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Keyword: volatile oils; health; prospection; intellectual property.

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Scientific and Technological Mapping in Essential Oils Therapists in Dentistry

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Abstract

Essential oils play a very important role in terms of applicability and economy, and their use in dentistry brings natural alternatives to diseases worldwide. Science needs incentives to generate knowledge and, when used in technology, it can benefit society. The aim of this study was to assess the balance between scientific and technological research. It is an exploratory and descriptive research of essential oils in dentistry, in two international databases, Scopus and Espacenet. In the results, there was an insignificant correlation between science and technology for essential oils in dentistry, even considering the period studied and the research limitation. As a conclusion, it was observed that there is a disparity between the financing for scientific and technological production.

Keywords: volatile oils; health; prospection; intellectual property.

1. Introduction

The use of essential oils is an old practice, where only copaiba oil has been used for more than 500 years in traditional folk medicine, with wide use in different applications (PIERI; MUSSI; MOREIRA, 2009). Markets such as pharmacy, cosmetics and food also seek the development of products with the greatest number of components of natural origin, especially those of vegetable origin, exploring biodiversity in a rational way, but there is little incentive from institutions to stimulate the applicability of research in technology, which can lead to a loss of commercial and economic opportunities (AMARAL; FIERRO, 2013). And speaking of economics, this is huge around the essential oils market, with a forecast of US $12 billion by the year 2023, which will lead to an expansion of applications in different areas, as happened with orange oil, whose increased use by the elderly population led to an improvement in their therapeutic applications (CRYSTAL MARKET RESEARCH, 2018).

Essential oils extracted from plants can play a relevant role and are of great interest in the world community, given the great diversity of activities with antifungal functions (Scalas et al., 2018), antispamodic activity (Makrane et al., 2019), activity antimicrobial (Helal et al., 2019), antioxidant and antibacterial effects (El Hamdaoui et al., 2018), among others, in addition to the fact that the use of natural substances can offer less risk to human health, as well as less resistance on the part of microorganisms due to their diverse nature.

In the health field, specifically dentistry, oral diseases such as periodontitis, dental caries and oral candidiasis are included in the list of the main health problems of people, in such a way that about 60% to 90% of school-age children and almost 100 % of adults have cavities, and there may be tooth loss in case of severe periodontal disease (BODIBA; SZUMAN; LALL, 2018). As for candidiasis, it is known that it is an opportunistic disease caused by fungi of the genus Candida, with several predisposing factors such as xerostomia, immunosuppression and use of dental prostheses, associated with factors such as host, parasitic load and fungal virulence. There are conventional treatments, but in recent decades, there has been a search for new antifungal agents, represented mainly by essential oils from plants (FERRÃO et al., 2020). Thus, the great need for research that can study the various forms of therapeutic applications of plants that may prove to be effective, safe and economical has its value (BODIBA; SZUMAN; LALL, 2018).

Based on the information above, the question arose as to whether there is a balance between what is researched and what is actually sought to patent, choosing the area of oral health, as it understands that health as a whole begins with the mouth, being the gateway to the organism, and the transfer of technology can play an important role in the economic development of a country. Therefore, the general objective of this research is to draw a comparative profile identifying whether the countries that are most financed for scientific production are the ones that have the most patents published in essential oils, in dentistry, from data collected in databases of publications scientific and technological, in addition to specific objectives, such as identifying quantitative data of scientific documents produced by affiliated entities in each country, profile of scientific production with support from funding entities, countries that have published scientific documents the most, international classification of patent applications and number of published patents.

2. Method

It was an exploratory and descriptive research of essential oils in dentistry, aiming to outline an overview regarding the financing of scientific production and registration of published patents, through the search in two international bases, Scopus and Espacenet. The Scopus database was chosen because it is perhaps considered one of the largest databases of abstracts and citations in peer-reviewed literature, covering several areas (ELSEVIER, 2015). The choice of the Espacenet database, on the other hand, for having a volume of around 90 million patent documents (CARVALHO; SANTOS, 2019), thus allowing a good evaluation for the desired research, but not covering all possibilities, a since there are other bases for research. It is worth mentioning that Technological Prospecting methods have been used for several decades in several countries, as a means of guiding the efforts undertaken for research, development and innovation (AMPARO; RIBEIRO; GUARIEIRO, 2012).

Thus, the Scopus database was analyzed on 2019/05/22, for scientific publications, and the Espacenet database on 2019/06/26, for published patent registrations, through the Capes Portal. The keywords chosen for the search were: ‘Essential oil *’ for Scopus, and ‘Essential oil *’ AND ‘Dental’ for Espacenet. The data were exported to the Microsoft Excel program (ID n. 00197-19045-27357-AA398) to analyze them in the form of graphs according to the research objectives. For the composition of the graphics in the Scopus database, it was necessary to perform a search of the country of origin, on the Google website, of each affiliation, financing and publication, aiming in all items to establish a quantitative by country. As for the

data on the technological part, we sought to extract from the International Patent Classification the subclass of greater quantity for filing patents, in addition to the countries that had more patents published until the date of the research. As for the statistical method, Pearson's correlation was used for the variables: most financed countries for the publication of scientific research versus countries that obtained the most published patents.

3. Results

The results obtained in this research will be presented in sequence, following the initial order for the Scopus database, where the scientific mapping was carried out, and later, for the Espacenet database (technological mapping) through patent research.

3.1 Results found in the scientific database

The Scopus database with the keyword 'essential oil *' returned 51,450 articles, 8,101 of which were open access and 43,349 from other categories, from 1825 to May 2019.

The number of scientific documents produced by the affiliated entities of each country indicates that Brazil has 5,342 publications, and Iran, 4,645, are the countries that most produce scientific documents by their affiliates. It should be noted that in the case of Brazil, the number of publications related to the theme is the result of a number of 24 Brazilian institutions, which have an average of around 223 publications. Among the 10 institutions that most produce scientific documents in the world, there are three Brazilian, one from the Southeast and two from the Northeast, namely: The University of São Paulo (USP) - 457 documents; Federal University of Sergipe - 364; and Federal University of Ceará - 362. The University of São Paulo - USP is the fourth institution that publishes the most, with the Federal University of Sergipe in 8th position, followed by the Federal University of Ceará, in 9th position.

Another result found in this research was the profile of scientific production with the support of financing entities (Figure 1), with Brazil standing out for having more than twice the amount of work financed in relation to China, and 9.5 times more than the United States. Among the five institutions that most finance in the world, according to the researched theme, there are three Brazilian women: the National Council for Scientific and Technological Development (CNPq) with 1,134 funding, the Coordination for the Improvement of Higher Education Personnel (CAPES) with 788, and the São Paulo State Research Support Foundation (FAPESP) with 236.

Figure 1 - Number of scientific papers funded by country (Greater than 100). Source: Scopus database

As for the countries that most published scientific documents in the Scopus database regarding essential oils, India, Brazil, Iran and China presented a value of publications above 4,000 documents each, with the United States as the fifth country that published the most (3,894 documents).

3.2 Results found in the technological database

The international classification of patent applications (CIP) in essential oils in dentistry that stood out in quantitative terms in the survey, carried out in the Espacenet database on 06/26/2019, was the A61K (382, in absolute terms), as expected, since it refers to preparations for medical, dental or hygienic purposes. Followed by A61P (69), which corresponds to specific use of cosmetics or similar preparations for personal hygiene, and A61Q (65), being described as specific therapeutic activity of chemical compounds or medicinal preparations. It is noticed that the sum of the classifications A61Q and A61P, give a value less than the value of half of the total of A61K.

Figure 2 shows the number of patents published internationally by countries or organizations, with 91 patents published, in a total list of 16 countries, with publication dates ranging from 1952/11/19 to 2019/04/30. China has a number of published patents related to essential oil in dentistry equivalent to almost the sum of the number of Japan, Republic of Korea, Russia and the United States combined.

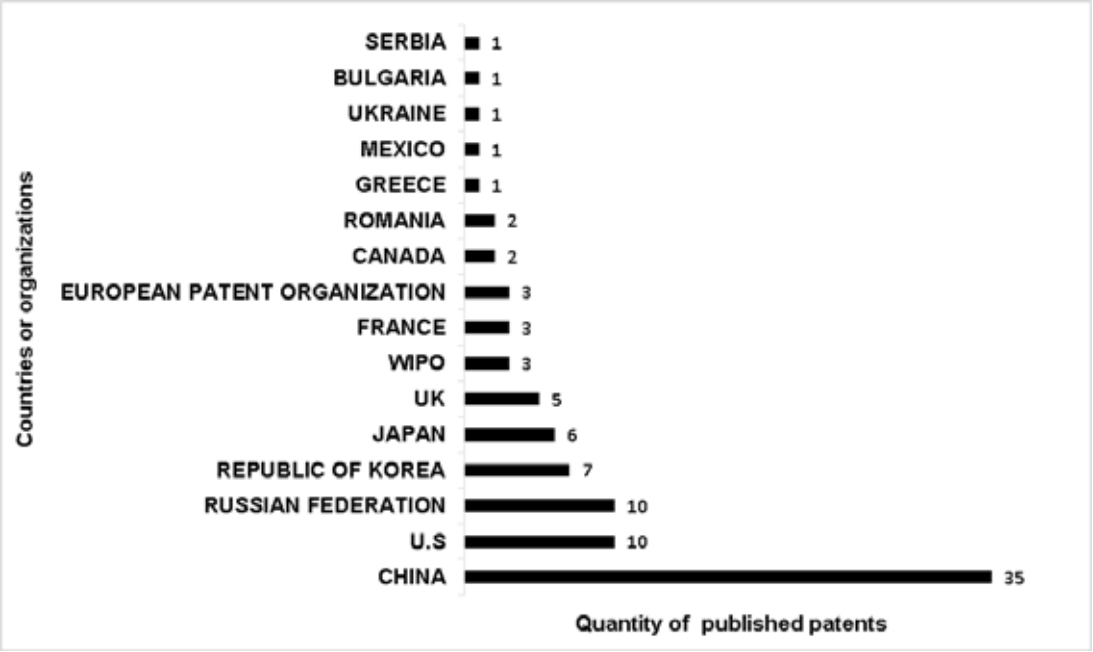

Figure 2 - Number of patents published by countries or organizations. Source: Espacenet (WIPO: World Intellectual Property Organization)

3.3 Correlation between variables

Based on the parameters presented in Mukaka (2012), an insignificant correlation was observed for the variables 'most funded countries for the publication of scientific research' and 'countries that have most published patents'. This fact was not expected since financing research requires financial resources, being, in general, public, and its transformation into technology through the registration of patents would be the apparent return of this investment to society.

4. Discussion

It was observed with this research in the Scopus database that Brazil and Iran are the countries that most produce scientific documents by their affiliates with an important participation of 3 Federal Universities in Brazil, and 2 of Iran. As for the profile of scientific production with support from financing entities, Brazil and China have presented over 1000 funded works, with emphasis on 3 Brazilian institutions: CNPq, CAPES and FAPESP. As for the countries that most published scientific documents regarding essential oils, India, Brazil, Iran and China published more than 4,000 documents each. Regarding the Espacenet database, the international classification of patent applications (CIP) in essential oils in dentistry that stood out in terms of quantity in the research was A61K, and finally, China has a larger number of patents published internationally in relation to countries like the United States and Russia, and Brazil does not appear in this list.

Based on the results of the Scopus database, some reflections were possible. One factor that may have contributed to Iran's position with this large number of publications by its affiliates is the formation of the pact of Islamic countries belonging to the Organization of Islamic Cooperation (OIC), in 2016, documented by Bagci et al. (2016), and published by Statistical, Economic and Social Research and Training Center for

Islamic Countries (SESRIC), which presents a 10-year program, aiming at sustainable development and the use of science and technology, through the incentive to research and technological capacities ensuring a conductive policy environment. In addition, the scientific academy The Royal Society (2020) states that there is current evidence of investment in education, science and innovation, with support from governments, companies, agencies. As for Brazil, which stands out in the 3 items researched about science in the Scopus database, Fazzio (2017) notes that the country had the institutionalization of academic activity later in comparison to other countries in Latin America, but it was not always so, because according to Guedes (2011), an increase in scientific production does not mean an increase in financial resources for publication. Although Fazzio (2017) highlights that even in a situation of economic crisis, investment and financing in research is important, Soares (2018) adds that due to the institutional structure of Brazil, the results of the research in it are much more academic, not specifically resulting in social and economic return. Victor (2014) identified that Brazil's position in the world ranking of scientific publications is largely due to the work of CNPq. Zago (2018) also noted that Brazil and India stood out as the largest publishers in research, although Morgantti and Del Pino (2019) note that, in the case of Brazil, the institutionalization of science and technology as a policy to encourage development depends on government priorities. Chinsembu (2016) observed some characteristics of research in the countries, emphasizing that basic research was done mainly in Brazil, Europe and Australia. This fact is corroborated by Ferreira (2014) who observed an increase in interest in essential oils, whose activities were investigated, by researchers such as Prado et al. (2018), Teles et al. (2019), Valor et al. (2018), Helal et al. (2019), who sought new treatment options that were less aggressive and safer to health. However Soares (2018) drew attention to areas such as health, which, although important for society as a quality of life factor, is not considered as important for research. It is worth mentioning the consideration of Negri (2018) for the quantitative assessment of scientific production, that the most used indicator is the number of publications in internationally indexed journals, and in the case of Brazil, an acceleration was noticed as from the 2000s. Guedes (2011) warns of the care with the number of publications that are only to show productivity, as required by graduate programs. Thus, Negri (2018) suggests another indicator of scientific production that would be the number of citations of a scientific article (impact factor), which ends up requiring articles with better qualities.

As for the results in the Espacenet database, Moura et al. (2019) in its search for patent filings in Brazil and worldwide registrations for the health area, also found predominance for the A61K area. This author points out that the assignment of the CIP code is carried out by the inventor and the patent examiner, and it must not be forgotten that there may be more than one classification associated with that invention in the same document. Negri (2018) adds that patents are very important for the protection of most innovations, especially in some industries, such as pharmaceuticals. Although Brazil does not appear on the international list of published patents, there was an increase in the number of such intellectual protection in other areas in that country, which according to Soares et al. (2016) and Negri (2018) resulting from deposits made by non-residents, and among deposits made by residents, it is worth mentioning the increase in requests from universities and research institutes. This is perhaps partly due to the creation of technological innovation centers in these institutions, resulting from the Technological Innovation Law of 2004, inspired by the US law (Bayh-Dole Law) (SILVA; VASCONCELLOS, 2018). Also according to Soares et al. (2016), this trend of a greater number of requests made by non-residents in Brazil, is also shared by other Latin American

countries, a fact that suggests that the results obtained in the patent application do not reflect the national effort to promote technological innovation. Moura et al. (2019) also observed a greater predominance of multinational companies among the largest depositors in Brazil, being associated with three areas: health, information technology and electronics. Negri (2018) pointed out that there is more balance between the distribution of patents between residents and non-residents in developed countries. One should consider the aspect related to the reading of patents, there is a more specific audience, as stated by Ouellette (2017) in his work, concluding that researchers in the areas of biotechnology and chemistry observed the reading of patents as a source of technical information more than than researchers from other areas, which demonstrates a need for improvements, including increased accessibility of patents for those who have never used this resource, as well as greater acceleration in the publication of patents, due to the delay of 18 months before publication. In addition to this aspect, it is worth mentioning that from the health research point of view, Negri (2018) also adds the great period for the development of a medication, for example, which can reach up to 10 years, between studies on the molecule, tests preclinical and clinical studies in humans. Assessing the position of the United States, which despite not being among the largest publishers of scientific articles, have published patents, authors such as Arora, Belenzon and Patacconio (2017) observed that after the Bayh-Dole Act, American universities became more engaged in the commercialization of their research, registering patents in an increasing way. This fact in relation to the laws was observed by the authors Mueller and Perucchi (2014) who stated that laws may or may not encourage the technological market. Looking now to understand the prominent position of China in relation to the number of patents published internationally, a parallel was drawn with the area of biotechnology, in which authors such as Streltsova and Linton (2018) observed that there was an increase in patent applications among the BRICS countries (Brazil, Russia, India, China and South Africa), China being the most active of the group, having as a major factor for this aspect the strong initiative that Chinese researchers receive to patent. According to these same authors, Russia experiences a lower growth, as it works with predominantly domestic patents in this area. Negri (2018) stressed that more important than patenting their technologies, is the importance of transferring and appropriating the knowledge produced by universities for society and for companies, in order to avoid the amount of patent filings that will never be technically developed. For Póvoa (2010) from the point of view of social well-being, universities should try to license their patents so as not to place an initial exclusivity, except if there are no interested parties, but the possibility of a “license for research ”, in which it can allow researchers who intend to use the knowledge protected by patents to aim to promote the advancement of scientific research. Still in this regard, the authors Mueller and Perucchi (2014), reinforced the need for the university to be an active producer of knowledge that can be patentable, although there are still challenges to be reached once the tradition is focused on scientific information. One must consider a very important factor for the health area, which would be the cost to set up a research center, because according to Negri (2018) infrastructure is an essential aspect for the development of science and technology in a country. In addition, he adds, that in the case of Brazil, this infrastructure is very concentrated in the Southeast and South regions. This fact brings an interesting aspect regarding the results of this study, because despite the inequality between the Brazilian regions, there is the Federal University of Sergipe, from the Northeast, among the 8 institutions that most presented scientific publications on the subject in question, thus recognizing its great challenge.

Finally, there is the result of the insignificant correlation between the variables science and technology, a fact corroborated by the authors Han and Magee (2018) in which they reported that although there is an increase in citations of scientific articles by patents, there is no obvious relationship between science and technology, since it is a very complex and multivariable interaction. Roczanski (2016) also highlighted that innovation results from a complex process and that it depends on other factors related to knowledge within an environment that involves science, technology, learning, production, politics and demand. Soares and collaborators (2016) sought to characterize the Brazilian innovative system in order to understand the evolution of innovation in the country, and realized the need to create mechanisms that could increase investments in research and development in the country. Silva and Vasconcellos (2018) suggest that Brazil, in addition to presenting regional disparities, of having universities considered young, in different stages of maturity, autonomy and financial resources compared to institutions in Europe and the United States, presents latent research gaps in the interaction university-industry. Negri (2018) adds that the country is in an intermediate position, both in the production or use of knowledge and new technologies, but with a minority performance in filing patents, either in the country itself or abroad. The authors Silva, Pereira and Araújo (2019) add regarding the importance of the internationalization of higher education, as a strategy used by universities in order to meet the demands of society in the current century, aiming at institutional development, as well as global projection. Authors such as Rosa and Frega (2017), through a research at a Brazilian university, found answers where most of the interviewees said that there was no appreciation of patents in the university sphere, as there are with scientific publications, and identified possible actors that could interfere in the process of technology transfer under the aspect of the Technology Transfer Offices (ETT), researchers and university, visible in table 1.

Table 1: possible stakeholders who may interfere in the process of technology transfer from the aspect of Technology Transfer Offices (TTO), researchers and University.

	Barriers	Facilitators	Motivators
ETT	· Ignorance in the drafting of patents; · Turnover of human capital; · * Lack of University-Company interaction mechanisms; · * Obstacles to international patenting.	· Competence of managers; · Search for the dissemination of the culture of intellectual property; · Outsourcing of the patent writing process.	
Researchers	· Overload of activities; · Ignorance and lack of interest in the process.	· Academic experience	· Protective awareness; · The transfer of resources for research and economic gains; · Academic prestige.

Universities	· University bureaucracy; · Lack of support and encouragement.		

Source: Adapted from Rosa and Frega (2017).

As a suggestion for improvements in some sectors, Negri (2018) adds reformulations in some areas, such as: Education, Infrastructure, Environment, Innovation in health. Silva and Vasconcellos (2018) observed that although universities are not at the center of the National Innovation Systems model, it is possible to see their greater involvement in this process. For Klofsten et al. (2019) knowledge exchange and collaboration is needed to support organizational innovation, teaching and research and local development, since universities are research-based organizations that create links that link knowledge production to its dissemination, that is, being entitled to the university's 3rd mission, which according to Castro (2011) is based on knowledge transfer. Diaconu and Dutu (2014) complement that to fulfill the third mission, it is necessary to involve in the identification and use of designed tools that can highlight the results of scientific research, as long as there is due financial support to them, in addition to employee motivation, with the intention of increasing the university's prestige in the community. Finally, Ranga and Etzkowitz (2013) pointed out that in the case of adopting an approach of the Triple Helix system (university-industry-society) to innovation, it should focus mainly on measures that can support the formation and consolidation of three areas: Knowledge, Innovation and Consensus.

5 Conclusion

As final considerations of this research, there is the scientific aspect that Brazil presents a significant number of documents published by authors linked to Brazilian institutions in the Scopus database, related to essential oils in general. The numbers are higher than those of Iran, the country that came closest to the number of scientific publications, as well as presenting a larger number of funded works, followed this time by two countries that make up the BRICS, China and India. As for the number of published scientific documents, there is a greater record for the countries: India, Brazil, Iran and China. As for the technological aspect evaluated in the Espacenet database, there was greater emphasis on patents in the A61k category. This is a result considered logical, as patents were selected that involve essential oils in dentistry. In the criterion number of patents granted, China has a higher number, a fact that can be understood by the incentive given to that country for patent registrations. It is noticed that China, in addition to producing scientific content, also does so in technology, maintaining a coherence between science and technology with a return to society. Finally, the insignificant correlation between research and technology, even considering the period studied and the limitation of research in two databases, suggests a disparity between financing scientific production and technological production. In this way, new studies with other variables and other fields of research are suggested, in order to verify the reproduction of this scenario.

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