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Perspectives for application of jabuticaba and its residues

Perspectivas para aplicação da jabuticaba e seus resíduos

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Native tropical fruits have received increasing prominence for being rich sources of bioactive compounds that can add value to industrial processing, in the agricultural sector, and biological and chemical studies. Accordingly, jabuticaba is Brazilian tropical fruit with high growth in the market, with great potential for application in sectors that use anthocyanins and phenolic compounds at some stage of processing. This scenario's perception motivated the development of the present bibliometric study to collect and analyze data extracted from the Scopus platform on the use of jabuticaba and its residues in different applications. The papers were evaluated for annual publication profile, geographical distribution, keywords, research subject areas, most productive journals and authors, most cited papers, and hot issues on selected literature. Among the articles analyzed, Brazil led the ranking of documents registered on the theme, whose growth outlook is optimistic for the coming years, especially with the knowledge of the jabuticaba tree's cultivation and needs. Keywords analysis confirmed the potentiality of the jabuticaba due to its phenolic compounds, opening space for discussion of its benefits in the areas of Agricultural and Biological Sciences; Chemistry; Biochemistry, Genetics and Molecular Biology, as well as Medicine and Nursing.
Keywords: jabuticaba, bioactive compounds, bibliometrics.

As frutas tropicais nativas têm recebido destaque cada vez maior por serem ricas fontes de compostos bioativos que podem agregar valor ao processamento industrial, no setor agrícola, e aos estudos biológicos e químicos. Nesse sentido, a jabuticaba é uma fruta tropical brasileira com alto crescimento no mercado, com grande potencial de aplicação em setores que utilizam antocianinas e compostos fenólicos em alguma etapa do processamento. A percepção desse cenário motivou o desenvolvimento do presente estudo bibliométrico para coletar e analisar dados extraídos da plataforma Scopus sobre o uso da jabuticaba e seus resíduos em diferentes aplicações. Os artigos foram avaliados quanto ao perfil de publicação anual, distribuição geográfica, palavras-chave, áreas temáticas de pesquisa, periódicos e autores mais produtivos, artigos mais citados e questões importantes na literatura selecionada. Entre os artigos analisados, o Brasil liderou o ranking dos documentos registrados sobre o tema, cujas perspectivas de crescimento são otimistas para os próximos anos, principalmente com o conhecimento do cultivo e das necessidades da jabuticabeira. A análise das palavras-chave confirmou a potencialidade da jabuticaba devido aos seus compostos fenólicos, abrindo espaço para discussão de seus benefícios nas áreas de Ciências Agrárias e Biológicas; Química; Bioquímica, Genética e Biologia Molecular, bem como Medicina e Enfermagem.
Palavras-chave: jabuticaba, compostos bioativos, bibliometria.

1. INTRODUCTION

Jabuticaba is a small tropical fruit, native to the Brazilian Atlantic Rainforest, grown on a large scale in Brazil's south and southeast regions. The fruit has approximately three centimeters in diameter, whose peel varies between shades of purple and black while its inner part is a white pulp with a sweet taste due to the high sugar content [1-3]. According to the literature, jabuticaba has nine different species belonging to the family Myrtaceae [4]. The best-known species are *Plinia Cauliflora* (DC) Berg, a synonym of "*Myrciaria cauliflora*", and usually called jabuticaba-paulista or jabuticaba-açu; *Plinia jaboticaba* (Vell), popularly known as jabuticaba-sabará; and *Plinia trunciflora* (Berg), called jabuticaba-de-cabinho [5]. The genus *Plinia* resulted from a proposal to change the term *Myrciaria* that designated this class previously [6, 7]. That is why it is expected that related studies did not follow a specific nomenclature pattern since the terms *Plinia* and *Myrciaria* are recurrent in the literature.

In the industrial food sector, jabuticaba is used as an ingredient in producing fermented beverages, liqueurs, or pre-gelatinized flours [8]. Unfortunately, the jabuticaba's peel and seed are not yet used in industrial processing, even though these fractions represent 40-50% of the fresh fruit weight [9]. Several studies point to jabuticaba residues' potential as rich sources of bioactive compounds, such as ellagic acid, anthocyanins, and quercetin [10, 11]. These compounds are responsible for the fruit great functional activity, which allows a wide range of applications in the food industry, as already exposed, in addition to the pharmaceutical Silva et al. (2014) [12]; Wu et al. (2013) [13] and cosmetics industries [14]. This type of use reduces food waste, generates capital, and represents an important and sustainable initiative for environmental preservation [15, 16].

Jabuticaba peel has been researched for a series of new productions. For instance, Asquieri et al. (2009) [17] produced a jabuticaba brandy from its peel and sludge. Da Silva et al. (2010) [18] showed that jabuticaba peels act as good natural pigmentation sources, representing a viable alternative to obtaining dyes. Santos and Cunha (2019) [19] developed a gellan gel (containing jabuticaba peel) that can act as anthocyanin carriers. Di Maio et al. (2019) [20] senriched cow's milk with phenolic compounds extracted from jabuticaba peel, corroborating with the increase in the gallic acid content and the antioxidant capacity of milk.

Taking into account the large volume of studies related to the use of different fractions of jabuticaba, the present work developed a bibliometric review focused on quantifying and analyzing data extracted from scientific articles published on Scopus from 2014 to 2019. Bibliometry allows the investigation and guidance of studies, providing vital information regarding possible patterns and trends that may benefit future research on a given subject [21-23]. This method was also used as a statistic tool to collect production indexes to evaluate the published works. Currently, bibliometric studies on jabuticaba and its residues are practically nonexistent in the literature, reinforcing the present investigation's importance. As it is a type of fruit rich in bioactive compounds that can benefit multiple industrial applications, the analysis presented in the following sections favors and expands the scope of both studies developed and future investigations on this specific theme.

2. MATERIALS AND METHODS

In order to select the scientific research on jabuticaba utilization and the application of its residues (peel, seeds, and bagasse) on different types of processing, a bibliometric analysis was carried out in the Scopus database, the most extensive base of peer-reviewed scientific literature. This search was performed in January 2020 and the following query was used: (TITLE-ABS-KEY ((jab?ticaba* OR myrciaria OR cauliflora OR plinia OR trunciflora OR "Brazilian Grape")) AND ALL ((waste* OR residue* OR bagasse* OR skin* OR seed* OR peel* OR leaf* OR pulp* OR draff* OR grain*))). This set was restricted to 2014 to 2019 and for research articles only, thus excluding book chapters, reviews, and conference papers. The strategy in using scientific and popular names aimed to increase the probability that all nomenclatures and synonyms would be included in the search.

The documents found were read in full and passed through a screening process to select only those that fit the proposed theme correctly. Data on annual publication, affiliation, author, keywords, subject areas, most productive journals, and most cited papers have been collected for further analyses. After the initial filtering procedures, the VOSViewer® software was used to construct the bibliometric maps. Journal-level metrics such as CiteScore, SCImago Journal Rank (SJR), Source Normalized Impact per Paper (SNIP), and Impact Factor (IF, Clarivate Analytics) were used for evaluation purposes.

3. RESULTS AND DISCUSSION

3.1 General trends: publications and languages

Figure 1 shows the trends of studies involving the use of jabuticaba from 2014 to 2019. Initially, 403 research articles were found, but after a thorough content analysis, 138 articles were selected. Regarding the number of publications, the results indicated an increasing frequency distribution, except in 2017, when there was a decrease in published articles (12) in relation to the previous year. Nevertheless, there was significant growth in studies in 2018 (36), representing an increase of 57.14% over the sum of the past years. As also observed in 2019, this growth is expected to continue in the coming years since jabuticaba is considered a high potential raw material, capable of being used in several technological fields. That is why it is essential to expand the investigations involving the different parts of this particular fruit and its extracts [24, 25]. Regarding the languages used, English was the predominant one (90.07%), followed by Portuguese (8.23%) and Spanish (1.7%).

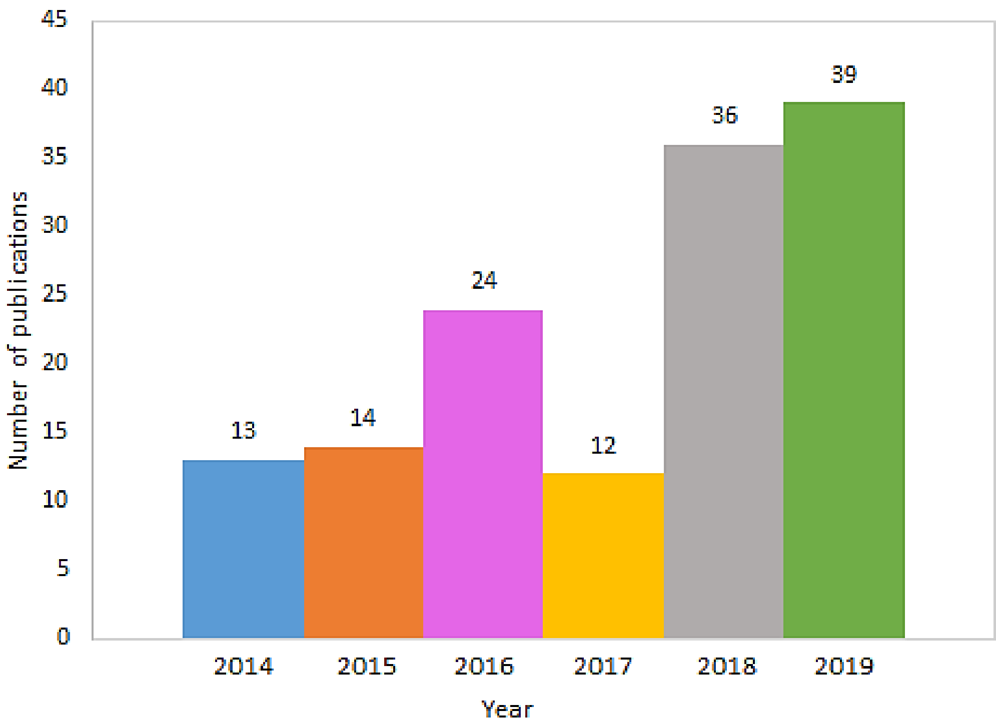

Figure 1: Number of papers published on the Scopus database between 2014 and 2019 involving the use of jabuticaba and its residues on different perspectives.

3.2 Distribution of publications by country

The choropleth map in Figure 2 expresses the geographic distribution of publications on the jabuticaba's use. Brazil was the most productive country (131), and for this reason, its color is more intense, followed by Spain (5), Portugal (3), Taiwan (3), and United States (3). What draws attention is that Brazil alone presents 94.93% of total publications, which can be easily associated with the Brazilian origin of jabuticaba, whose expansion of cultivation to other countries was limited for a long time [26]. This explains the Brazilian interest in developing studies to address the potential and applications of this fruit. As reported by the Company Warehouse and General Warehouses of São Paulo [in Portuguese: Companhia de Entrepostos e Armazéns Gerais de São Paulo], jabuticaba was the 74th most traded product in Brazilian warehouses in 2017. That same year, there was a milestone in jabuticaba trade between Brazilian cities with the sale of 2,459.91 tons [27].

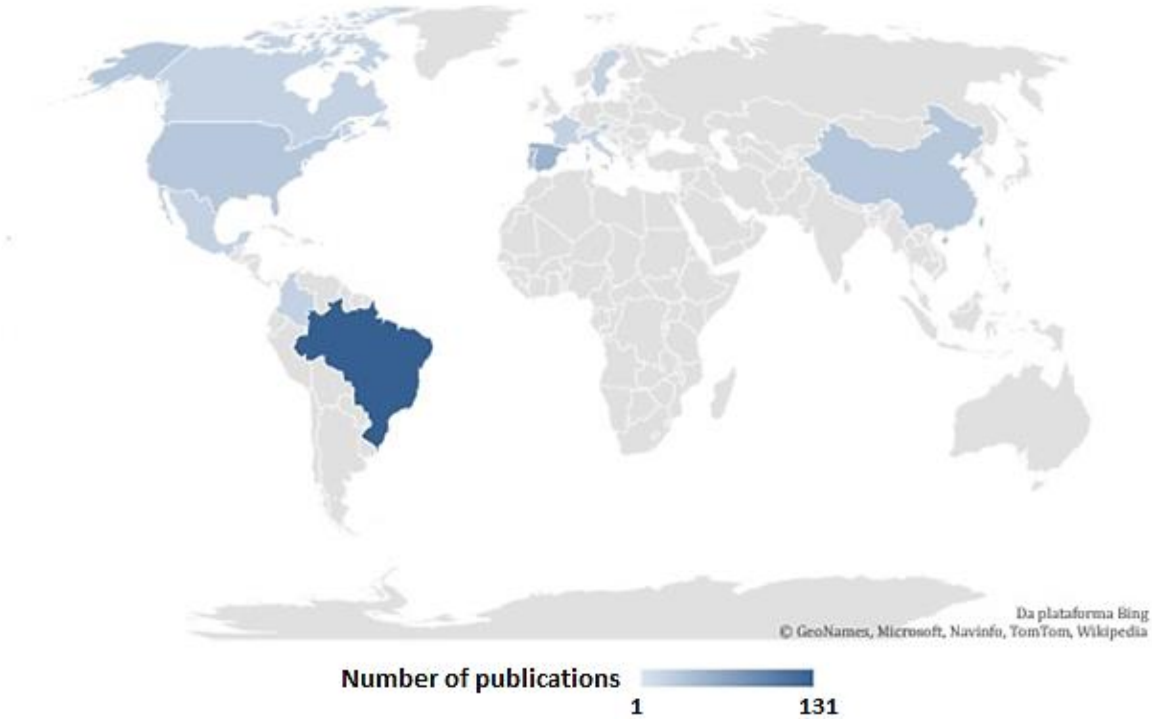

Figure 2: Geographical distribution of published articles on the jabuticaba research.

The first cultivation tests outside their country of origin began in North America, more specifically in the USA, with production also in Central America and other South American countries, such as Bolivia, Paraguay, and Argentina [28, 29]. However, despite being already exported to different countries, factors such as climate, soil, and forms of cultivation still influence the harvest's final productivity, corroborating the reduced number of works developed in other countries.

3.3 Keyword analysis

For the co-occurrence analysis, the VOSViewer® software extracted 1753 keywords. The author keywords and the keywords indexed by the Scopus database corresponded to 468 and 1458, respectively. In this perspective, the knowledge of the most frequently used author keywords serves as an indicator to point the main trends and research topics on the rise within the scientific community [30]. In order to structure the data collected, the singular and plural forms of inflection were associated and related to its direct synonyms to avoid repetition of words with the same meaning. Figure 3 shows the most used author keywords and the existing relations between them.

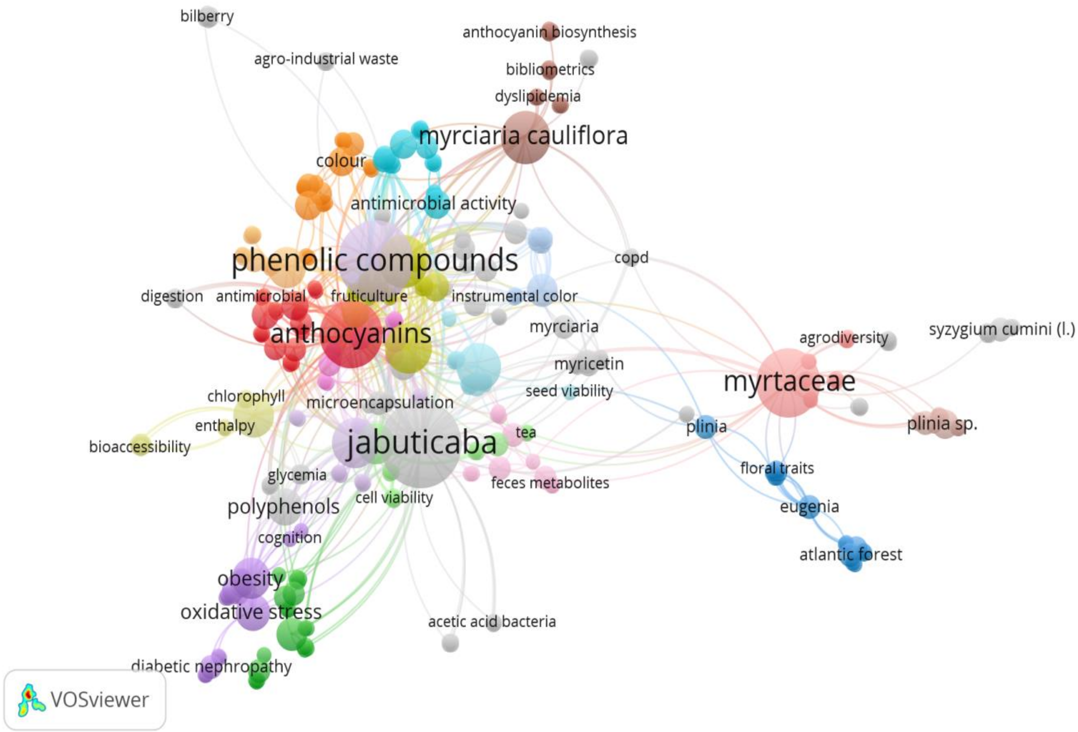

Figure 3: Author keywords co-occurrence network.

Knowing that bigger node sizes and edge thicknesses are indicative of higher occurrences and stronger connections, respectively, “jabuticaba" (27) was the most frequently used keyword, followed by "phenolic compounds" (23) and “Myrtaceae” (17). While “jabuticaba” is justly the object of interest of the present study, even appearing in the chosen search query, “phenolic compounds” refers to the chemical structure of a group of bioactive compounds present in the fruit. On the other hand, “Myrtaceae” is jabuticaba’s plant family. The keyword “anthocyanins”, a phenolic secondary metabolite found in the fruit mentioned above, had 16 occurrences, whereas “Myrciaria cauliflora" own 10 occurrences. According to the literature, *Myrciaria cauliflora* is the most abundant species cultivated in Brazilian territory Gomes (1983) [31]; Wu et al. (2013) [13], explaining why this term appeared more times than those that represent other jabuticaba species.

Besides presenting the bigger node sizes due to the higher occurrence, the keywords "jabuticaba" and "phenolic compounds" also had the strongest interconnection. This justifies the higher number of research regarding the characterization and use of phenolic compounds found in the jabuticaba for application in different productive sectors [9, 10, 32, 33]. In addition, there was also observed a strong interconnection between “anthocyanins” and the two leading author keywords. This behavior is explained by studies carried out on the multiple benefits of this substance, which has the high antioxidant capacity and pharmacological properties, such as improvement of the human intestinal microbiota, inhibition of tumor cell proliferation, and prevention of cardiovascular diseases [34, 35].

Among the keywords indexed by the Scopus database, “Myrtaceae” (43) had the highest occurrence on documents, followed by “fruits” (41) and “antioxidants” (35). Comparing these keywords with those presented by the authors, the only one in common was “Myrtaceae”. This situation is repeated by considering all keywords since the most frequent terms were "Myrtaceae", “fruits", and “antioxidants” with 52, 44, and 42 documents registered, consecutively. Thus, it is clear that there is no direct dependency between these three keyword categories since, even though some terms have been repeated, the frequencies of use were different.

3.4 Research subject areas

The Scopus database classified the research papers in different subject areas, and those with at least four publications are exhibited in Fig. 4. The most productive research area was Agricultural and Biological Sciences (46%), while Chemistry and Biochemistry, Genetics and Molecular Biology shared the second position (12% each). Due to the multifunctionality of the bioactive compounds present in the jabuticaba, a wide range of subject areas was found. Such compounds refer to polyphenols, a broad class of antioxidants capable of acting against free radicals and responsible for jabuticaba's diverse physicochemical characteristics [36, 37]. For example, in the industrial food sector, pulps and residues' functional properties confer essential nutritional characteristics to processed products [8].

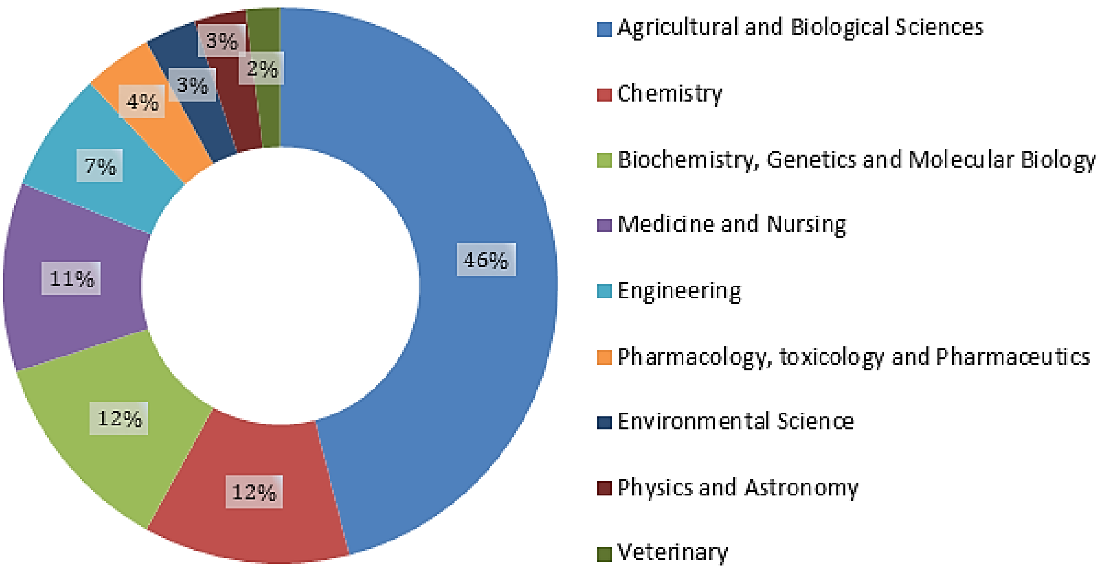

Figure 4: Subject areas categorized by the Scopus database in publications on jabuticaba.

3.5 Most productive journals

Table 1 describes the most productive journals on the current theme. The values of CiteScore, SJR, and SNIP indexes, from the Scopus database and the IF, from Web of Science, were also presented. All the metrics are from 2019. Most documents were published by Food Chemistry (9; 6.52%), whereas the second and third positions were occupied by Food Research International (8; 5.80%) and Food Science and Technology (7; 5.07%), respectively. Besides presenting the more expressive number of citations (187) and IF (6.306), Food Chemistry also had the highest values of CiteScore (10.7), SJR (1.775), and SNIP (2.37). It is interesting to analyze a journal performance by different metrics and not only by its impact factor, which makes no correction for the self-citation problem or distinguishes citation distribution curves. This can be exemplified by comparing the journals ranked sixth and seventh in Table 1. Although both published three documents, the Journal of Agricultural and Food Chemistry, even with an IF slightly lower, presented much fewer citations than LWT – Food Science and Technologies (23 against 60), a difference of more than 60%. Furthermore, all other metrics referring to the Journal of Agricultural and Food Chemistry showed higher values.

Table 1: Top 10 most productive journals and their associated metrics ranked by number of publications.

	Journals	NP	NC	CiteScore	SJR	SNIP	IF
1	Food Chemistry	9	187	10.7	1.775	2.370	6.306
2	Food Research International	8	102	6.2	1.440	1.661	4.972
3	Food Science and Technology	7	10	1.9	0.455	0.911	0.455
4	Revista Brasileira de Fruticultura	6	7	0.9	0.397	0.695	–
5	Journal of Functional Foods	5	171	5.9	0.998	1.235	3.701
6	Lwt – Food Science and Technology	3	60	6.4	1.313	1.642	4.006
7	Journal of Agricultural and Food Chemistry	3	23	6.1	1.086	1.388	4.192
8	Ciência e Agrotecnologia	3	6	2.1	0.376	1.051	1.098*
9	Natural Product Research	3	4	3.3	0.463	1.198	2.158
10	Fruits	3	2	1.6	0.264	0.751	–

*NP: number of publications; NC: number of citations; *IF from 2018.*

Lastly, the contribution of different research areas, as exhibited in Figure 4, is strongly reinforced by the journals pointed in Table 1. They covered since food engineering, plant bioactives, probiotics, and vitamins until chemistry and biochemistry of foods. This interdisciplinary is a reflection of jabuticaba's multifunctionality, a propitious scenario for multiple applications.

3.6 Collaborations between authors

Authors with the most significant productive indexes, who collaborated, at least, with one citation at Scopus, are shown in Fig. 5. Altogether, 626 authors were identified, but 81.63% of scientists registered only one document. This means that the history of articles published in sequence by different researchers is low, signaling research, albeit promising, in its initial phase. M.R Maróstica-Júnior (h-index of 28) was the most productive author, contributing to 11 papers on jabuticaba and its residues. The second and third positions belong to A.D. Corrêa (h-index of 15) and C.B.B. Cazarin (h-index of 16), who published seven and six articles, respectively. Although Agricultural and Biological Sciences was the primary publication area of all these authors, their Scopus profile exhibited at least five other subject areas listed in Fig. 4. This comprehensive professional profile can put them in a better place in the future for developing interdisciplinary research, which is considered more challenging than those studies focused on one discipline [38]. Another fact that the first three most prolific scientists have in common is their Brazilian affiliation, which was already discussed (see section 3.2).

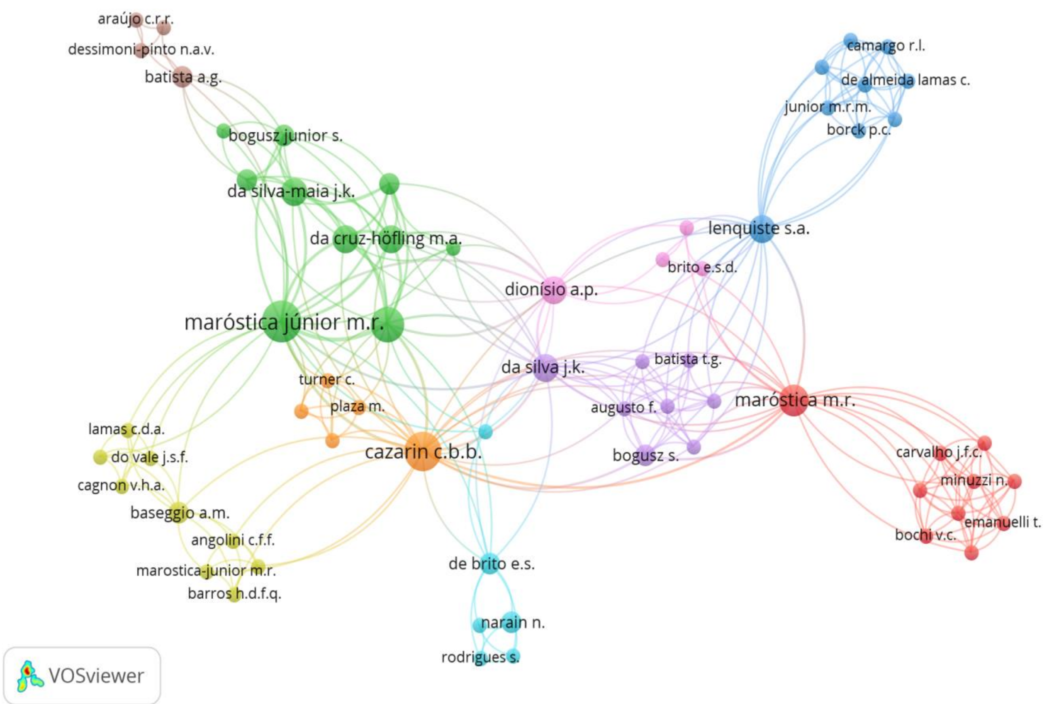

Figure 5: Collaboration map among the most productive authors.

3.7 Highly cited papers

The ten most cited papers on jabuticaba utilization were detailed in Table 2. Between 2014 and 2019, the citations ranged from 33 to 76. Of the ten papers listed, three were published in journals that did not appear in Table 1, even though this table brought the top ten most productive journals. This was the case of Industrial Crops and Products, Meat Science, and Journal of Dairy Science. This could be because citation rates are influenced by many factors, differing from one research area to another. Scientific journals with a broader scope tend to be more cited than those more specialized or with applied subject areas [39].

Table 2: Top 10 highly cited papers on jabuticaba research in Scopus database.

	Title	TC	Journal	Year
1	Screening of the chemical composition and occurring antioxidants in jabuticaba (*Myrciaria jaboticaba*) and jussara (*Euterpe edulis*) fruits and their fractions [8]	76	Journal of Functional Foods	2015
2	Ultrasound extraction of phenolics and anthocyanins from jabuticaba peel [40]	59	Industrial Crops and Products	2015
3	Characterization of antioxidant polyphenols from *Myrciaria jaboticaba* peel and their effects on glucose metabolism and antioxidant status: A pilot clinical study [41]	54	Food Chemistry	2016
4	Intake of jaboticaba peel attenuates oxidative stress in tissues and reduces circulating saturated lipids of rats with high-fat diet-induced obesity [42]	52	Journal of Functional Foods	2014
5	Use of the jabuticaba (*Myrciaria cauliflora*) depulping residue toproduce a natural pigment powder with functional properties [12]	45	LWT- Food Science and Technology	2014
6	Oxidative stress in probiotic Petit Suisse: Is the jabuticaba skin extract a potential option? [43]	36	Food Research International	2016
7	Evaluation of non-thermal effects of electricity on anthocyanin degradation during ohmic heating of jaboticaba (*Myrciaria cauliflora*) juice [44]	36	Food Chemistry	2015
8	Effect of jabuticaba peel extract on lipid oxidation, microbial stability and sensory properties of Bologna-type sausages during refrigerated storage [45]	35	Meat Science	2015
9	Microencapsulated jabuticaba (*Myrciaria cauliflora*) extract added to fresh sausage as natural dye with antioxidant and antimicrobial activity [46]	34	Meat Science	2016
10	Effect of incorporation of antioxidants on the chemical, rheological, and sensory properties of probiotic petit suisse cheese [47]	33	Journal of Dairy Science	2016

TC: total of citations.

Although an advanced examination of the main trends is carried out in the next section, a more direct analysis has been done to provide a general idea of what these articles have covered. The most cited paper, "Screening of the chemical composition and occurring antioxidants in jabuticaba (*Myrciaria jaboticaba*) and jussara (*Euterpe edulis*) fruits and their fractions" (76), was written by Inada and collaborators and published in the Journal of Functional Foods in 2015 [8]. The authors determined the bioactive compounds and the chemical composition of different jabuticaba fractions, such as pulp, peel, seeds, and depulping residues, identifying eleven phenolic compounds, as vitamin C, Fe, Mn, and Cu. Generally, the works were developed using jabuticaba residues but with a different focus, such as extraction of anthocyanins and phenolic compounds, exploring medicinal properties, and using natural pigments for its functional properties. Cited 59 times, Rodrigues and collaborators evaluated an ultrasound-assisted method to extract bioactive compounds from the jabuticaba peel. The yields achieved were said superior to others, confirming a residue rich in anthocyanins and ellagic and gallic acids [44]. The third position in the ranking, with 54 citations, is the single-blind placebo-controlled crossover research conducted by Plaza and collaborators [45]. The authors evaluated the role of polyphenols in contributing to the jabuticaba peel's antioxidant capacity, which showed significant amounts of anthocyanins, ellagic acid, and flavonol derivatives. All these works are a sample of jabuticaba relevance concerning its bioactive compounds, reinforcing its multifunctionality and serving as an incentive for initiatives to add value to the residues.

3.8 Hot issues on selected literature

The 138 selected publications portrayed different processing approaches for jabuticaba and its residues. Fig. 4 showed the research areas with the highest numbers of registered documents on the theme, and, based on this classification, some hot issues were discussed in the following sections.

3.8.1 Agricultural and Biological Sciences

Jabuticaba residues have attracted significant attention in the pharmaceutical sector due to its composition rich in various phenolic compounds, such as anthocyanins, flavonoids, tannins, and phenolic acids. Diverse studies have attested to its antibacterial functions, according to the papers published by [33, 48]. The authors showed that jabuticaba extracts have good antibacterial activity, with the ability to inhibit the growth of Staphylococcus aureus, a bacterium that causes several human diseases. Hacke et al. (2016) [49] showed that the crude extract of jabuticaba seed (partially purified) exhibited a high antioxidant and antimicrobial potential for gram-positive and gram-negative bacteria. The extracts were rich in ellagitannins and ellagic acid, compounds belonging to the tannins and polyphenols class, respectively, and probably responsible for the seeds' antioxidant and antimicrobial activities. Other phenolic extracts of jabuticaba, mainly the ethanolic extract, also showed high potential in bacterial inhibition during the wound healing process [33]. In addition to proven antibacterial action, studies are attesting to the jabuticaba antifungal benefits [50, 51].

In the food sector, Baldin et al. (2016) [46] used microencapsulated jabuticaba extract (MJE) as a natural dye, with antioxidant and antimicrobial activity, for fresh pork sausage. The results obtained proved the proposal's effectiveness since, at 2% MJE, a decline in the lipid oxidation of the sausage was observed during 15 days of storage, reducing microorganisms over 1 log CFU. In contrast, for Bologna sausages, the addition of jabuticaba peel extract did not positively affect microbial stability during storage [45]. Further investigations are still necessary to make possible this replacement, given the great fruit’s potential. Jabuticaba’s use can serve as a strategy to reduce the amount of money spent with cochineal carmine, a type of pigment with several food applications, but at a high cost, which is why it is today is usually replaced by synthetic alternatives.

In agriculture, Oliveira et al. (2019) [52] described the formation and development of reproductive buds in jabuticaba, given the scarcity of knowledge about the agronomic characteristics associated with its cultivation. The authors concluded that the jabuticaba bark acts as a protective layer, facilitating the shoots' reproductive survival. Considering that jabuticaba is not available throughout the year, mainly due to its short harvest time, the presented study can become a useful tool to transform this scenario, increasing the availability of the fruit and expanding its application potential.

In correlation, the literature confirms that the accumulation and distribution of nutrients in the jabuticaba seedlings are more concentrated in the leaves than in the stem and root. The concentration of micronutrients, such as iron, manganese, and zinc, and macronutrients, such as nitrogen, sodium, and potassium, varies from one species to another and directly influences the reproductive plant's quality [53]. Therefore, knowing the distribution of such elements helps correct nutritional deficiencies during the plant's development, providing adequate fertilization and increasing crop productivity. Becker et al. (2015) [54] evaluated five different maturation stages of jabuticaba cultivated in the southeastern region of Brazil, observing a series of changes over time: decrease in fruit firmness, increase in both the intensity of the color of the skin and the activity of the soluble pectin and associated polygalacturonase. To determine the fruit's physicochemical characteristics can help producers and investors improve its conservation since jabuticaba is known for its rapid post-harvest deterioration.

3.8.2 Chemistry

The articles belonging to the current sample focused on applications benefited by the bioactive compounds found in jabuticaba. Morales et al. (2016) [55] demonstrated that fruit pomace is rich in bioactive compounds with high potential to act as ingredients in food manufacturing for humans and animals. Paludo et al. (2019) [10] studied the action of bark and seed extracted from jabuticaba for the deactivation of reactive oxygen species (ROS) and reactive nitrogen species (RNS), whose imbalance may be related to diabetes, cancer, cardiovascular diseases, neurodegenerative diseases, and liver diseases. The intake of exogenous antioxidants helps to prevent these diseases, that is why jabuticaba can be used to enrich pharmaceutical, cosmetic, and food products. Zhao et al. (2019) [56] showed that some of the jabuticaba's compounds could perform anti-inflammatory activities or even treat lung diseases. Accordingly, the main bioactive compounds identified for promoting these applications refer to anthocyanins, phenolic and polyphenolic compounds, vitamin C, and tannins [12, 57].

The use of jabuticaba has become increasingly promising to add nutritional value to food and beverages. In this sense, Böger et al. (2019) [58] showed that the concentrations of jabuticaba extract in ice cream production enable increased phenolic compounds' rates and their associated antioxidant capacity. For Rocha et al. (2019) [59] whey protein beverages containing concentrated phenolic extract have a large amount of anthocyanins (especially cyanidin-3-O-glucoside and delphinidin-3-O-glucoside) that help in the product's natural coloring. In addition to whey, fermented jabuticaba beverages are considered functional and have high antioxidant potential when associated with vasorelaxation capacity Sá et al. (2014) [60]; Dias et al. (2016) [61] produced vinegar from jabuticaba and identified seventeen different compounds, which stand out aldehydes, higher alcohols, acetate, and ethyl ester acids. The authors concluded that the organic acids and volatile compounds identified were responsible for adding functional value and aroma to the vinegar.

3.8.3 Biochemistry, Genetics and Molecular Biology

Different researchers have studied the chemical and biological characteristics of jabuticaba and its derivatives. Lemos et al. (2019) [62] state that the fruit pulp used in the production of traditional sweets has high acidity, low pH, and the presence of pigments that fight free radicals Santos and Cunha (2019) [19] used the crude extract of jabuticaba as a photosensitizer in antimicrobial photodynamic therapy. The plant's mechanism of action was the production of singlet oxygen, and as no microbes can resist this compound, jabuticaba was considered an excellent alternative treatment resource. On the other hand, the jabuticaba shell flour inserted in biscuits' production promoted a better sensory acceptance and increased the associated energy value [16]. The production of jabuticaba peel powder proved to be a natural dye potential. It may even replace synthetic dyes due to its large amount of bioactive substances, carotenoids, and sugars [63]. Besides, science has reported the production and chemical characterization of jabuticaba peel tea, which showed high anti-radical capacity and bioactive sources, signaling a successful extraction of the fruit's functional substances [64].

3.8.4 Medicine and Nursing

Laboratory tests applied to animals have been developed to evaluate the functions performed by extracts of jabuticaba and associated residues. Batista et al. (2017) [65]; Nogueira-Lima et al. (2019) [66] showed that the insertion of jabuticaba bark in the rats' diet prevented body weight gain, reduced peripheral insulin resistance, and protected them against metabolic disorders. Using the same waste, Silva-Maia et al. (2019) [67] conducted a randomized study in rats and found out that ingestion of the jabuticaba's infusion was associated with a reduction in the severity of experimental colitis, with enough potential to be used as an additional treatment in inflammatory bowel diseases. The benefits achieved were attributed to the fruit's anti-inflammatory action and its ability to inhibit oxidative stress. Such a biological condition consists of an imbalance between circulating antioxidants and an overproduction of ROS – unstable and very reactive molecules that can transform other molecules when colliding with them. In humans, oxidative stress can be linked to cardiovascular disease, diabetes, Parkinson's and Alzheimer's diseases.

In addition to the peel, other jabuticaba's parts were used in studies published by the scientific community, such as hydroalcoholic extract, whose potential effects refer to the attenuation of renal and cardiac hypertrophies, prevention of hemodynamic and functional changes, and promotion of improvements in vascular responses [68-70]. In correlation, total fruit extracts can act as a hypoglycemic and antioxidant agent in type 2 diabetic mice Hsu et al. (2016) [71], and seed extracts showed protective action against micronuclei when induced in combination with cyclophosphamide [72]. Finally, the aqueous extracts of seeds and leaves of jabuticaba showed anticoagulant and antiplatelet activity, being favorable against oral cancer cells [73, 74].

4. CONCLUSION

The bibliometric study carried out on the search platform Scopus in the period between 2014 and 2019 showed an increasing trend of research on the use of jabuticaba and its residues in recent years, mainly in applications concentrated in the area of Agricultural and Biological Sciences. The 138 articles analyzed revealed that Brazil occupy a dominant position in the research, with a percentage of 94.93% of the registered documents presenting some authorship with Brazilian affiliation. Such expressiveness can be observed by analyzing the ten most cited articles on jabuticaba since they had at least one Brazilian author's participation. This is linked both to the fruit's Brazilian origin and to the significant relevance associated with its use. On the other hand, Food Chemistry was the journal with the most influential trends within the theme, presenting the largest number of published articles and the best journal-level metrics, followed by Food Research International and Food Science and Technology.

Although the Agricultural and Biological sciences being the most significant thematic area in terms of volume of publication, the presence of bioactive compounds and their high antioxidant capacity have put jabuticaba and its residues in a promising position in the fields of medicine and nursing. The literature highlights a series of potential benefits for human health: inhibition of antibacterial activity, prevention of cardiovascular and neurological diseases, control of diabetes, and anti-inflammatory potential. Despite this, in order to add value to the residues of jabuticaba broadly and sustainably, it is necessary to carry out more in-depth investigations on other applications of the fruit and the development of new technologies because of its functional and nutritional potentials. Meanwhile, the presented bibliometrics supports researchers concerning the main trends and the agents involved, categorizing the published works. Other tools can also be applied in the future to improve the accuracy of bibliometric analyzes.

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