

# TECHNOLOGICAL PROSPECTION ON WAYS TO PEEL, PULP AND EXTRACT THE MAIN RAW MATERIALS FROM OIL SEEDS WITH EMPHASIS ON MACAÚBA

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## ABSTRACT

*The biofuels industry has benefited from technological innovations applied to macaúba, a palm tree native to Brazil with a high oil content in its seeds. Efficient peeling and pulping methods are crucial to optimize the production of biofuels from this raw material to increase its availability and quality. An advanced search in the database of the National Institute of Industrial Property (INPI), in the title and summary fields, referring to patents related to machinery for peeling, pulping and extracting macaúba oil and fruits was performed. The results were satisfactory because we did not find patents related to our research topic. This fact provides us with a unique opportunity to develop our own patent. Finally, it identified gaps in the Brazilian macaúba processing market, but also pointed to a promising path for future innovations in the sector.*

**KEYWORDS:** INPI; Macaúba; Patents; Innovation; Biofuels.

## I. INTRODUCTION

The technological information presented by patent documents can be considered to be one of the main industry inputs, playing a fundamental role in the world of technology and innovation. With accelerated advances in areas such as artificial intelligence (Mesquita Machado & Winter, 2023a), biotechnology (Gersten, 2005) and renewable energy (Escalante et al., 2022a), patents play an important role in ensuring the protection of pioneering ideas of knowledge in the world of technology and innovation.

However, the emergence of new technologies has also brought stimuli, such as the need to balance protecting innovations with promotion, collaboration and continuous development. Furthermore, patents in emerging sectors, such as artificial intelligence and biogenetics, have raised debates regarding the limits of patentability and ethical impacts. Within this constantly changing perspective, a balance between protection of intellectual property and technological progress is fundamental to driving innovation in a sustainable and adequate manner (Wang et al., 2023).

Patents direct and protect inventions. The National Institute of Industrial Property (INPI), according to law no. 9,279, guarantees the right to obtain a patent to the author of the invention or utility model. In addition, it guarantees ownership under the established conditions and can request non-disclosure of its appointment.

The holder has the right to control the production, commercialization and use of his creation for a determined period, generally 20 years, counting from the date of submission of the request (Geri & Pereira, 2017). The patents cover a variety of sectors, such as electrical, electronic and mechanical engineering, chemistry, instruments, consumer goods, furniture, and games, among other sectors. By promoting the public disclosure of discoveries, patents encourage collaboration, continuous research and healthy competition, while at the same time offering inventors the opportunity to reap economic benefits through the commercial exploitation of inventions in which ideas are not protected, but rather, intellectual creations in their different protection formats (De-Carli et al., 2017). Competition opens more opportunities for creating and appropriating value, and patent registrations are part of a metric and a relevant indicator to measure innovation.

In Brazil, the patent system plays an important role in promoting innovation and economic development. INPI is the body responsible for granting patents in the country. However, the patent granting process has historically been marked by challenges related to delays and bureaucracy. The long periods required for analyzing and granting patents have been criticized, and it can take several years for a patent to be effectively granted (Negri, 2018). This fact can affect the competitiveness of companies and discourage investment in research and development.

Brazil underwent reforms in the patent system with the aim of streamlining the grant and analysis process and facilitating the registration of trademarks in the country. These reforms led to the implementation of new procedures and systems and resulted in a reduction in the time required for analyzing applications and brands and the reinforcement of the INPI examiners (Alvarez et al., 2023). The agility of analysis processes and the modernization of INPI practices are key elements for strengthening the patent system in the country, and they boost technological and economic progress (National Institute of Industrial Property - INPI, 2021).

The biofuels industry linked to renewable resources has benefited from technological innovations, such as the application of methods for peeling, pulping and extraction of oil from macaúba. These techniques have proven to be crucial for optimizing the production of biofuels from this high-quality raw material (da Costa Lima Pires et al., 2023).

Macaúba is a palm tree native to Brazil, and its seeds have a high oil content, which makes it a promising source for the production of biofuels (Escalante et al., 2022b). Through efficient peeling and pulping, the seeds can be separated more quickly and economically, thereby increasing the availability of raw material for the extraction of oil.

After extracting macaúba oil, it can be transformed into biofuels, such as biodiesel, contributing as a more sustainable energy source and reducing dependence on fossil fuels. Therefore, the application of these processing practices in the production of biofuels from macaúba demonstrates the synergy between innovations in the renewable energy sector and advances in processing techniques for natural raw materials (Pydimalla et al., 2023).

Biofuel production in Brazil faces significant challenges that can be improved by implementing more efficient solutions. The country has an environment conducive to the cultivation of raw materials such as sugar cane and soybeans, which are essential for the production of ethanol and biodiesel, and the mandatory mixture of biodiesel in diesel in Brazil was 12% in the year 2023, according to Empresa Brasil de Comunicação (EBC).

Issues such as sustainable land management, optimization of conversion processes and mitigation of environmental impacts still need to be addressed (Morone et al., 2023). Investment in more advanced technologies for the cultivation, harvesting and processing of raw materials, in addition to promoting policies to encourage research and innovation, can not only improve the efficiency of biofuel production, but also reduce its potential negative impact on natural resources and contribute to the country's transition to a more sustainable and diversified energy matrix (Kurniawan et al., 2022; Moradiya & Marathe, 2023). Relevant patents in macaúba processing (peeling, pulping and oil extraction) were identified, as well as mapping by state and region, based on the Brazilian market and the database of the National Institute of Industrial Property (INPI).

## **II. MATERIAL AND METHODS**

The identification of patents was performed in the INPI national patent database. Patent records related to macaúba and machines with the potential to peel, pulp and extract the oil from the fruit were

analyzed. The diversity of fruits utilized for the same purposes and mapping of their occurrence based on the number of patent applications per region were also identified.

The advanced search in the title and abstract fields was filtered for patents that presented direct applications to fruits similar to macaúba or that were similar to the study. The keywords used were “pulper”, “peeler” and “extractor”. The inclusion of the patents found was performed by two blind reviewers (RMRA and TAM). Disagreements between reviewers regarding study selection were resolved with the assistance of a third reviewer (ASR). The second analysis of these patents found was the selection of the most relevant patents for the study in which they were chosen on the basis of the criterion of similarity to macaúba or its purposes. The following data were recorded: year of deposit, year of concession and product orders. The selected variables included the total number of applications and patents granted in the period up to 2023, the number of patents per holder(s) up to 2023 and the year of filing.

It is important to highlight the fact that patent applications are kept confidential for eighteen months because of Brazil's participation in the International Patent System and its status as a signatory to the Patent Cooperation Treaty (PCT) since 1978. This system includes 157 countries according to the World Intellectual Property Organization (WIPO, 2023). For this reason, it was decided to select dates from 2022 onwards to include patents that are already available in the database.

This period of secrecy is maintained from the patent filing date or the earliest priority, when applicable. After this interval, the patents are published in the INPI Industrial Property Magazine. The depositor can request the publication of his application to be brought forward in advance. This condition limited the acquisition of recent data for the analysis of the current scenario of technology development involving macaúba in the present work.

During searches in the INPI database related to the pulping machine, we encountered objections in the results. In the search, the keywords used had to be modified to “depulpadeira” and “depulpadora”, to better identify relevant patents. The keywords for the peeling machine remained normal.

For the extraction of oil, the Patentscope database was used as a resource, employing the keywords “extratora de óleo vegetal” and “extrator de óleo vegetal”. More precise results were later obtained regarding the machinery proposed in the search. Using the Patentscope, the patent codes were found, and they were inserted into the INPI's advanced search field to try to find the patents again. In short, this procedure was performed with the purpose of maintaining the research standardized and accurately representing the results, which were satisfactory.

### III. RESULTS AND DISCUSSION

The research conducted resulted in the identification of a total of forty-eight patents, of which ten refer to pulping machines, thirty refer to peeling devices and eight to oil extraction. However, for the purposes of detailed analysis, only those patents that demonstrated direct relevance to the study objectives were selected.

**Table 1** – Patents relevant to the study.

PULPING MACHINE				
Code	Deposit	Status	Year granted	Title
PI 0800741-1	2008	In progress	----	Pequi pulper
MU 9001546-0	2010	Granted	2017	Pulping machine
BR 20 2017 020482 6	2017	Granted	2023	Photovoltaic açai pulper
BR 20 2014 013471 4	2014	In progress	----	Tucumã pulping machine
MU 9000113-3	2010	In progress	----	Guarana pulping machine
MU 8103255-2	2001	Rejected	----	Continuous vertical pulper for açai fruit
MU 7502184-6	1995	Rejected	----	Multifruit pulping machine
PEELING MACHINE				
Códe	Deposit	Status	Year granted	Title

BR 10 2021 005934 6	2020	Granted	2021	Coconut peeling machine
BR 10 2019 018704 2	2017	In progress	----	Green coconut peeling machine
BR 10 2019 009142 8	2013	In progress	----	Green and dry coconut peeling machine
BR 20 2017 024201 9	2011	Granted	2022	Semi-automatic fruit peeling machine
BR 10 2016 022653 8	2009	Granted	2021	Automatic fruit peeling machine

## OIL EXTRACTOR

Code	Deposit	Status	Year granted	Title
MU8900412	2009	In progress	----	Equipment for the production of vegetable oil and fresh soybean meal
MU8700070	2007	In progress	----	Vegetable and animal oil and meal extractor
MU8801763	2008	In progress	----	Configuration applied to vegetable oil extruder machine
BR102016006988	2016	Granted	2023	Vegetable seed oil extraction equipment
BRPI0102089	2001	Rejected	----	Mechanical press for extracting vegetable oil
BRPI0404158	2004	Rejected	----	Manual vegetable oil extractors

Within this set of filtered and selected patents, six patents relevant to the oil extraction process were specifically identified. Five were related to macaúba peeling, and seven focused on pulping. This thorough patent analysis lead to a deeper understanding of the technological innovations present in the field of macaúba processing and revealed the predominant areas of focus and emerging trends.

Among the forty-eight patents identified, the selection of the most relevant for the purposes of the study occurred through a careful evaluation process. The key criterion was the proximity between the patented innovation and the central aspects of macaúba processing. As a result of this analysis, a set of eighteen patents, that is, 37.5% of those analyzed, were chosen for further analysis, by code, deposit, status, year of grant and title.

Another relevant point is that less than 34% of the patents were granted, some of which took up to twelve years, almost 45% of the patent processes are still in progress, some have been waiting since 2007, and finally, approximately 21% were rejected (Table 1).

According to Mesquita, Machado & Winter (2023b), the long wait for a patent in this area of technology can cause problems for the inventor. If it takes more than five years to obtain a patent, the technology may already be outdated when the patent is finally granted. The average waiting period for patents granted in the study was approximately seven and a half years. Thus, incentives and ideals for accelerating and maintaining concession times need to be analyzed and adapted to this new global scenario.

### 3.1 Pulping machine

There are no more current patent applications for pulping machines (Figure 1); that is, relevant patents can be developed and applied in this area, which is one of the objectives for the work. The relevant machines selected were the pequi pulper, pulping machine, photovoltaic açai pulper, tucumã pulping machine, guarana pulping machine, continuous vertical pulper for açai fruit, and the multifruit pulping machine (Table 1). Thus, the most relevant fruits were açai, pequi, tucumã and guaraná. The one that most closely resembles macaúba is tucumã. Despite being very similar fruits, they are very different species and are obtained from different regions.

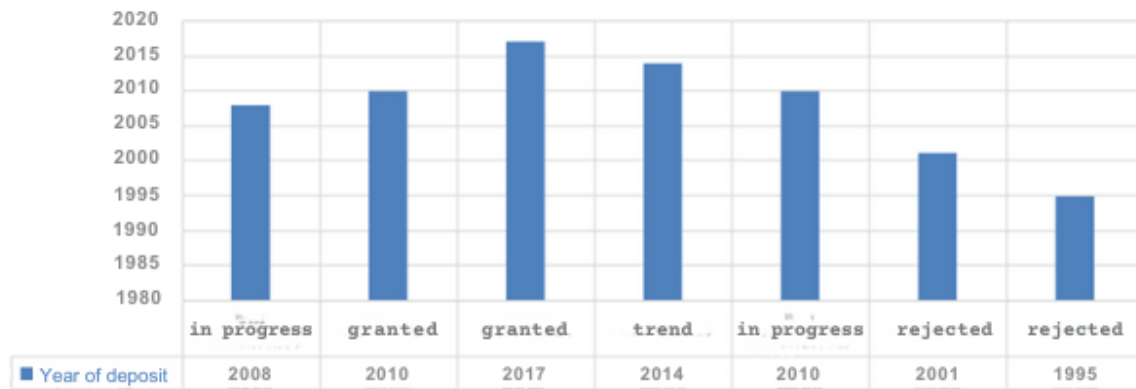


Figure 1 – Year of patent for pulping machines.

Only two of the patents were granted, one in 2017 and the other in 2023. Two were rejected and three are in progress. Those processes in progress were filed in 2008 and 2010 and have still not received a favorable opinion (Table 1). Regarding the region, more than 86% of the relevant patents were from the north of Brazil, two in Amazonas and Pará and one in Amapá and Tocantins, with only one in São Paulo, whereas no patent application for the topic in question came from Minas Gerais.

### 3.2 Peeling machine

The keyword used in the search at INPI was “peeler”, and the nonexistence of current patent applications for this type of machine was verified. This result is similar to that obtained in the search for pulper machines. That is, in this field, the searches were detailed where, of the thirty patents found, only five were relevant to the study, less than 16%. Consequently, the lowest frequency of use among the three machines was observed.

The following relevant machines were selected: coconut peeling machine; green coconut peeling machine, green and dry coconut peeling machine, semi-automatic fruit peeling machine, and automatic fruit peeling machine (Table 1). Among these options, the most significant fruit was the coconut. However, it is important to note that the coconut is not similar to macaúba because these fruits belong to different species and regions, which highlights their differences. However, the selected machines can bring very important ideas for the development of a patent similar to that for the macaúba, mainly due to the fact that nothing directly associated with the fruit of the study was found. Furthermore, three of the five patents were actually granted in 2021 and 2022, some of which took ten years to be accepted. Two patents are in the analysis process, one from 2013 and the other from 2017, and of those selected for the study, none have been rejected so far (Figure 2).

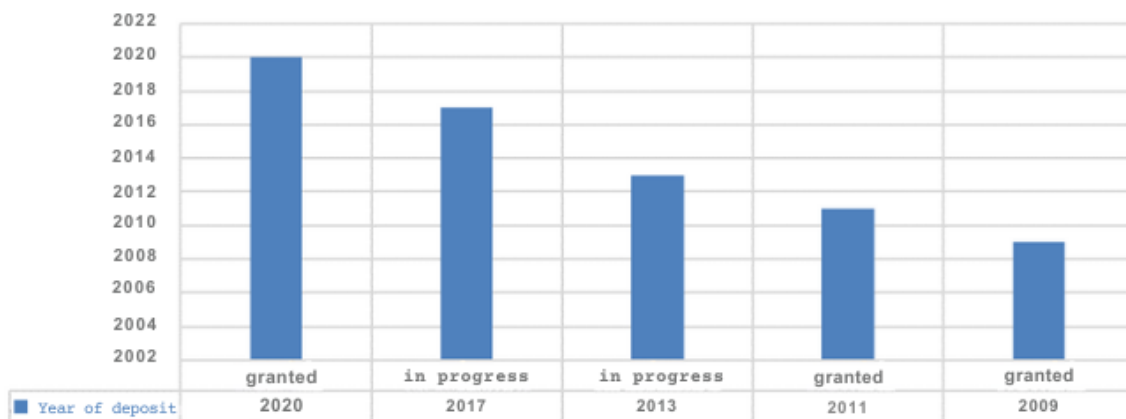


Figure 2 – Year of patent for the peeling machines.

In regional terms, 40% of the relevant patents are concentrated in the Southeast region, in the state of São Paulo and in the Northeast in the states of Ceará and Rio Grande do Norte, each with one patent. Interestingly, only one patent is registered in Rio Grande do Sul, whereas no patent applications related to the topic under analysis were submitted in Minas Gerais.

### 3.3 Oil extractor

The absence of recent patent applications for this specific type of machine was noted. This gap suggests that an opportunity to develop and implement relevant patents in this area exists. This fact aligns with one of the central objectives of the work. Of the eight patents found, six were relevant, totaling 75% of the patents.

The following relevant machines were chosen: equipment for the production of vegetable oil and fresh soybean meal, vegetable and animal oil and bran extractor, configuration applied to vegetable oil extruder machine, vegetable seed oil extraction equipment, vegetable oil extracting mechanical press, and manual vegetable oil extractor (Table 1).

Within these alternatives, soy stood out as the most relevant product. However, It should be understood that, even if there is no similarity with macaúba, the purpose is the same for both products. The selected machines can offer valuable insights for the development of a patent more closely related to macaúba. This fact is especially significant, given that no information was found related to the fruit that is the objective of this work, highlighting the importance of creating it.

It should be noted that only one of the patents was actually granted, being filed in 2016 and only granted in 2023, a delay of seven years. Two patents were rejected, and three are currently in the evaluation process. The three patents under evaluation were deposited long ago, in 2008, 2009 and 2010, and to date, they have not received a positive verdict (Figure 3).

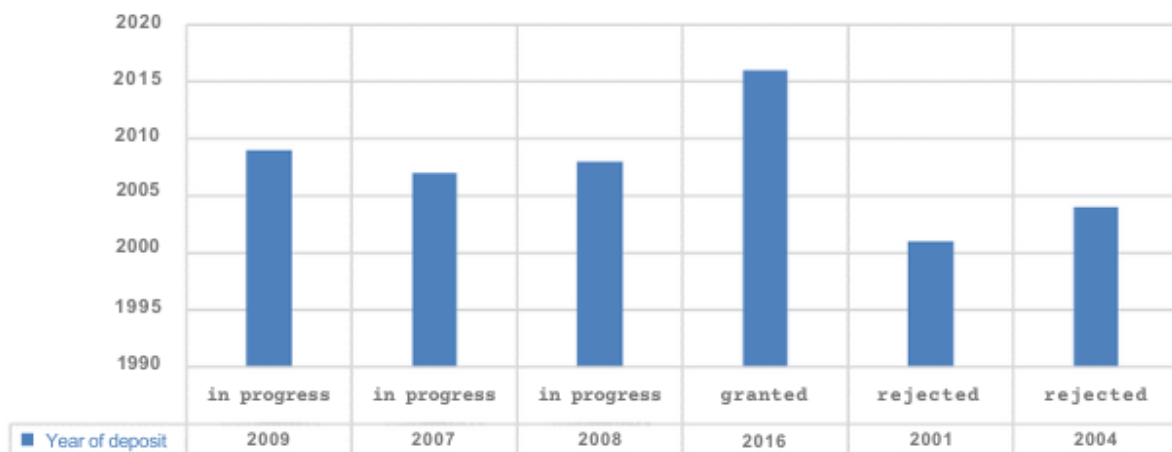


Figure 3 – Year of oil extractor patent.

### 3.4 Geographical diversification with regard to oil extraction.

Of the relevant patents, 50% were concentrated in the Southern region, with two patents in Rio Grande do Sul and one in Paraná. Only one patent was found in Amazonas, whereas the state of Minas Gerais still had no patent applications related to the topic under analysis. Finally, one patent was produced by each of the states of Maranhão and Ceará (Figure 4).

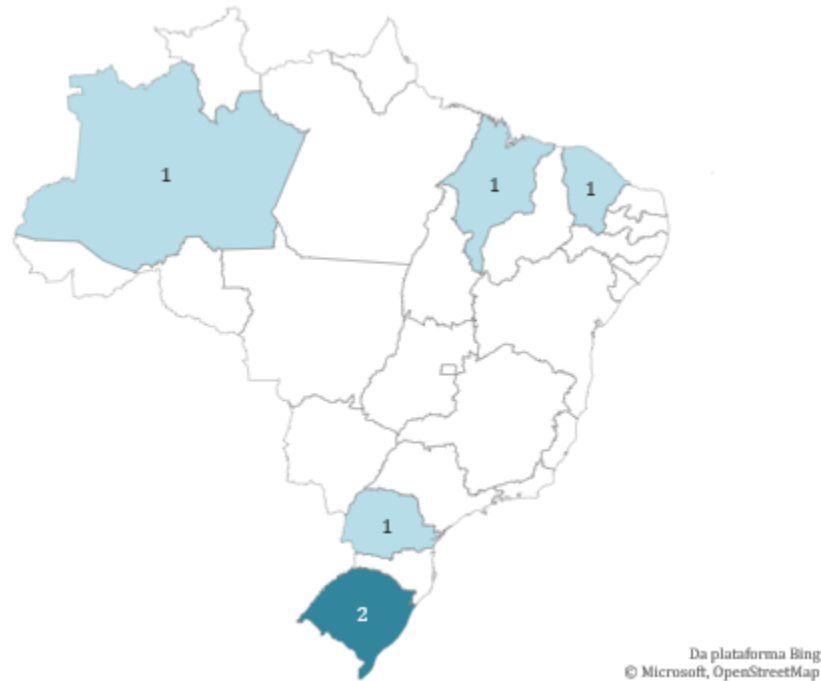


Figure 4 - Number of patent applications for the oil extractor by region.

### 3.5 General comparison

Finally, the region in which the three main types of relevant machines predominated was the North of the country. Almost 40% of the patents found were registered in this area, with the Amazon contributing more than 42% of this total. In the South, the state of Rio Grande do Sul stood out, being responsible for 75% of the patent applications in this region. In the Southeast, the state of São Paulo was the only one in which patent applications were submitted. In contrast, Minas Gerais did not register any applications, which drew attention to possible opportunities for developing new records and searches for innovation and technology related to macaúba. Finally, the Northeast closed with more than 22% of the ideas relevant to the study.

After a comprehensive analysis, it was found that, to date, no relevant patents related to macaúba have been registered in the INPI system. Given this gap, the significant prospect of exploring the formulation of innovative concepts and the search for new equipment designed to serve both small and medium-sized producers emerges. This prospect is a very important initiative, especially in terms of enhancing the value of the products sold. The proposal is not just to sell products in their raw state, but to offer a variety of enriched products with greater value, as has already been done in other countries, as Charles Aworh (2015) has already mentioned.

A concrete example of this fact is the commercialization of oil extracted from macaúba mesocarp for the production of biodiesel, combined with the use of the solid portion for the production of animal feed. This approach demonstrates the potential for creating a more complete and sustainable production cycle, contributing to the maximization of economic benefits and the effective use of each macaúba component (Dias et al., 2021; Evaristo et al., 2016; Tilahun et al., 2020; Trentini et al., 2017).

## IV. CONCLUSION

No recent patents related to the research topic were found. This lack of patents provides a unique opportunity to develop a patent based on the gaps identified in macaúba processing, especially in peeling, pulping and oil extraction. Looking to the future, there is a vast field of possibilities to explore, which can direct efforts towards research and development of new technologies and methods to optimize these processes, seeking to increase efficiency and reduce costs. Furthermore, considering the mapping of patents by state and region, there is room for strategic collaborations with local and

regional institutions, taking advantage of resources and knowledge specific to each area. Finally, this article not only identified gaps in the Brazilian macaúba processing market, but also suggested a promising path for future innovations and strategic partnerships that can further drive the development of this sector.

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## REFERENCES

- [1]. Alvarez, L. de O., Filgueiras, R., & Angeli, R. (2023). Desafios na Identificação de Patentes em Domínio Público no Brasil. *Cadernos de Prospecção*, 16(4), 1292–1308. <https://doi.org/10.9771/CP.V16I4.50485>
- [2]. Charles Aworh, O. (2015). Promoting food security and enhancing Nigeria's small farmers' income through value-added processing of lesser-known and under-utilized indigenous fruits and vegetables. *Food Research International*, 76(P4), 986–991. <https://doi.org/10.1016/j.foodres.2015.06.003>
- [3]. da Costa Lima Pires, P., da Silva César, A., Cardoso, A. N., Favaro, S. P., & Conejero, M. A. (2023). Strategies to improve the competitiveness of an agroindustrial system for a macauba based oil production in Minas Gerais State, Brazil. *Land Use Policy*, 126, 106552. <https://doi.org/10.1016/J.LANDUSEPOL.2023.106552>
- [4]. De-Carli, E., Segatto, A. P., Alves, F. S., & Kuribara, F. M. (2017). Characterization on the patents deposits from Brazil's Public Research Institutes from 2004 to 2013. *RAI Revista de Administração e Inovação*, 14(2), 168–177. <https://doi.org/10.1016/j.rai.2017.03.008>
- [5]. Dias, E. F., Hauschild, L., Moreira, V. E., Caetano, R. P., Veira, A. M., Lopes, M. S., Guimarães, S. E. F., Bastiaansen, J., & Campos, P. H. R. F. (2021). Macauba (*Acrocomia aculeata*) pulp meal as alternative raw material for growing-pigs. *Livestock Science*, 252. <https://doi.org/10.1016/j.livsci.2021.104675>
- [6]. Escalante, E. S. R., Ramos, L. S., Rodriguez Coronado, C. J., & de Carvalho Júnior, J. A. (2022a). Evaluation of the potential feedstock for biojet fuel production: Focus in the Brazilian context. In *Renewable and Sustainable Energy Reviews* (Vol. 153). Elsevier Ltd. <https://doi.org/10.1016/j.rser.2021.111716>
- [7]. Escalante, E. S. R., Ramos, L. S., Rodriguez Coronado, C. J., & de Carvalho Júnior, J. A. (2022b). Evaluation of the potential feedstock for biojet fuel production: Focus in the Brazilian context. In *Renewable and Sustainable Energy Reviews* (Vol. 153). Elsevier Ltd. <https://doi.org/10.1016/j.rser.2021.111716>
- [8]. Evaristo, A. B., Grossi, J. A. S., Pimentel, L. D., de Melo Goulart, S., Martins, A. D., dos Santos, V. L., & Motoike, S. (2016). Harvest and post-harvest conditions influencing macauba (*Acrocomia aculeata*) oil quality attributes. *Industrial Crops and Products*, 85, 63–73. <https://doi.org/10.1016/j.indcrop.2016.02.052>
- [9]. Geri, L., & Pereira, L. (2017). *PATENTES: incentivo ou barreira à inovação?* 274–286. <https://doi.org/10.7198/s2318-3403201700080029>
- [10]. Gersten, D. M. (2005). *The Quest for Market Exclusivity in Biotechnology: Navigating the Patent Minefield*. <https://www.sciencedirect.com/science/article/pii/S1545534306701043>
- [11]. Instituto Nacional da Propriedade Industrial - INPI. (2021). *Indicadores de Propriedade Industrial 2020*.
- [12]. Kurniawan, S. B., Ahmad, A., Imron, M. F., Abdullah, S. R. S., Othman, A. R., & Hasan, H. A. (2022). Potential of microalgae cultivation using nutrient-rich wastewater and harvesting performance by biocoagulants/bioflocculants: Mechanism, multi-conversion of biomass into valuable products, and future challenges. In *Journal of Cleaner Production* (Vol. 365). Elsevier Ltd. <https://doi.org/10.1016/j.jclepro.2022.132806>
- [13]. Mesquita Machado, T., & Winter, E. (2023a). Artificial intelligence and patents in Brazil: Overview on patentability and comparative study on patent filings. *World Patent Information*, 72. <https://doi.org/10.1016/j.wpi.2023.102177>



- [14]. Mesquita Machado, T., & Winter, E. (2023b). Artificial intelligence and patents in Brazil: Overview on patentability and comparative study on patent filings. *World Patent Information*, 72, 102177. <https://doi.org/10.1016/J.WPI.2023.102177>
- [15]. Moradiya, K. K., & Marathe, K. V. (2023). Life cycle assessment (LCA) of marine microalgae cultivation and harvesting process for the Indian context. *Sustainable Energy Technologies and Assessments*, 56. <https://doi.org/10.1016/j.seta.2023.103063>
- [16]. Morone, P., Cottoni, L., & Giudice, F. (2023). Biofuels: Technology, economics, and policy issues. *Handbook of Biofuels Production*, 55–92. <https://doi.org/10.1016/B978-0-323-91193-1.00012-3>
- [17]. Negri, F. (2018). *Novos caminhos para a inovação no Brasil* (Vol. 1).
- [18]. Pydimalla, M., Husaini, S., Kadire, A., & Kumar Verma, R. (2023). Sustainable biodiesel: A comprehensive review on feedstock, production methods, applications, challenges and opportunities. *Materials Today: Proceedings*. <https://doi.org/10.1016/J.MATPR.2023.03.593>
- [19]. Tilahun, W. W., Saraiva Grossi, J. A., & Favaro, S. P. (2020). Mesocarp oil quality of macauba palm fruit improved by gamma irradiation in storage. *Radiation Physics and Chemistry*, 168. <https://doi.org/10.1016/j.radphyschem.2019.108575>
- [20]. Trentini, C. P., Santos, K. A., Antonio da Silva, E., Garcia, V. A. dos S., Cardozo-Filho, L., & da Silva, C. (2017). Oil extraction from macauba pulp using compressed propane. *Journal of Supercritical Fluids*, 126, 72–78. <https://doi.org/10.1016/j.supflu.2017.02.018>
- [21]. Wang, M., Yan, H., Ciabuschi, F., & Su, C. (2023). Facilitator or inhibitor? The effect of host-country intellectual property rights protection on China's technology-driven acquisitions. *International Business Review*. <https://doi.org/10.1016/j.ibusrev.2023.102165>
- [22]. WIPO. (2023). *O PCT conta agora com 157 Estados Contratantes*. [https://www.wipo.int/pct/pt/pct\\_contracting\\_states.html](https://www.wipo.int/pct/pt/pct_contracting_states.html)