main publication sources as a function of time.

search revolution. Additionally, it is possible to mention that these advances obtained can possibly be reinforced under the premise that science is a decisive factor in the development of defense, economy and culture of a country [25].

Based on the above, it is possible to infer that the high number of publications on engineering strategies in food-cut plant materials for the prevention of EDROSH led by China, can be associated with the cutting-edge level in scientific research that this country has; This is significant evidence that allocating resources to the generation of knowledge and research is of utmost importance for the development of studies that contribute to the positioning of countries in places of high scientific performance [13]. On the other hand, it was possible to corroborate that the development of bibliometric analysis allowed to differentiate the countries that have a great contribution in emerging issues (Figure 2b), it also allowed to demonstrate the transcendence of the subject studied and the relevance of the contributions made by various countries as time progressed.

Figure 2c illustrates the evolution of the main sources of publication as a function of time. The results showed that the journal *Molecules (https://www.mdpi.com/journal/molecules)* experienced a significant growth in annual publication occurrences during the period 2018 and 2022. This result can be attributed to the fact that Molecules is currently the leading international chemistry journal classified Q2 in JCR and Q1 CiteScore Q1 open access. Additionally, it can also be explained by the frequency of publication every two weeks under the "*online"* modality that handles this means of dissemination, which is supported by the participation of institutions such as the International Society of Nucleosides, Nucleotides and Nucleic Acids (IS3NA), the Spanish Society of Medicinal Chemistry (SEQT) and the International Society of Heterocyclic Chemistry (ISHC) in the production and publications. In the second instance, the growth in the annual occurrences of publications of the journal *FOODS (BASEL, SWITZERLAND) (*https://www.mdpi.com/journal/foods*)* in the period 2019 and 2002, which is also an open access journal related to food science that has a Q1 classification in JCR and CiteScope, is highlighted. which positions it as a second means of publication relevant to the subject of study. In contrast, it is noteworthy that in the rest of the identified publication sources there were no drastic variations in the annual occurrences of publication depending on the observed time, which could be associated with the preservation of their publication policies over the years.

Additionally, from these results it is possible to infer that the journal Molecules in 2020 presented the highest number of annual occurrences in publications around the topic of interest. In contrast, *Foods* magazine despite having a significant number of annual occurrences of publication, its growth began in 2018 with a peak in 2021. This result makes the journal *Molecules* a highly relevant means of dissemination with a wide scope regarding the engineering strategies applied in the prevention of EDROSH, which agrees with those mentioned with [13], who were able to determine which was the journal with articles of greater impact in relation to its thematic axis. These results help researchers to identify the journal with the greatest impact in relation to the topic they wish to investigate, in such a way that they can facilitate the decision-making process in the process of making public the findings of their research [26]. Additionally, it is possible to mention that since the *journal Molecules* is the one with the highest number of annual recurrences in publications, it could be considered as a good option to aspire to a publication process with propensities to high visibility [23].

Descriptive analysis

In Figure 3a, a map of conceptual structure drawn by the. Analysis of multiple correspondences and consisting of a total of 50 keywords that were grouped into two clusters. The first component was considered as the main one, since it represented 69.76%, while the second component represented 9.06%, which were the result of the homogeneity analysis of the matrix of indicators that allowed to obtain the Euclidean representation of low dimension from the analyzed database. This result indicates a high reliability in the conformation of the clusters, considering that the classification of these was carried out by the level of relationship that coexisted between the related keywords in the metadata of the analyzed documents. Additionally, the results indicate that the contribution to the central theme of the study on EDROSH can be attributed to two approaches, one of them from an "engineering perspective" that corresponds to the red cluster and the other from an approach oriented towards the "pharmaceutical, biomedical or health" part associated with the blue cluster [27,28].

Based on the above, it is highlighted that these approaches contribute to the subject of study from their perspective, the engineering from the development of products from vegetable food matrices, which show the use of technological strategies for processing food matrices complemented by instrumental analysis to preserve the nutritional properties and functional characteristics of bioactive compounds present in food. On the other hand, in the biomedical approach it is possible to associate the contributions from the study and development of experimental protocols to analyze the health benefits derived from the recurrent use of bioactive compounds, fundamentally oriented to the generation of knowledge associated with the production of drugs and the treatment of specific diseases, from urinary tract infections to the formation of cancer cells. In this way, an appropriate complement is evident between the clusters identified for the generation of knowledge,

which allows to reveal strategies of solution to the current diseases derived from oxidative stress that have been associated with cardiovascular diseases, chronic obstructive pulmonary disease, chronic kidney disease, neurodegenerative diseases and formation of cancer cells [29,30].

Figure 2b illustrates the factor map of the documents with the greatest contribution to the thematic area. It is observed that in the engineering approach the authors with the greatest contributions to literature have been *Nuria Martínez-Navarrete, Agata Marzec, Jolanta Kowalska, Emilia Janiszewska-Turak and David Bernardo López-Lluch*. In the blue cluster corresponding to the pharmaceutical or biomedical area, their counterparts are *Betsy Foxman, Jia-Yue Xia, Munehiro Kitara, Kudiganti and Kindleysides*. The center of the map (crossing of dotted lines) corresponds to the average position of all published articles that were evaluated and represents the center of the research field. Although some distance is preserved between the clusters in relation to this point, it is evident that cluster 1 associated with the authors and works that contribute to the theme from the engineering approach has a greater relationship of proximity, which indicates that possibly these authors and documents can be considered as central to the subject today [31].

Figure 3c illustrates the thematic dendogram obtained from information processing. The dendogram or tree diagram allows to demonstrate the way in which the conglomerates are formed in each case and analyze the level of similarity derived from the conformation of the conglomerates. The result highlights the conformation of two clusters at an approximate similarity level of 1.5, in which the blue cluster is consistent with the terms previously identified and that were related to the "biomedical" cluster, while the red cluster clearly represents the conformation of another group that is characterized by being made up of keywords related to engineering techniques for the prevention of EDROSH [32].

Figure 4a shows the evolution of the approach of the keywords initially used in EDROSH studies over time. From this information it is possible to deduce that, since 2016, the generation of knowledge has been considered with the application of engineering techniques such as freeze-drying. This technique has been considered as a fundamental strategy for the design and elaboration of foods from plant materials that meet the appropriate requirements for the formation of a healthy diet. In addition, that these foods also contribute to the prevention of diseases associated with various health conditions that occur from oxidative stress and that have been reported by the World Health Organization and Food and Agriculture Organization. Freeze-drying is a well-known technique for producing high-quality solid and powdered foods. It is considered as the preferred method for drying foods containing heat-sensitive compounds and oxidizing compounds because it works at low temperatures and high vacuum. Freeze-drying is used in the preparation of dry products from various plant-derived foods, such as apple, guava, strawberry, blackberry, pumpkin, tomato, asparagus, coffee, tea, garlic, ginger, maple syrup, among others that have been reported in the literature [33-36].

On the other hand, a greater number of investigations related to the processing of fruits and that were developed recently was also found; These studies also mention the cases of application of these plant materials and the benefits they confer on human health. The benefits to human health by plant materials have been associated with the influence of macronutrients, micronutrients and a series of bioactive substances or secondary metabolites such as carotenoids, tocopherols, polyphenols, anthocyanins, among others, present in these products. For his part, [37,38] he considered that the application of products of plant origin in human health is an emerging research area of great relevance for future studies. Also, in recent publications it was found that the use of fruits also has high application in the preparation of medicines. This application may be due to the antioxidant properties present in plant materials, since it is known that the imbalance between endogenous antioxidants and free radicals (oxidative stress) is associated with different diseases or with human aging [39].

Figure 4b shows the frequency of keywords and thematic trend over the years. The repeated and more frequent use of the terms "human", "freeze-drying" and "fruits/chemistry" in the years 2018, 2019 and 2020, respectively, is highlighted. Through this graph it is possible to monitor the most frequent keywords that have been used in scientific publications, in such a way that it is possible to estimate their incidence in the central theme related to the prevention of EDROSH. Within this aspect, it is highlighted that one of the key words that has persisted the most over time has been "seeds/chemistry", which is directly related to the central topic of the study.

Data visualization

In addition to the results obtained in the data analysis phase (Figure 3 and Figure 4), the data visualization section was complemented by co-occurrence networks (Figure 5) and collaboration networks (Figure 6). Initially, Figure 5a illustrates a network of co-occurrence of keywords for each research stream. There are also two networks, one of "engineering cut" congruent with the red cluster and the other, the blue cluster oriented towards the "pharmaceutical, biomedical and health" part. Words like "human," "female," "male," "adult," and "middle-aged" stand out in the line of pharmaceutical, biomedical and health research. For the engineering research line again the most relevant keywords were "freeze-drying", "fruits/chemistry", "animals" and "plant extract/chemistry".

Figure 3: a) Concept structure map; b) Factorial map of the documents with the greatest contribution; c) thematic dendrogram.

Figure 4: a) Evolution of themes as a function of time; b) Trending topics by keywords.

Figure 6b represents the thematic map based on density and centrality. Centrality indicates the degree of relevance or importance of the topic and density the degree of development of the chosen topic. The figure is basically divided into four parts. The topics that appear in the lower left are emerging topics, that is, new topics that can arise or appear to contribute to the research area. The topics found at the bottom right correspond to the basic or transversal themes. The upper left refers to niche topics, i.e., specialized or segmented. Finally, the upper right part represents the driving themes that drive the globality of the theme; They are considered as developed and essential topics [31]. According to the above, four bubbles can be observed that resulted from the analysis of keywords. The two largest bubbles correspond to motor themes and refer to the repeated use of terms such as "humans", "fruits/chemistry", "masculine", "feminine", "animals", "plant extract/chemistry" and "freeze-drying", these being of high centrality and density. On the other hand, emerging topics are represented by smaller bubbles, which indicates a lower proportion of related keywords, but that over time could probably gain strength and generate greater contributions. For the current of engineering research, the driving topics of research are the freeze-drying of materials of plant or animal origin, this can be attributed to the imminent need to preserve food, prolong its shelf life and maintain most of its bioactive properties [40,41].

For the stream of pharmaceutical, biomedical and health research, the driving issues can be explained by the applications of plant-based materials in the health of men and women. Fruits, for example, have an important source of bioactive molecules that can replace synthetic chemicals in the various fields of the food, cosmetic and pharmaceutical industry, because they have excellent biocompatibility, bioavailability, safety and stability. In addition to being environmentally friendly, some extracts and bioactive

Figure 5: A) Co-occurrence network, keyword network map; b) thematic map by keywords.

components are promising, because they possess antiproliferative properties for cancer cells, hepatoprotective properties against free radicals and also tend to lower the regenerative properties of stem cells at the stomach level [42-47].

Analysis of cooperation networks

Figure 6 aillustrates collaborative networks at the country level. It is possible to observe the level of collaboration between countries and their influence, in this sense, the countries of dark blue tonality represent greater influence in the development of the theme. It is inferred that China, the United States, Spain, Brazil, Poland and Italy have solid and well-constituted collaboration networks. In addition, it is highlighted that the strongest cooperation relations are made up of China-United States and the United States-Croatia, meanwhile, Spain is one of the countries with the greatest cooperation relations that has important ties with Poland, Italy and Brazil. Similarly, Figure 6b shows the different collaborative networks between countries. China again appeared as the country with the most collaborations. Its main cooperation networks are linked to countries such as the United States, Japan, New Zealand, France and Australia. The second country with the largest number of networks was the United States, which has scientific research linked to Croatia, Chile, France, Germany and Brazil, which allows strengthening its contributions to the subject of the study. Likewise, Brazil maintains collaborations with Spain, Poland and Italy and also appears as an important actor for collaborative work and knowledge generation associated with the prevention of EDROSH.

At the same time, it is demonstrated which is the country with the greatest interaction and exchange of information, these findings are confirmed by other authors such as, who based on their results were able to estimate the most productive country in terms of information flow; But they also determined the most repre-

Figure 6: a) Country Collaboration Map; b) Collaboration networks at the country level; c) Collaboration networks at author level.

sentative groups of countries and their respective leaders. Such is the case of the present study where the grouping of countries in relation to their flow of information is evident, being divided into three groups led by China, the United States and Spain (Figure 6b) [23].

Figure 6c illustrates collaborative networks at the author level. Eleven clusters of collaborative networks were observed. The largest of all clusters (blue cluster) was made up of authors such as *Domian e* and *Kowaslk*. These authors make up a group of researchers that has achieved a large number of scientific publications according to the theme. Based on the above, this cooperation network allowed to give credit to these authors, considering in particular their publications and determining their impact on the participation of research related to the topic of interest, for which they are considered as outstanding authors [23,26].

Likewise, the second most important cluster was identified with the color red. It is supported by interactions led by authors such as *Wojdyo,* who has strong ties to *Nowickap* and *Lench K*. Other important authors in the other clusters were *Badri a, Barbu* v, *Yang d, Wang and*, among others. It is relevant to mention that in the graph the size of the circle is proportional to the number of publications; The lines between the circles, as well as between the countries, indicate a cooperative relationship and the thickness indicates the strength of the links.

Based on the above panorama, it is possible to affirm that the contribution to the subject is being to some extent driven by mechanisms for generating new knowledge from different territorial contexts and from an international approach. This event can be reflected in the possible impact that scientific publications can have for the prevention of diseases derived from oxidative reactions of the human body that derive from interactions with unpaired molecular structures such as free radicals. Similarly, cooperation networks also reflect the support of developed countries to developing countries, which do not yet have sufficient economic and technological capital to address issues of significant impact world-

wide; At the same time, they demonstrate an exchange of information in order to improve and complement research conditions in areas of increasing importance [48-50].

Conclusions

The results obtained on the bibliographic production related to EDROSH show that the analyses carried out in this research area since 2006 have been significantly consolidated. In 2014 began an increase in publications and visibility of published scientific documents and due to the boom of 2017, it was possible to arouse the interest of researchers again. This event contributed to overcome the increase of 2014, which positioned China as the most influential territory in the generation of knowledge in this research topic. He also categorized China as a reference country in research and study of technological tools to obtain products that prevent diseases caused by oxidative stress in humans. The presence of other countries with strong influence and knowledge in this area such as the United States and Brazil can be considered as a relevant advance for the formation of knowledge networks associated with this type of research. Finally, it is clear the need to continue strengthening at the economic level and with specialized human capital for the development of science, technology and innovation activities that contribute to the development of research of this type to developing countries that are just beginning to produce information in this field of study.

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