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TECHNOLOGICAL PROSPECTING OF THE GENUS Prosopis BASED ON PATENT ANALYSIS

PROSPECÇÃO TECNOLÓGICA DO GÊNERO Prosopis POR MEIO DE ANÁLISE PATENTÁRIA

PROSPECCIÓN TECNOLÓGICA DEL GÉNERO Prosopis MEDIANTE ANÁLISIS DE PATENTES

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ABSTRACT

Plants of the genus Prosopis are recognized for their adaptability and potential in many technological applications. Widespread in subtropical and tropical regions of North and South America, North Africa, and East Asia, these plants have attracted significant attention. This article presents a study on the technological monitoring of the genus Prosopis, using patents as a source of information between 2004 and 2024. The Questel Orbit® platform was used to gather the information, applying the following keywords as search terms: “Prosopis”, “Prosopis juliflora”, and “Algaroba”. The search resulted in 74 patents, among which five species of the genus Prosopis were identified. India stood out as the country with the highest number of registered patents, totaling 34. Among the applicants, the Federal University of Campina Grande, Brazil, was the most prominent, with five patent filings. The areas with the greatest technological activity were food chemistry, basic materials chemistry, and pharmaceuticals. These data highlight the versatility and potential of Prosopis in various technological areas, emphasizing the importance of investment in research and development to further explore its applications.

KEYWORDS: Prosopis juliflora. Algaroba. Technological prospecting.

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RESUMO
As plantas do gênero *Prosopis* são reconhecidas por sua adaptabilidade e potencial em diversas aplicações tecnológicas. Amplamente distribuídas em regiões subtropicais e tropicais da América do Norte e do Sul, Norte da África e Leste Asiático, essas plantas têm atraído considerável atenção. Este artigo aborda o monitoramento tecnológico do gênero *Prosopis*, utilizando patentes como fonte de informação no período de 2004 a 2024. A plataforma Questel Orbit® foi utilizada para coletar as informações, aplicando-se as seguintes palavras-chave como termos de busca: *"Prosopis", "Prosopis juliflora"* e "algaroba*".* A busca resultou em 74 patentes, entre as quais foram identificadas cinco espécies do gênero *Prosopis.* A Índia destacou-se como o país com o maior número de patentes registradas, totalizando 34. Entre os requerentes, a Universidade Federal de Campina Grande (Brasil) foi a mais proeminente, com cinco registros. As áreas com maior domínio tecnológico foram química de alimentos, química de materiais básicos e farmacêutica. Esses dados evidenciam a versatilidade e o potencial do gênero *Prosopis* em diversas áreas tecnológicas, enfatizando a importância do investimento em pesquisa e desenvolvimento para a exploração de novas aplicações da planta.

PALAVRAS-CHAVE: *Prosopis juliflora*. Algaroba. Prospecção tecnológica.

RESUMEN
Las plantas del género Prosopis son reconocidas por su adaptabilidad y potencial en muchas aplicaciones tecnológicas. Extendidas en regiones subtropicales y tropicales de América del Norte y del Sur, África del Norte y Asia Oriental, estas plantas han atraído una atención significativa. Este artículo aborda un estudio sobre el monitoreo tecnológico del género de plantas Prosopis, utilizando patentes como fuentes de información. La plataforma Questel Orbit® se utilizó para recopilar la información, aplicando las siguientes palabras clave como términos de búsqueda: "Prosopis", "Prosopis juliflora" y "Algarroba". La búsqueda arrojó 74 patentes, entre ellas se identificaron cinco especies del género Prosopis. India se destacó como el país con el mayor número de patentes registradas, con un total de 34. Entre los solicitantes, la Universidad Federal de Campina Grande, Brasil, fue la más destacada, con 5 registros. Las áreas con mayor dominio tecnológico fueron la química de alimentos, la química de materiales básicos y la farmacéutica. Estos datos resaltan la versatilidad y el potencial que demuestra Prosopis en diversas áreas tecnológicas, enfatizando la importancia de la inversión en investigación y desarrollo para explorar más aplicaciones de la planta.

PALABRAS CLAVE: Prosopis juliflora. Algarroba. Prospección tecnológica.

INTRODUCTION

The genus *Prosopis* belongs to the family Fabaceae or Leguminosae and includes around 44 species of thorny trees and shrubs. Among the most common species are *Prosopis juliflora*, *Prosopis farcta*, *Prosopis velutina*, *Prosopis glandulosa*, *Prosopis laevigata*, *Prosopis pallida*, and *Prosopis cineraria*. It is widely distributed in subtropical and tropical regions of North and South America, North Africa, and East Asia (Sharifi-Rad *et al*., 2019). Possessing characteristics of high ecological value, this genus exhibits resistance to heat, drought, salinity, and alkalinity. Furthermore, it has the capacity to stabilize and improve soil by promoting nitrogen fixation (Mudgil, 2020). Beyond favorable environmental conditions, *Prosopis* provides a variety of benefits, such as fruits, firewood, timber, livestock feed, vegetables, construction materials and fences, medicine, and shade (Zhong

et al., 2022). Due to the usefulness of all parts of the plant, *Prosopis* is known in India as Kalpataru, meaning “wonderful tree” and “king of the desert” (Howari *et al*., 2020).

The species *P. juliflora* and *P. pallida* exhibit significantly higher performance compared to other species of the genus *Prosopis* in dry tropics (Al-Soqeer *et al*., 2023). *Prosopis juliflora* pods can be used in various ways due to their high nutrient content, with derivatives including gum and flour. In addition, *P. juliflora* seeds also exhibit high nutritional potential and bioactive activity (De Lemos *et al*., 2023). *Prosopis juliflora* pods contain 82–92% dry matter, 7–16.2% crude protein, 12.3–23.4% crude fiber, 0.4–3.5% ether extract, and 1.4–5.8% ash. Additionally, the pods are rich in calcium, magnesium, potassium, iron, and zinc, and are also rich in the amino acid lysine (Al-Soqeer *et al*., 2023).

Prosopis can also be used in traditional medicine to treat various ailments. For example, extracts from *Prosopis* leaves have demonstrated antibacterial, antihyperglycemic, antihyperlipidemic, and antioxidant properties (Zhong *et al*., 2022). Furthermore, *Prosopis juliflora* has a wide range of applications in other areas, including soil treatment (e.g., phytoremediation), polluted water treatment as a natural coagulant, and biofuel production (Saleh *et al*., 2023). In the pharmaceutical and cosmetic industries, applications of *Prosopis juliflora* are also observed, as *Prosopis* gum has potential as an emulsifier and encapsulating agent (Mudgil; Barak, 2020).

Due to its high ecological value and versatility across multiple technological applications, this genus demonstrates strong potential for further development. To understand technological progress in this field, technological prospecting stands out as an essential tool for mapping and identifying emerging trends and innovations, as it provides valuable information for prospective technological analyses (Fernandes *et al*., 2022). From this perspective, mapping is carried out through patent monitoring, which involves tracking documents that grant temporary rights to specific technological developments. Patent monitoring enables the understanding of technological context, trends, and innovation dynamics (Alves; Santos; Silva, 2018). Given the large volume of documents stored in patent databases, the use of tools to filter and analyze such data is crucial for facilitating analysis within a technological domain (Ozcan; Islam, 2017). One notable tool in this context is Questel Orbit®, an advanced patent intelligence platform offering various resources for analyzing and managing patent information. Questel Orbit® covers over 99.7% of patent filings worldwide, including the top five intellectual property offices: China, the United States, Japan, South Korea, and the European Patent Office (Chaves *et al*., 2023).

However, despite the extensive ecological, nutritional, and industrial relevance of the genus *Prosopis*, there is still a lack of systematic and comprehensive studies focused on mapping its technological development through patent analysis, particularly integrating temporal trends, geographic distribution, and application domains. This gap limits a broader understanding of innovation dynamics and the identification of emerging technological opportunities associated with this genus.

Based on the information presented, this article aims to conduct a survey of the current state of the art for plants of the *Prosopis* genus, using a systematic patent monitoring approach to examine technological developments through the Questel Orbit® platform.

METHODOLOGY

The technological prospecting of plants from the *Prosopis* genus was conducted through technological monitoring, utilizing information from patent documents. The primary search tool used was the Questel Orbit® platform, which accesses patents from various internationally renowned databases, including Espacenet, the United States Patent and Trademark Office (USPTO), the European Patent Office (EPO), the World Intellectual Property Organization (WIPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the Canadian Intellectual Property Office (CIPO), the National Institute of Industrial Property (INPI), the State Intellectual Property Office of the People's Republic of China (SIPO), and the Intellectual Property Office (IPO).

The research methodology employed to map patents in the context of *Prosopis* species involved searching using keywords and/or the International Patent Classification (IPC) as input for the *Questel Orbit*® tool. Initially, a macro analysis was performed, using keywords such as "*Prosopis*," *Prosopis juliflora*, and "algaroba." Boolean operators AND, OR, and truncation (+) were used in the search to find possible derivations in the title and abstract fields, aiming to obtain the largest number of documents between the years 2004 and 2024. This proposed time frame was chosen considering technological development over the last 20 years, during which patented knowledge typically remains protected.

The selected patent documents were read with the aim of analyzing the information according to the species of the genus, chronology, depositing countries, inventors, and technological domains. For better description and visualization, the selected documents were converted into graphs.

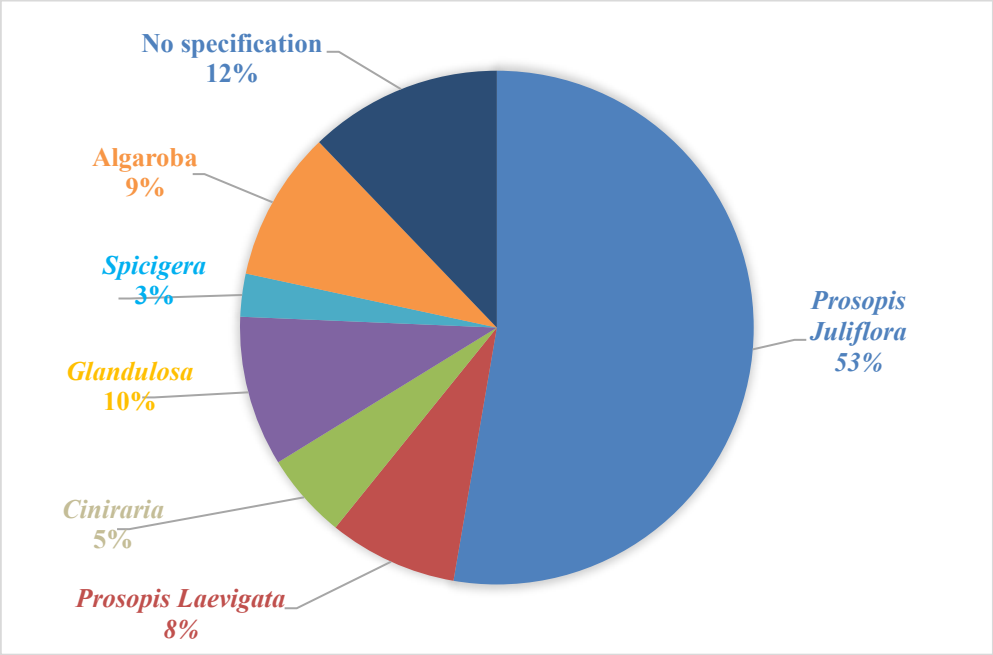
RESULTS AND DISCUSSION

Species of the genus *Prosopis*

A total of 79 patents were obtained, and after data analysis, 74 documents were selected as being of relevance to the area of interest.

The use of the key-word "*Prosopis*" allowed for the search of documents that cover all species in this genus. As a result, 62 patents were found. Among them the species *Prosopis juliflora* had the most representation, with 39 documents (53%), the species *laevigata* with 6 (8%), *cineraria* with 4 (5%), *glandulosa* with 7 (10%), *spicigera* with 2 (3%) and 9 (12%) that did not specify the species in question, only mentioning the genus "*Prosopis*", as illustrated in Figure 1.

Figure 1. Species of the genus *Prosopis*



Source: Questel Orbit® (2024).

It is important to highlight that the keyword “algaroba” was used in the search, because it is the commonplace manner of referring to the species in question. With that, 7 documents were found (9%) that contained the word “algaroba”. Due to it being a Brazilian expression, the documents found were from INPI (National Institute for Industrial Property), a federal autarchy associated with the Ministry of Economy, responsible for the management of industrial property in Brazil.

Chronological evolution

When analyzing the graph presented in Figure 2, which describes technological evolution in terms of the number of patents per year, a pattern of growth and decline over 20 years can be observed. From 2004 to 2008, the period was marked by low initial activity, not exceeding two patents per year. Notably, during this period, there was a patent describing the process of obtaining vinegar from *Prosopis juliflora* (algaroba) pods.

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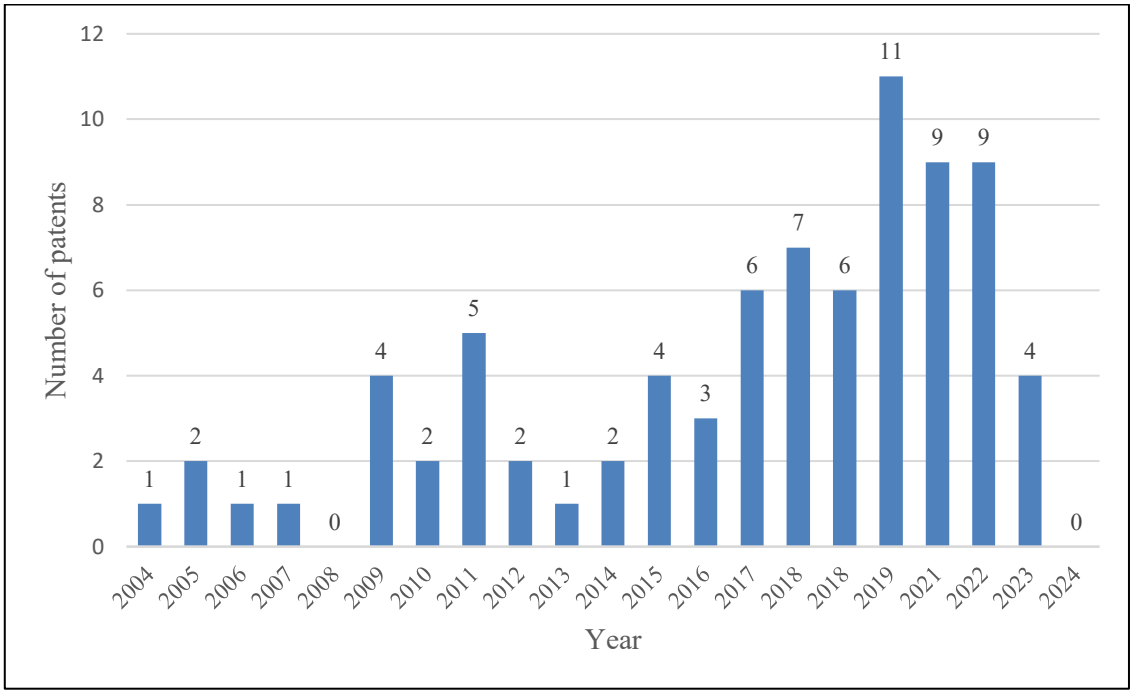
Figure 2. Evolution of technological production in the number of patents per year



Source: Questel Orbit® (2024).

From 2009 and onwards there was a gradual increase in the number of patents, followed by fluctuations until 2016. During this period we can observe the diversity in the applications of *Prosopis juliflora*, like the extraction of ethanol from its pods, demonstrating its potential for the production of biofuels. Other examples include the use of biofilters for treatment of residual water in an efficient and sustainable manner, in the production process for xanthan gum and the development of additives for animal feed looking to better its nutritional performance.

The most significant period was between 2017 and 2020, with a sharp increase in patent requests, especially in 2020, with the highest number of requests for registry (11). This growth can be attributed to a larger focus in research and development of products related to *Prosopis juliflora*. The patents registered during this period cover a wide range of fields, from food, with bovine hamburger patties and biscuits containing flour from algaroba pods, to environmental studies, with technologies for the removal and restoring of heavy metals and an activated coal filter for the treatment of industrial wastewater. Beyond that, in the field of material engineering, processes for the production of lime from the ashes of algaroba biomass and biodegradable films obtained from the processing of its pods.

From 2021 onwards there was a slight decrease, possibly attributed to the global impact of the pandemic, that reduced the available resources for innovation activities, research and development (R&D) in many sectors of the economy and research institutions (Guderian *et al*., 2020). Despite the decrease in registries, during this period the innovation surrounding *Prosopis* continued

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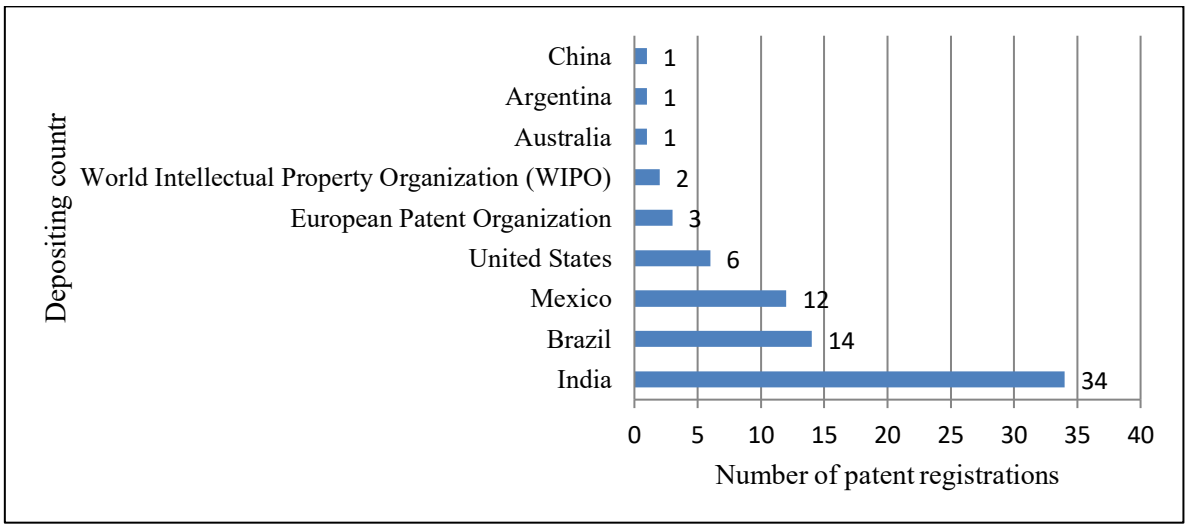
to bring promising applications to light, such as: development of a method and composition of concrete using algaroba tree stems, demonstrating the viability of more sustainable construction materials. The use of powdered algaroba bark as biological residue for the production of alternative packaging for food, promoting ecological solutions that reduce plastic waste. Furthermore, advancements in the field of medicine have also been observed, highlighted by the method for the preparation of algaroba seed extract, that acts as an antidiabetic. In the field of technology, the creation of superconductor devices utilizing porous carbon derived from algaroba. And in the cosmetics industry, in the creation of compounds for skincare.

Patent distribution by countries

Regarding the countries of origin of the patents, India stood out with 34 patents in total, as can be seen in Figure 3. The species *Prosopis juliflora* predominates in the patent records from this country. The algaroba was introduced to India in the late 19th century, initially for land reclamation and to boost the production of firewood, fodder, timber, and fiber. However, over time, this plant began to show considerable potential in various other areas, leading to a significant increase in the number of patents registered in this country (Hussain *et al*., 2020). The high number of registrations can be justified by India's significant growth in the Global Innovation Index (GII) over the past 10 years. The GII is an index published by the World Intellectual Property Organization (WIPO), an annual metric that assesses the innovation environment in different countries around the world. India advanced from 66th place in 2013 to 40th place in 2023 in the lower-middle-income group, a leap of 26 positions, representing the largest progress ever achieved by a major economy (WIPO, 2023).

Figure 3. List of Countries of Origin for Patents



Source: Questel Orbit® (2024).

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In Brazil, the predominant species is also *Prosopis juliflora*. The country ranks second in the protection of technologies related to algaroba, with 14 registrations. When analyzing Brazilian patents, it is observed that the technologies were registered in the patent database of the National Institute of Industrial Property (INPI). The country stands out for presenting innovations in various scientific fields. In the food sector, patents describe foods containing algaroba developed to increase the nutritional value of products by providing essential nutrients. In environmental science, filters made from algaroba raw material are used for water treatment. In biotechnology, algaroba is used in the integrated production process of xanthan gum from its pods. In the cosmetic field, extracts of algaroba are incorporated into cosmetic formulations.

The broad applicability of algaroba in Brazil is attributed to its abundance as a raw material, allowing for innovative and sustainable use of local resources (Gonçalves *et al*., 2021). This result is reflected in the 2023 Global Innovation Index data, which recognized Brazil for its progress in sustainable innovation and efficient use of natural resources. In 2023, Brazil advanced to the 49th position in the global ranking, reflecting significant growth in areas such as creativity and technological development, making it the most innovative economy in Latin America and the Caribbean (WIPO, 2023).

Mexico follows closely in third place with a total of 12 patent registrations. A more detailed analysis of the country's patent records revealed that the predominant species in the innovations is *Prosopis laevigata*, which is expected due to the wide distribution of this species in semi-arid and arid regions of the territory (Morales-Domínguez *et al*., 2019).

The invention patents registered in Mexico stand out mainly areas: food and nutrition, with innovations in methods for manufacturing and formulating food products; and pharmaceuticals and healthcare, with innovations focusing on the use in two *Prosopis laevigata* in different therapeutic forms, such as ethanolic extract, biofilm, and ointment, used as healing agents with antibacterial properties.

Despite the United States being among the most innovative economies in the world in 2023, as indicated by the Global Innovation Index (WIPO, 2023), only 6 patent registrations related to *Prosopis* were found. This suggests that the United States may place lower priority on research and development of technologies associated with this genus compared to other countries. Furthermore, the low number of patents in this country may be related to the removal of *Prosopis* for charcoal production and the replacement of deforested areas with pastures for livestock feed (Eschen *et al*., 2021).

Patent filings by applicants

The graph in Figure 4 describes the number of patent registrations by applicants. The Federal University of Campina Grande (UFCG) is the institution with the highest number of registrations, totaling 5 patent documents.

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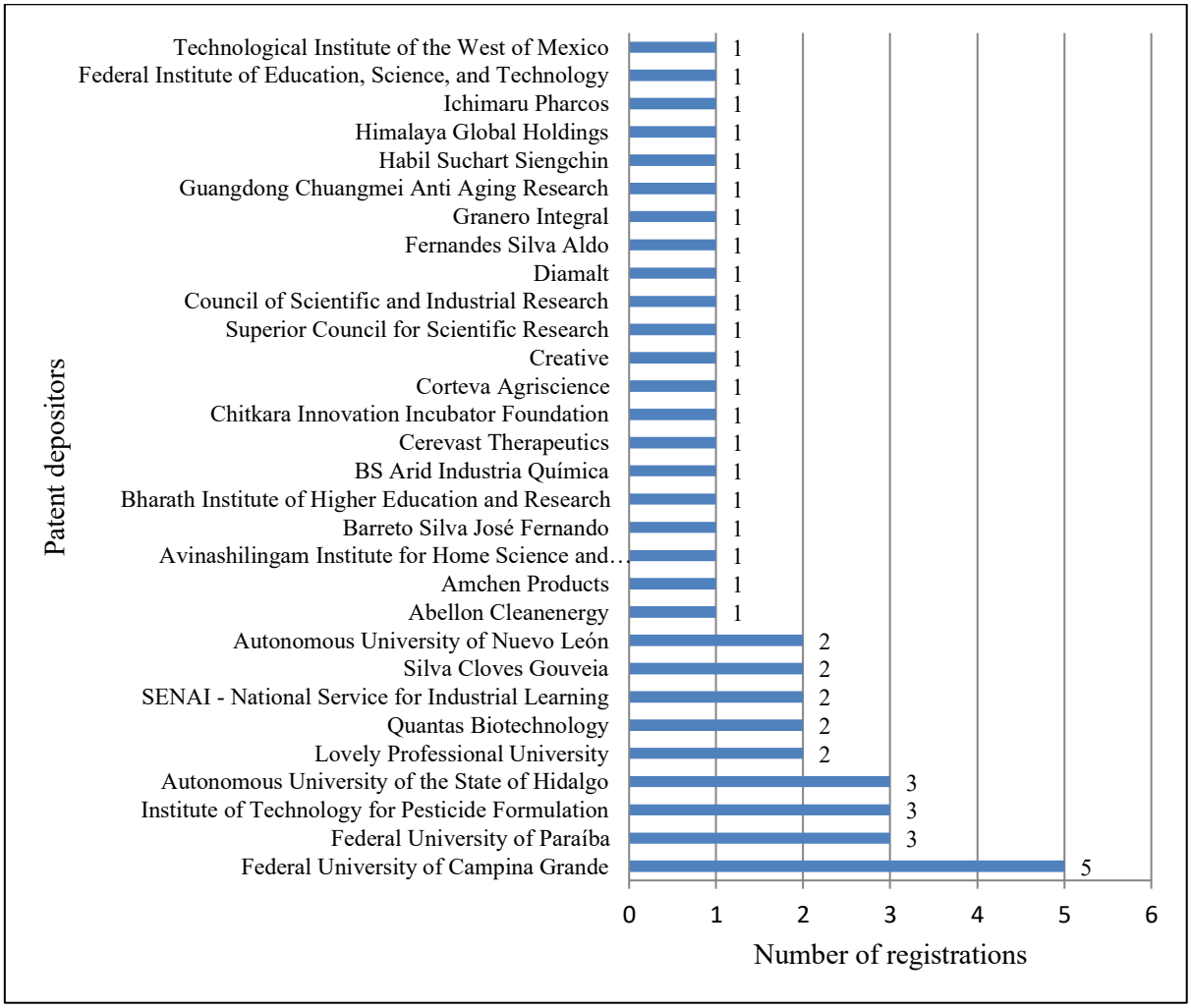
The Federal University of Paraíba (UFPB), the Pesticide Formulation Technology Institute (IPFT), and the Autonomous University of the State of Hidalgo (UAEH) each have 3 patent registrations.

It is interesting to note that two of the largest patent applicants, UFCG and UFPB, are federal higher education institutions in Brazil, located in the state of Paraíba. This highlights a significant hub of innovation and research in the region concerning the species *Prosopis juliflora*.

The Pesticide Formulation Technology Institute (IPFT), located in India, specializes in the research and development of technologies related to pesticide formulations. The institute has three patent applications describing synergistic botanical compositions for insecticides and larvicides using *Prosopis juliflora* in their formulation. The three patents from the Autonomous University of the State of Hidalgo (UAEH), located in Hidalgo state, Mexico, are related to foods with nutritional benefits.

Figure 4. Chart of Patent Registrations by Applicants



Source: Questel Orbit® (2024).

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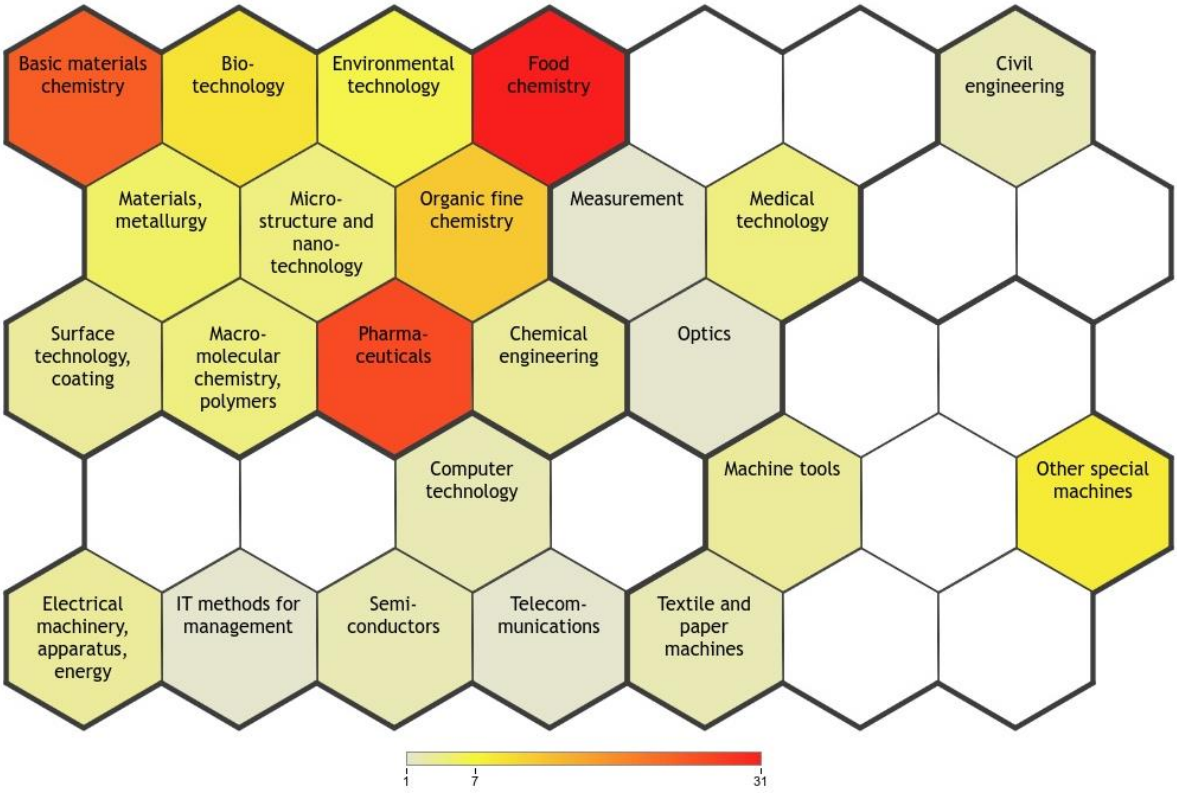
Registries of patents as they relate to fields of technology

In Figure 5 different fields of technology are presented. The goal of the graph being presented is to identify and visually demonstrate the distribution of patents across different fields of technology. The results are based on the codes of the International Patent Classification (IPC) present in a collection of patents. The codes have been grouped in 35 fields of technology, which have been represented in the graph.

Figure 5. Graph with the fields of technology



Source: Questel Orbit® (2024).

The area of study with the most citations was "food chemistry", followed by "basic material chemistry" and "pharmaceuticals". The prominence in food chemistry comes from the nutritional properties that the genus *Prosopis* presents. These properties are most prominently present in the pods, which contain essential proteins (7 to 22%), for the growth and repair of body tissue, high carbohydrate content (30 to 75%), making them a good source of energy, rich in fibers (11 to 35%), that contribute to digestive health, low fat content (1 to 6%), making it a healthy option, calcium (0,33%) and phosphorus (0,44%), fundamental for bone formation. Due to these nutrients, *Prosopis* brings lots of benefits to human and animal nutrition (Zhong *et al*., 2022).

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Additionally, through the graph shown in Figure 5, other technological domains can be observed, such as "biotechnology," "fine organic chemistry," "other special machines," and "materials, metallurgy," highlighting the diversity of technological applications that the *Prosopis* genus presents.

CONSIDERATIONS

Based on the technological mapping carried out through the analysis of patent documents related to the genus Prosopis (algaroba), 74 records were identified, covering five species: *Prosopis juliflora*, *Prosopis laevigata*, *Prosopis cineraria*, *Prosopis glandulosa*, and *Prosopis spicigera*.

A temporal variation in patent filings was observed over 20 years, with a higher concentration between 2017 and 2020. India stood out with 34 records, followed by Brazil (14) and Mexico (12). In Brazil, the state of Paraíba stands out as an innovation hub, particularly with UFCG and UFPB.

The main technological areas identified were food chemistry, basic materials chemistry, and pharmaceuticals, highlighting the versatility and potential of the genus *Prosopis* across different applications.

As limitations, the analysis was restricted to the Questel Orbit® database and the selected keywords, which may not capture all relevant technologies, in addition to the fact that not all innovations are patented.

As future perspectives, it is recommended to expand the databases, adopt broader search strategies, and integrate scientific literature to provide a more comprehensive analysis of the technological development of the genus *Prosopis*.

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