



## Research and development on jaboticaba (*Myrciaria Cauliflora*): overview on academic research and patents

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### Abstract

*Myrciaria Cauliflora*, popularly known as jaboticaba, is a Brazilian native fruit, rich in antioxidants, such as anthocyanins, flavonoids and tannins. In the wake of its properties, the jaboticaba is the study object of current paper which verifies worldwide research and technological development on the fruit. Data on academic research were retrieved from the following databases: Web of Science (WoS), Scopus and Scientific Electronic Library Online (SciELO) and the patents were retrieved from Instituto Nacional de Propriedade Industrial (INPI), European Patent Office (ESPACENET), Derwent World Patents Index (DWPI) and Patentoscope. Studies on the jaboticaba have been frequently developed in recent years and are concentrated in areas of agriculture and food science and technology. Further, there is a gap between scientific research and technological development, albeit complementary.

**Keywords:** *Myrciaria cauliflora*; research; trends; bibliometrics; technology.

**Practical Application:** Study on the academic research and technological developments of jaboticaba through articles and patents in order to forecast and analyze the trends involving this fruit.

## 1 Introduction

Several exotic fruits, native to Brazil, are largely unexplored although they are potential sources for the production of new products (Peixoto et al., 2016). Jaboticaba (*Myrciaria cauliflora*), also tagged Brazilian grape, jabotica, sabará, is a non-climateric, highly perishable fruit (Morales et al., 2016). This fruit is native to Brazil and may be found throughout the country, especially in the southeastern region (Alves, 2011). Argentina, Uruguay and Paraguay (Trevizani et al., 2011) are also home to *Myrciaria cauliflora*.

The fruit has several color tones, ranging between purple and black, due to the great amount of anthocyanin contents in the peel that covers the fruit's pulp (Veggi et al., 2011). The jaboticaba has a pleasant taste and is a source of phenolic compounds, such as flavonoids, tannins and phenolic acids (Pereira et al., 2016).

Although the jaboticaba is normally consumed *in natura*, the fruit is also used by the fruit industry for the production of juice, candies, jellies and liquors (Lima et al., 2008). Most phenolic compounds, with antioxidant properties, may be found in the peel. They are capable of complexing free radicals and prevent oxidation reactions caused by free radicals, impairing or delaying lipid oxidation in food (Almeida et al., 2015).

The compounds in the jaboticaba have other biological activities, with anti-inflammatory, anti-diabetic, anti-obesity

properties, besides a capacity to combat chronic obstructive lung disease (Wu et al., 2013). Other qualities of the jaboticaba peel comprise adstringent factors against diarrhea and skin rushes. Several studies have shown that teas and juices made from the jaboticaba peel may help in the treatment of allergies, hair fragility, tonsillitis, intestine infections, varicose veins, asthma and others (Ferreira et al., 2012).

The above shows the potential of research development on the jaboticaba. A study has been undertaken with data on academic and patents research to investigate trends in the technological and scientific development of the jaboticaba.

## 2 Materials and methods

A survey at the following three databases, Web of Science (WoS), Scopus and Scientific Electronic Library Online (SciELO), was undertaken to analyze comprehensively the scientific field on the subject. Choice was based on the importance of the above databases in Bibliometrics. WoS is one of the most important data sources (Van Leeuwen, 2006), while Scopus is also employed for its quality and reliability (Garousi & Mantyla, 2016). Further, SciELO features vast indexation of Brazilian scientific journals at no costs.

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Research focused on the 1914-2016 period and was foregrounded on keywords of the papers' titles: jaboticaba, jaboticaba, and *Myrciaria Cauliflora*. One hundred and seventeen documents were retrieved from database WoS, 112 from Scopus and 57 from SciELO. However, 41.96% were repeated papers and thus only 166 documents were analyzed. Data were analyzed with Microsoft Excel (v. 2010) based on the year of publication, type and source of documents, authors, language, study field and countries.

Data survey on patents in highly significant databases on technological prospection was undertaken to analyze the technological development of the jaboticaba. They included the Instituto Nacional de Propriedade Industrial (INPI), the European Patent Office (ESPACENET), national and international collection of patents of Patentescope from the The World Intellectual Property Organization (WIPO) and the Derwent World Patents Index (DWPI), a Thomson Reuters database integrated to the Web of Knowledge. Consequently, an overall idea of technologies involving jaboticaba could be obtained.

Keywords used in current research comprised "jaboticaba" or "jaboticaba" or "*Myrciaria cauliflora*", in the abstract or title of the patents. All patents involving the theme proposed in current research could be obtained. Data were collected and selected in a Microsoft Excel (v. 2010) program sheet from where patents that did not match the criterion by which jaboticaba was the main focus of the research or among the main prime-matters of the invention were excluded.

Thirteen patents occurred at the INPI database, 69 at the Derwent database, 50 at the WIPO database and 22 at the EPO database, with a total of 154 patent applications. However, only 111 documents complied with the aims of the research. Since there were 32.7% repeated applications, only 74 patent applications were studied. Posterior to selection of data, a matching analysis was undertaken with regard to main authors, institutions, countries of origin, year of application, International Patent Classification (IPC) and fields of application, given in graphs that revealed frequency of data discussed below.

### 3 Results and discussion

#### 3.1 Academic research

There were eight types of documents. Papers amounted to 87.88% of total publications, followed by papers read in scientific events (4.82%), abstracts (3.61%), reviews (1.2%) and others (chapter of books, newspaper articles, editorials and notes).

Figure 1 shows increase in publication on the jaboticaba throughout the years. The first document was published in 1914 and publications remained constant till 1992. There was

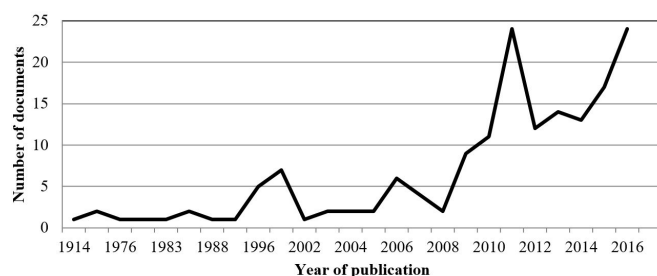


Figure 1. Temporal analysis of publications on the jaboticaba.

a significant increase in the number of publications from 2008 henceforth, with the 2012-2016 period featuring the greatest number of documents (24 per year). This fact reveals that academic interest in jaboticaba is quite a recent thing.

Figure 2 demonstrates countries with most publications on jaboticaba, at each database. Brazil has the highest rate of publications at all databases studied, with more than 80% of documents, probably related to the fact that the jaboticaba is native to Brazil and retrieval material on the fruit for studies is naturally more available. The USA ranks second in Web of Science and Scopus databases, other countries, such as China and Portugal also rank at the top in these databases. SciELO database indicates only Latin American countries.

The papers were published in 71 scientific journals. Table 1 shows the journals with the greatest number of papers and their impact factor. The journals Revista Brasileira de Fruticultura, Food Research International and Food Science and Technology (Campinas) published the greatest number of papers on the jaboticaba. Although these three Brazilian journals produced most papers on the theme, they do not have a significant impact factor when compared to international journals. Or rather, they have a lower impact rate within the scientific community. On the other hand, Food Research International, Food Chemistry and Journal of Functional Foods have a high IF, revealing their importance in academic research.

Papers were written in five different languages, most of which (72.12%) were in English, as expected in international journals. Brazil was the country with most scientific publications on jaboticaba and Portuguese was the second-ranking language (23.03%) in which papers were written. The Revista Brasileira de Fruticultura published most papers: two papers (1.21%), one in English and the other in Portuguese were published. The other documents were published in German, Spanish and Italian, respectively at 0.61%, 2.42% and 0.61%.

Research fields are tagged differently in each database, as Figure 3 shows. WoS, Scopus and SciELO respectively provided 22, 18 and 4 different fields, even though several papers may comprise complementary ones. Research on the jaboticaba is more frequent in the field of Agrarian and Biological Sciences at the three databases. Studies deal with improvement in the crop

Table 1. Main scientific journals with most papers on the theme.

Title	NP	R (%)	IF
Revista Brasileira de Fruticultura	26	15.66	0.340
Food Research International	11	6.63	3.182
Revista Food Science and Technology (Campinas)	8	4.82	0.729
Food Chemistry	5	3.01	4.052
Journal of Functional Foods	5	3.01	3.973
Acta Horticulturae	4	2.41	-
Journal of Food Engineering	4	2.41	3.199
Journal of Food Science	4	2.41	1.649
Journal of the Brazilian Chemical Society	4	2.41	1.096

NP = number of publications; R(%) = percentage of total paper in each journal; IF = impact factor according to Journal Citation Reports 2015.

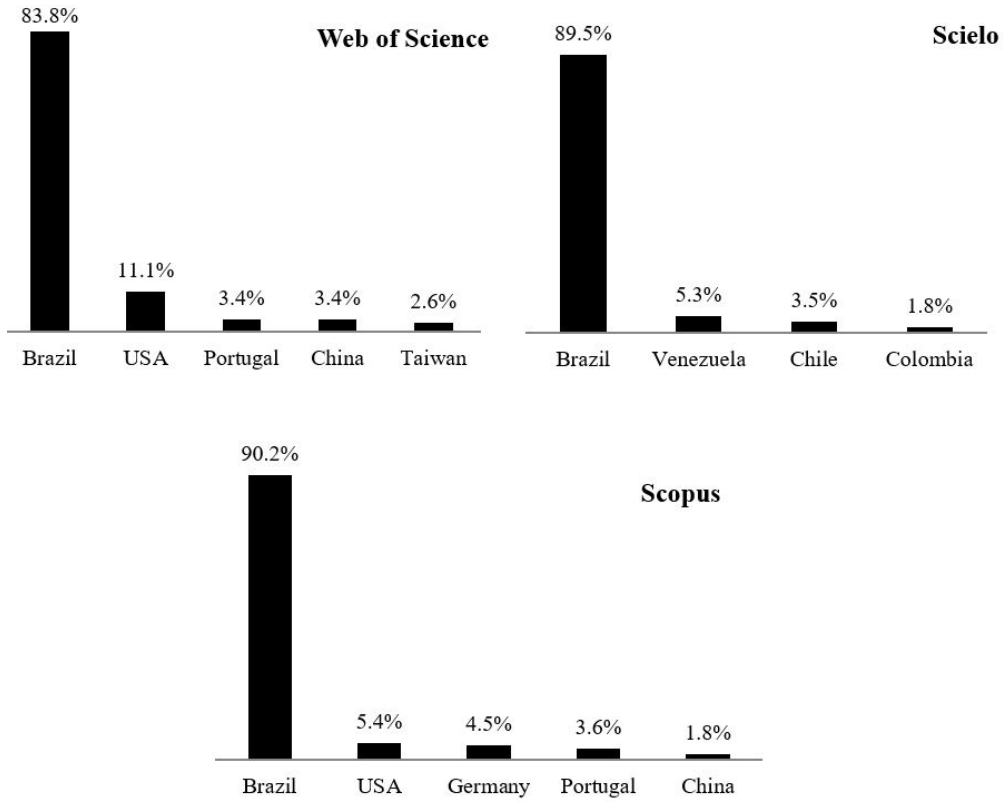


Figure 2. Main countries with the greatest number of publications in each database.

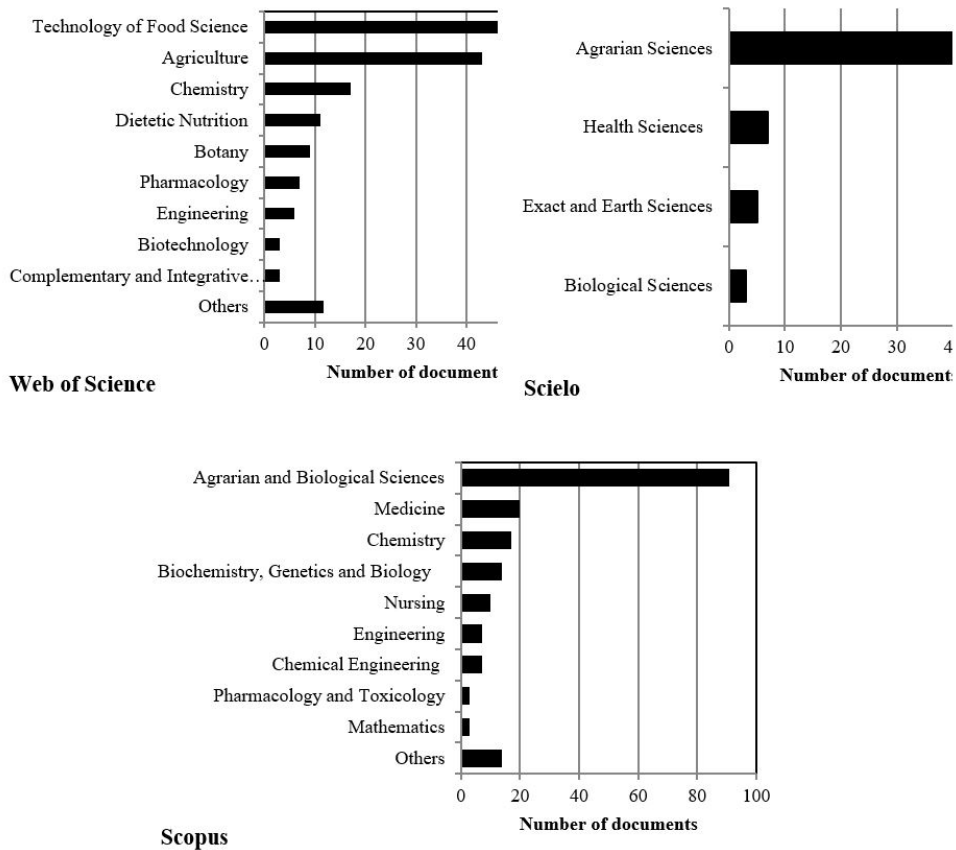


Figure 3. Categories of most studied fields at each database.

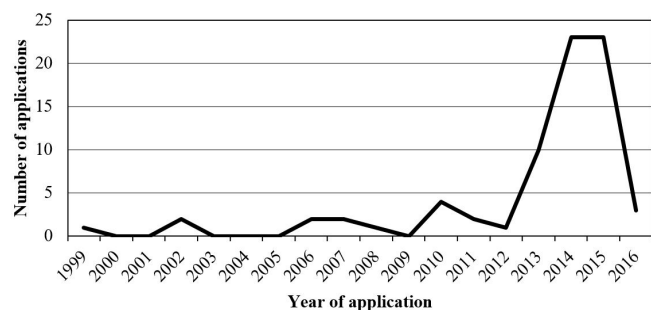
and with the use of the fruit for the development of products. Chemistry and Nutrition fields have great relevance on the studies on the jaboticaba, since the fruit has several important compounds such as anti-oxidant substances. Botany and Genetic Engineering may be underscored with regard to the plant's genetic improvement. Engineering, Bio-technology and Pharmacology are other important fields.

The analysis of the main authors was also performed. The first three authors with most papers, Citadin, I. (17 publications), Danner, M. A. (14 publications), and Sasso, S. A. Z. (14 publications) are Brazilian. Their publications within the agricultural field, with studies on genetic improvement and the cultivation of the jaboticaba shrub were published in Brazilian scientific journals, particularly the *Revista Brasileira de Fruticultura*. Other authors such as Maróstica, M. R., Batista, A. G. and Meireles, M. A. A. published most of their papers in high IF journals, such as *Food Research International* (IF: 3.182), *Journal of Functional Foods* (IF:3.973) and *Food Chemistry* (IF: 4.052) in the fields of food technology, nutrition and chemistry.

Moreover, the authors with the greatest number of publications are affiliated to Brazilian IHEs, demonstrating the influence of the country on jaboticaba research. Further, IHEs hail from south and southeastern Brazil, from the states of Paraná, São Paulo and Minas Gerais. Average co-authorship reached approximately 8 authors per paper. Papers featuring 5 authors were the most numerous (22.22%), followed by 4 and 6 authors, at 17.36%, and by 3 authors, at 12.50%. Minimum number of authors was 1 (1.39%) and maximum was 16 with one paper (0.69%).

### 3.2 Technological development

The first patent application involving the jaboticaba was titled “Cosmetic Composition Containing Moisturizing Plant Extract” dealing with jaboticaba extract for the production of a cosmetic with a high hydrating capacity for skin and hair. Application occurred in 1999 by a Japanese company and the patent was conceded in 2010. Figure 4 shows evolution through time of patent applications on this fruit and demonstrates that the number of applications on jaboticaba worldwide is relative low till 2012, but increased between 2013 and 2015. In fact, studies on the jaboticaba are recent and involve technological development due to in-depth knowledge on its potential characteristics



**Figure 4.** Temporal evolution of patent applications on *Myrciaria cauliflora*.

hitherto unknown. Only a small number of patents were applied for in 2016. It is worth mentioning that there are patents in the confidentiality period causing the apparent reduction on the number of patent applications in 2016.

China, Brazil, United States (US), Japan, Taiwan, Singapore and Russia are the countries involved in technologies on jaboticaba. Jaboticaba technology market is dominated by China (CH) with 70.3% of applications, followed by Brazil (BR) with 12.2%, United States (US) with 10.8% and Japan (JP) with 2.7%. The graph reveals a robust concern and predominance by China in the development and protection of technologies on jaboticaba. China has the greatest number of patent applications in several areas, perhaps related to policies on technology innovation and transference linked to foreign entrepreneurs (Nonnenberg, 2010).

According to Grueber & Studt (2010), the USA, China and Brazil are the main P&D countries in the field of agriculture and food production. However, they have different interests in the case of patent applications on technologies involving jaboticaba. Brazil has focused research on the development of sustainable technologies on reuse of wastes (peel and seeds) for the production of other types of food. The USA developed research on the fruit's compounds for the production of cosmetics and other pharmaceutical uses. On the other hand, China's research range from the production of beverages, food, culture improvement and the production of cosmetics from jaboticaba.

Most patent applications on technologies involving jaboticaba hail from private enterprises (49%), followed by individual researchers (36%), universities (13%) and governments (3%). The above proves the food and pharmaceutical industries' great interests on the jaboticaba due to its properties.

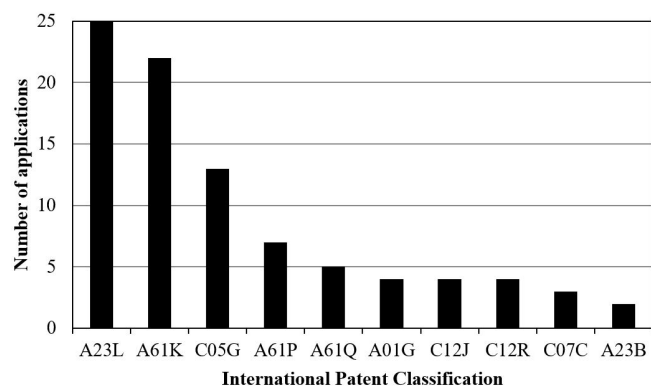
Half of the institutions with the greatest number of patents related to technologies on jaboticaba are located in China. The development of technologies on jaboticaba is mainly undertaken by companies and universities in China, US and Brazil. China has the greatest number of private companies with most application on jaboticaba. The Chinese company *Liuzhou Tianzi Horticulture* forwarded the greatest number of patent applications (10), between 2013 and 2014. Most technologies developed by *Liuzhou Tianzi Horticulture* involve the manufacture of fertilizers and cultivation methods for *Myrciaria cauliflora*. Mary Kay INC (US), Universidade Federal de Góias (Brazil) and Guangxi Lixiang Animal Husbandry CO LTD (China) have each one 4 patent applications.

Table 2 shows the main inventors with patent applications involving technologies on jaboticaba classified according to country of origin. China has the greatest number of inventors with the greatest number of patent applications on jaboticaba, averaging one inventor per application. Further, the USA averages a co-invention by four authors, followed by Brazil with three inventors per application.

Figure 5 provides the ten main IPCs related to technology on jaboticaba and reveals great concern on “Food, food products and non-alcohol beverages: preparation, treatment and conservation” (CIP A23L), with 25 (33.8%) applications, followed by “Preparations with medical, dentistry and hygiene ends” (CIP A61K), with 22 (29.7%) applications, “Fertilization

**Table 2.** Main inventors with patent applications on *Myrciaria cauliflora* per country.

Country	Inventor	N. applications
CHINA	Chen Caibao	10
	Chen Shujie	5
	Lin Y	4
	Chen Ming	3
	He Shufang	3
BRASIL	Lismaira Gonçalves	3
	Caixeta Garcia	
	Clarissa Damiani	3
	Francielo Vendruscolo	3
ESTADOS UNIDOS	Flávio Alves da Silva	3
	D'Armiento Jeanine	4
UNIDOS	Reynertson Kurt	4
	Kennelly Edward	4
	Wallace Alison	4
	Tiffany Florence	3
JAPÃO	Ohara Mitsuharu	1
	Seki Tetsuya	1
TAIWAN	Huang Hui-Pei	1
SINGAPURA	Nagahama Norikatsu	1
RÚSSIA	Флоренс тиффани [Florens Tiffany]	1

**Figure 5.** Main codes from the International Patent Classification related to *Myrciaria cauliflora*.

Mixtures” (CIP C05G) with 13 (17.6%), “Specific therapeutic activities of chemical compounds or medicinal preparations” (CIP A61P), with 7 (9.5%) applications, “Specific use of cosmetics or similar preparations for personal hygiene” (CIP A61Q), with 5 (6.8%) applications, “Horticulture, cultivation of vegetables, flowers, rice, fruits, vineyards, hops” (CIP A01G), with 4 (5.4%) applications. The above IPCs have been in the limelight in patent applications on the jaboticaba, most of which (85.1%) are tagged as “Human Needs”.

The jaboticaba may be employed in several ways and for different ends. Applications reveal that the fruit is greatly used in technological development in food (38.71%), in agriculture

(20.97%) and in the pharmaceutical industry (12.90%). Other fields include cosmetics, biotechnology and health.

### 3.3 Comparisons

Temporal analysis of scientific publications and patent applications shows that research and development on the jaboticaba have been increasing as from 2012. It is a current theme and highly relevant, with important expectations. In fact, more research work has been done and new discoveries have occurred.

Although Brazil is the country with most publications on the jaboticaba, China has most patents (70.3%), followed by Brazil (12.2%). This fact reveals that Brazil still does not have the tradition and investments required for technological development, exclusively concentrated on academic research. Contrastingly, China has a strong and established policy in technological development.

Another relevant fact is that the main authors of academic papers are not included in the list of patent inventors. No Brazilian author has patents on the theme under investigation. Patents mostly hail from industries (49%). The academia ranks third, with 13%. This boils down to the fact that universities produce theoretical knowledge which is not used for the development of technologies and, consequently, for production of income.

The fields of study of academic research are similar to those of the patents. Studies on food are more employed in patents, followed by agriculture, which is just the opposite of what occurs in the Universities. Pharmaceutical and biotechnological fields receive citations in both instances.

## 4 Conclusion

Scientific research and technological development should be complementary factors. Current analysis on the jaboticaba shows a gap in data. There is no link between research authors and patent inventors. Although Brazil has the greatest number of scientific publications, China has more patent applications. The fields under analysis in academic research and patents are similar. They are applications in the field of food science and technology and agriculture. The jaboticaba is a prime matter with great potentialities for further development, especially in the field of technological development.

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