

## **Scientometric analysis of scientific production on the genus *Campomanesia* Ruiz & Pav. (Myrtaceae) and most studied species - research trends involving native Brazilian plants**

**Análise cienciométrica da produção científica sobre o gênero *Campomanesia* Ruiz & Pav. (Myrtaceae) e espécies mais estudadas – tendências de pesquisa envolvendo plantas nativas brasileiras**

**Análisis cienciométrico de la producción científica del género *Campomanesia* Ruiz & Pav. (Myrtaceae) y las especies más estudiadas: tendencias de investigación que involucran plantas nativas de Brasil**

Received: 12/12/2021 | Reviewed: 12/17/2021 | Accept: 12/24/2021 | Published: 01/04/2022

**Rosa Maria de Brito Steckelberg**

ORCID: <https://orcid.org/0000-0002-7187-0623>  
Universidade Federal de Goiás, Brazil  
E-mail: [rosagoianesia2@gmail.com](mailto:rosagoianesia2@gmail.com)

**José Realino de Paula**

ORCID: <https://orcid.org/0000-0002-4424-7692>  
Universidade Federal de Goiás, Brazil  
E-mail: [jose\\_realino@ufg.br](mailto:jose_realino@ufg.br)

**Camila Aline Romano**

ORCID: <https://orcid.org/0000-0002-3564-6368>  
Universidade Federal de Goiás, Brazil  
E-mail: [camilaalineromano@gmail.com](mailto:camilaalineromano@gmail.com)

**Danilo Brito Steckelberg**

ORCID: <https://orcid.org/0000-0002-9050-5453>  
Universidade de São Paulo, Brazil  
E-mail: [danilosteck@gmail.com](mailto:danilosteck@gmail.com)

### **Abstract**

Brazil has rich biodiversity, harboring native plants with potential for medicinal use, including species of the *Campomanesia* genus. Although public policies to encourage phytotherapy advocate the best use of plant biodiversity, most species listed in official forms and monographs are exotic species. Thus, the aim of this study is to identify research trends involving the *Campomanesia* and main species, using scientometric tools, so that, by viewing and knowing the scientific production on the genus and species of pharmacological interest, possibilities for research with native species so that they can be integrated into Brazilian's unified health system (SUS). The research resulted in 302 publications up to September 2021. Bibliometric analyzes on genus were then carried out with data from the WoS platform and social network analysis through of scientometric mapping, using the Vosviewer (VOS) application. Species of the genus with more than 10 publications indexed in WoS were also analyzed. Brazil leads research on the genus and *C. xanthocarpa* (120/302); *C. adamantium* (70/302); *C. pubescens* (33/120); *C. phaea* (25/302); *C. lineatifolia* (21/302) and *C. guazumifolia* (10/302) were the species with the highest publication volume. It is the first work that analyzes the scientific production on these genus of Myrtaceae family and the aforementioned species, which revealed itself a promising field of research, yet little explored, which might encourage new studies aimed at better use of Brazilian biodiversity and the safe and effective use of native plants that may bring benefits to people's health and well-being.

**Keywords:** Bibliometric; Medicinal plants; Gabiroba; Guavira.

### **Resumo**

O Brasil possui rica biodiversidade, abrigando plantas nativas com potencial para uso medicinal, dentre elas as espécies do gênero *Campomanesia*. Embora as políticas públicas de incentivo à fitoterapia preconizem o melhor aproveitamento da biodiversidade vegetal, a maioria das espécies listadas em formulários e monografias oficiais constitui-se de espécies exóticas. Assim, o alvo deste estudo é identificar as tendências de pesquisa envolvendo *Campomanesia* e principais espécies, usando ferramentas da cienciométrica, para que, visualizando e conhecendo a produção científica sobre o tema, abram-se possibilidades de pesquisas com espécies nativas para que possam ser integradas ao Sistema Único de Saúde

(SUS). A pesquisa resultou em 302 publicações até setembro de 2021. Foram realizadas análises bibliométricas sobre o gênero com os dados da plataforma WoS e análises de rede de relacionamento por meio do mapeamento cienciométrico, usando o aplicativo Vosviewer (VOS). Foram analisadas espécies do gênero com mais de 10 publicações indexadas na WoS. O Brasil lidera as pesquisas sobre o gênero e *C. xanthocarpa* (120/302); *C. adamantium* (70/302); *C. pubescens* (33/120); *C. phaea* (25/302); *C. lineatifolia* (21/302) e *C. guazumifolia* (10/302) foram as espécies com mais publicações. É o primeiro trabalho que analisa a produção científica sobre esse gênero da família Myrtaceae e espécies acima mencionadas, o qual revelou um promissor campo de pesquisa, ainda pouco explorado, que pode incentivar novos estudos direcionados ao melhor aproveitamento da biodiversidade e ao uso seguro e eficaz de plantas nativas que possam trazer benefícios a saúde e bem estar das pessoas.

**Palavras-chave:** Bibliometria; Plantas medicinais; Gabiroba; Guavira.

### Resumen

Brasil tiene rica biodiversidad, albergando plantas nativas con potencial para su uso medicinal, incluidas especies del género *Campomanesia*. Si bien las políticas públicas de fomento de la fitoterapia abogan por el mejor uso de la biodiversidad vegetal, la mayoría de las especies enumeradas en formularios y monografías oficiales son especies exóticas. Así, el objetivo de este estudio es identificar las tendencias de investigación que involucran *Campomanesia* y las principales especies, utilizando herramientas cienciométricas, de manera que a partir de la visualización y el conocimiento de la producción científica sobre el género y las especies de interés farmacológico, las posibilidades de investigación con especies nativas para que puedan integrarse al sistema unificado de salud pública en Brasil (SUS). La búsqueda resultó en 302 publicaciones hasta septiembre de 2021. Se realizaron análisis bibliométricos de género con datos de la plataforma WoS y análisis de redes de relaciones mediante mapeo cienciométrico, utilizando la aplicación Vosviewer (VOS). También se analizaron especies del género con más de 10 publicaciones indexadas en WoS. Brasil lidera la investigación sobre el género y *C. xanthocarpa* (120/302); *C. adamantium* (70/302); *C. pubescens* (33/120); *C. phaea* (25/302); *C. lineatifolia* (21/302) y *C. guazumifolia* (10/302) fueran las especies con mayor volumen de publicación. Es el primer trabajo que analiza la producción científica sobre este género de la familia Myrtaceae y las especies mencionadas anteriormente, que reveló un campo de investigación prometedor, aún poco explorado, que puede impulsar nuevos estudios sobre el mejor uso de la biodiversidad brasileña y el uso seguro y efectivo de las plantas autóctonas que puedan aportar beneficios a la salud y el bienestar de las personas.

**Palabras clave:** Bibliometría; Plantas medicinales; Gabiroba; Guavira.

## 1. Introduction

Brazil, in its continental dimensions, covers areas with different edaphic, climatic and phytophysiognomic conditions. This variability favored the establishment of different ecosystem formations. The high levels of diversity and degradation due to agropastoral occupation meant that the country had three of its biomes listed among the 25 biodiversity hotspots on the planet (Myers, 2000). In addition to the immense variety of flora and fauna, the country also stands out for its socio-biodiversity, with an invaluable wealth of knowledge and cultures, represented by more than 300 indigenous peoples, quilombola communities, among others that have knowledge about the use and preservation of natural resources. In addition to traditional knowledge and availability of natural resources, the implementation of new technologies can enable the country, in a sustainable way, to increase the research and development of products of natural origin with diverse applicability, especially aimed at improving health and quality of life of people (Valli *et al.*, 2018). However, despite all this heritage, Brazilian biodiversity is underutilized. Most of the national economic activities are based on exotic species in agriculture, livestock and also in extractivism (Brasil, 2021).

The best use of our plant biodiversity is one of the great challenges contemplated in Brazilian public policies. In 2006, the National Policy on Medicinal Plants and Herbal Medicines was created, which established detailed guidelines in the National Program of Medicinal Plants and Herbal Medicines through Interministerial Decree 2.960/2008 (Brasil, 2008), involving 10 ministries. The main objective of the Policy and the Program was to guarantee the Brazilian population safe access and rational use of medicinal and herbal plants, promoting the sustainable use of biodiversity, the development of the production chain and the national industry (Brasil, 2015). Although the guidelines of the herbal medicine policy converge towards the enhancement of local biodiversity, most of the species listed in Brazilian's national healthcare system (SUS) programs are exotic species (Martins *et al.*, 2019; Medeiros, 2013).

The interest in researching native Brazilian plants of medicinal and pharmacological interest dates back to Brazil Colony, in the court of D. João VI, when the French naturalist Auguste de Saint-Hilaire (1779-1853), on his trips to the interior of Brazil, produced a scientific work that cataloged 283 plants distributed in 53 families. The Fabaceae family was the most representative in the work, with 20 species, followed by Solanaceae, Rubiaceae and Myrtaceae with 12, 10 and 9 species respectively (Brandão *et al.*, 2012).

The Myrtaceae family comprises 5,970 species distributed in 145 genera, including the *Campomanesia* genus, home to 38 species (The Plant List, 2013), one of them, *Campomanesia pubescens*, is present in the work of Saint-Hilaire (Brandão *et al.*, 2012). The species of the genus are widely distributed in Brazil and are known for the sweet-acid taste of their fruits. As for the common secondary metabolites for the genus, the phenolic compounds, anthocyanins, chalcones, coumarins, tannins and saponins stand out, in addition to the presence of volatile compounds in its leaves. Evidently there is phytochemical variation between species, but the presence of these classes of compounds could explain the traditional therapeutic use, which is why some species have aroused the interest of researchers, such as: *Campomanesia xanthocarpa*, *Campomanesia adamantium*, *Campomanesia guazumifolia*, *Campomanesia reitziana* and *Campomanesia lineatifolia*. Despite the growing publications showing the importance of the genus, not only in the food field, but also in pharmacological applications, there is still a vast field of research to be explored to investigate its potential, especially of native species (Duarte *et al.*, 2020; Lescano *et al.*, 2019).

A research modality that has been standing out in the field of evaluating scientific production and research trends is the scientometric study, whose term was coined by Russian scientist Nalimov and collaborators in the late 1960s. It is the application of quantitative methods on the development of science as an information process, in order to measure scientific production on a given topic, using data analysis tools that allow insights indicative of research trends, such as: research areas, authors, countries, impact of publications, research institutions, funding agents, among others, and the correlations between each variable (Nalimov & Mulchenko, 1971; Van Eck & Waltman, 2010).

Bibliometric research involving scientific production on ethnobotany suggests that this type of study can help formulate public policies that promote the best use and conservation of biodiversity (Ritter *et al.*, 2015). Based on the foregoing, the aim of this study was to analyze, with the aid of scientometric tools, the scientific production of *Campomanesia*, identifying research trends involving the genus and species of greatest interest so that this overview can stimulate new studies aimed at the use of native plants with biological activities for traditional use and as herbal medicines and thus can be contemplated in public policies to encourage integrative and complementary health practices.

## 2. Methodology

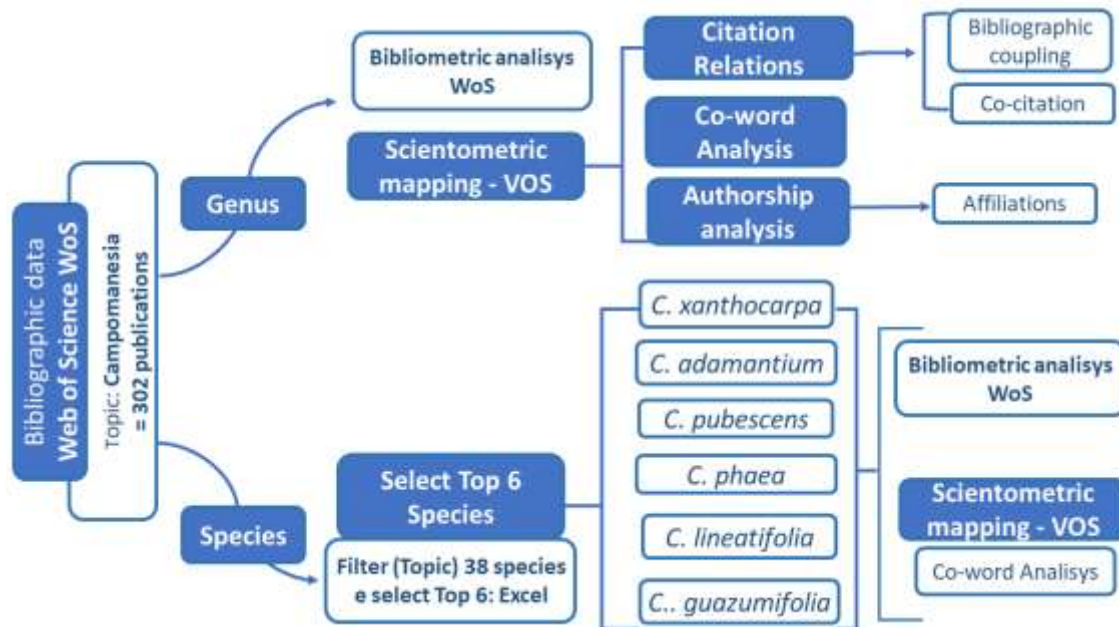
Survey data were obtained from the Web of Science (WoS). The keyword "Campomanesia" was tested in the "Topic" field of WoS in a previous search along with all the synonyms that appear in The Plant List platform. Only the main name produced results, thus, the search for the term "Campomanesia" in the topic dated until 09/30/2021 generated data for the analysis and scientometric mapping on the genus.

For the analyzes on the species, the term "Campomanesia" was used until 09/30/2021 and in the *Filter* field, each of the accepted names of species cataloged in "The Plant List" was added separately in spreadsheets organized in order decreasing in the number of publications. For this research, species with 10 or more publications were selected. Then, a Database was generated with each of the species selected according to the established criteria, which were: *C. xanthocarpa*, *C. adamantium*, *C. pubescens*, *C. phaea*, *C. lineatifolia* and *C. guazumifolia*. The information obtained on the indicators for the genus and species was analyzed separately. For the general bibliometric analyses, the WoS analysis tools were used and for the analysis of relationship networks and scientometric mapping, the VOSviewer application was used, based on the technique of visualization by similarities (VOS).

In the present study, for the analysis of relationship networks related to the *Campomanesia* genus, bibliographic coupling and cocitation for citation relationships were used. Figure 1 schematically represents the analysis tools used in this study.

The method applied in scientometric mapping comprises three categories of analysis: citation relationships, word co-occurrence and co-authorship relationships (Li *et al.*, 2021; Van Eck & Waltman, 2010). Citation relationships are the basic principle of scientometric mapping, as it is assumed that the more cited, the more relevant the work (Van Raan & Tijssen, 1993). Citing articles are mapped by bibliographic coupling, while cited articles are mapped by co-citation. Other important tools in scientometric analysis are co-word mapping and co-authorship mapping related to organizations. The first identifies the network of keywords used simultaneously by the authors and thus can reveal the main words and themes about the researched subject. The second reveals the relationship and collaboration networks between authors and institutions (Garfield, 2001).

**Figure 1**– Schematic representation of the methods and analysis tools used in the research.



Source: Authors.

### 3. Results and Discussion

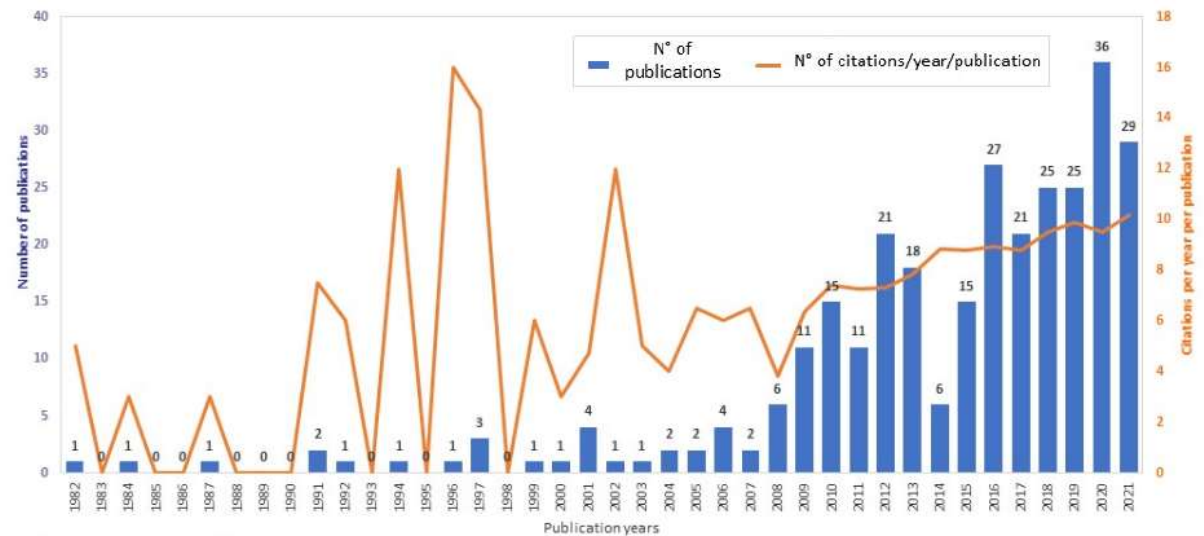
#### 3.1 Analysis of the scientific production on genus *campomanesia*

##### 3.1.1 Year and type of publication

The search for the term *Campomanesia* in the “Topic” field of WoS resulted in 302 publications. The first article indexed in the database was published in 1982, with the title “The development of the fruits and seeds of *Campomanesia* (Myrtaceae)”, published in the periodical *Brittonia* (Landrum, 1982). The year 2020, a year strongly marked by the Covid-19 pandemic, was the most productive, with 41 publications. Still under the impact of the pandemic, the year 2021 has already registered 29 publications up to the month of September. Figure 2 illustrates the evolution of research on gender over the years, both in number of publications and the evolution of citations and illustrates other numerical information obtained from WoS, such as types of publications, number of countries related to the research; lists open access publications as well as citation report data. Most of the publications found were of the article type (275 out of 302, which comprises 91%); there were 11 review articles (3.7%) and the rest were meeting abstracts, conference articles, notes, among others. The significant proportion of the number of original

articles in relation to review articles suggests that studies with plants of the genus are still scarce, which may mean a potential field of research that is still little explored.

**Figure 2** – Evolution of publications on *Campomanesia* genus on Web of Science.



<b>Total articles:</b>	<b>302</b>	<b>Countries:</b>	<b>24</b>	<b>Authors:</b>	1223	<b>Citing Articles</b>	1943	<b>Times cited</b>	2862
Articles:	275	Publications:	354	<b>Affiliations:</b>	211	<b>Without self-citation</b>	1731	<b>Without self-citation</b>	1957
Review:	11	Brazil:	277	<b>Journals:</b>	149	<b>Average per item</b>			9.48
Others:	24	Other countries:	77	<b>Publishers:</b>	81	<b>H-Index: 27</b>			
<b>All Open Access:</b>	<b>159</b>			<b>Funding Agencies:</b>	146				

Source: Authors.

From 1982 to 2005 there were a total of 23 published works, corresponding to 7,6% of the 302 publications. From 2006, year of the implementation of public policies to encourage the use of medicinal and herbal plants, until September of 2021, 275 studies were published (92.4%), an indicative that the policies, issued through the Decree of the Presidency of the Republic n° 5813 (Brasil, 2006), influenced the production of studies in this field.

### 3.1.2 Affiliations, countries, regions, research funding and collaboration networks between institutions

Brazil concentrates most of the studies on the *Campomanesia*, with 277 publications (91.7%), followed by the United States of America (USA) with 18 publications; Colombia, 9 studies; Sweden, 5; Spain 4; Argentina, Austria, France, Pakistan and Scotland with 2 publications each and 13 other countries with only one publication. Among these are some with an important history in research on medicinal plants such as China, India, Germany, Japan and Peru. As the species of the genus has an important geographic distribution in Brazil, in areas of tropical, subtropical and Cerrado forests (Landrum, 1986). Brazil's greater interest in researching the species of the genus is justified, and perhaps because of that, the funding agencies that most fostered research were precisely the Brazilian ones. Brazilian's National Council for Scientific and Technological Development (CNPq) and the Coordination for the Improvement of Higher Education Personnel (CAPES) contributed to the development of 71% of the research, with 119 studies funded by CNPq and 94 funded by CAPES, which corresponds to 39.7% and 31.3% respectively. Table 1 presents the ranking of affiliations that generated at least 5 publications and their origin (by region of Brazil or foreign country).

**Table 1** – Ranking of the institutions with 5 or more publications on *Campomanesia* by country or Brazilian region.

Affiliations	Count	% of 302	BR Region/Country
UNIVERSIDADE FEDERAL DA GRANDE DOURADOS	44	14,6%	Centro Oeste
UNIVERSIDADE DE SAO PAULO	37	12,2%	Sudeste
UNIVERSIDADE FEDERAL DO PARANA	36	11,9%	Sul
UNIVERSIDADE FEDERAL DE MATO GROSSO DO SUL	30	9,9%	Centro Oeste
UNIVERSIDADE ESTADUAL DE MATO GROSSO DO SUL	27	8,9%	Centro Oeste
EMPRESA BRASILEIRA DE PESQUISA AGROPECUARIA	21	6,9%	Nacional
UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL	20	6,6%	Sul
UNIVERSIDADE ESTADUAL DE CAMPINAS	17	5,6%	Sudeste
UNIVERSIDADE FEDERAL DE GOIAS	17	5,6%	Centro Oeste
UNIVERSIDADE FEDERAL DE LAVRAS	14	4,6%	Sudeste
UNIVERSIDADE FEDERAL DE SANTA MARIA	14	4,6%	Sul
INSTITUTO FEDERAL DO RIO GRANDE DO SUL	14	4,6%	Sul
UNIVERSIDADE FEDERAL DE SANTA CATARINA	13	4,3%	Sul
UNIVERSIDADE ESTADUAL PAULISTA	9	2,9%	Sudeste
UNIVERSIDADE ESTADUAL DE MARINGA	8	2,7%	Sul
UNIVERSIDADE FEDERAL DE MINAS GERAIS	8	2,7%	Sudeste
ARIZONA STATE UNIVERSITY	7	2,3%	EUA
INSTITUTO FEDERAL GOIANO	7	2,3%	Centro Oeste
UNIVERSIDADE DO ESTADO DE SANTA CATARINA	7	2,3%	sul
UNIVERSIDADE FEDERAL DE UBERLANDIA	7	2,3%	Sudeste
UNIVERSIDADE DE CRUZ ALTA	6	2,0%	Sul
UNIVERSIDADE FEDERAL DE SAO CARLOS	6	2,0%	Sudeste
INSTITUTO FEDERAL DE GOIAS IFG	5	1,7%	Centro Oeste
UNIVERSIDAD NACIONAL DE COLOMBIA	5	1,7%	Colômbia
UNIVERSIDADE DE BRASILIA	5	1,7%	Centro Oeste
UNIVERSIDADE ESTADUAL DE FEIRA DE SANTANA	5	1,7%	Nordeste
UNIVERSIDADE ESTADUAL DE GOIAS	5	1,7%	Centro Oeste
UNIVERSIDADE FEDERAL DO PAMPA	5	1,7%	Sul
UNIVERSIDADE LUTERANA DO BRASIL	5	1,7%	Sul
UNIVERSIDADE TECNOLOGICA FEDERAL DO PARANA	5	1,7%	Sul

Source: Authors.

Table 2 presents the data above classified by number of publications by regions of Brazil and foreign country. It is observed that among the affiliations with more than 5 publications, the Midwest Region (CO) was the most representative with 39.2% of publications, followed by the South Region with 32.5% and the Southeast with 27.2%. USA and Colombia were the countries with affiliations that published at least 5 articles. The data were further subclassified by states, where Mato Grosso do Sul (MS) leads the ranking with 102 studies, followed by São Paulo (SP), Rio Grande do Sul (RS), Paraná (PR), Goiás (GO), Minas Gerais (MG), Santa Catarina (SC) and Distrito Federal (DF) with 69, 50, 49, 34, 29, 18 and 5 publications respectively. Fruits of *Campomanesia spp*, known as “guavira”, since 2017 is considered a symbol of the state of Mato Grosso do Sul, established by state law (Mato Grosso do Sul, 2017). Plants of the *Campomanesia* can be found in Colombia, according to the Missouri Botanical Garden ([tropicos.org](http://tropicos.org)). They are also distributed in the 5 Brazilian regions and in the Phytogeographic Domains: Amazon, Caatinga, Cerrado, Atlantic Forest and Pampa (Oliveira; Costa & Proença, 2020).

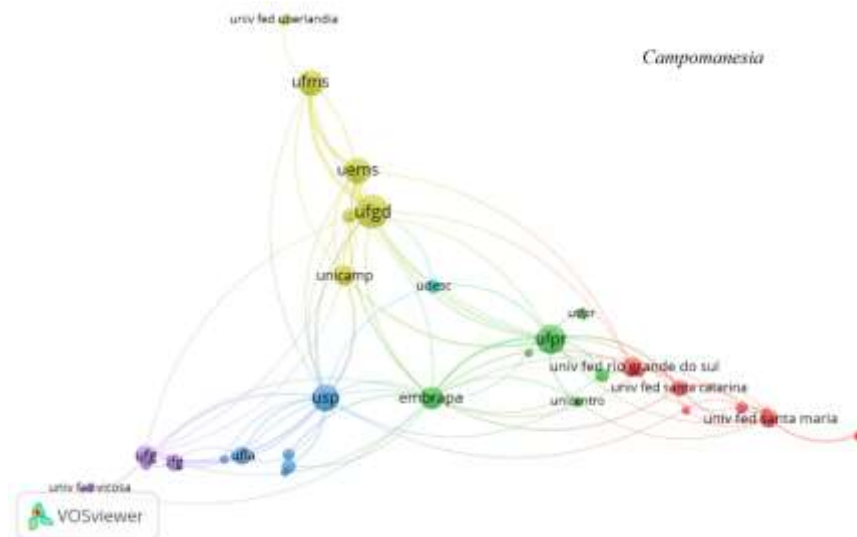
**Table 2** – Share of publications by Brazilian regions or countries (a) and by Brazilian states (b)

(a) Share of publications by Brazilian regions or countries			(b) Share of publications by Brazilian state		
Brazilian region / Country	Publications	Share	Brazilian state	Publications	Share
Midwest	141	39.2%	MS	102	28.7%
South	117	32.5%	SP	69	19.4%
Southeast	98	27.2%	RS	50	14.0%
Northeast	1	0.3%	PR	49	13.8%
National scope (Embrapa)	1	0.3%	GO	34	9.6%
USA	1	0.3%	MG	29	8.1%
Colombia	1	0.3%	SC	18	5.1%
<b>Total</b>	<b>360</b>	<b>100.0%</b>	DF	5	1.4%
			<b>Total</b>	<b>356</b>	<b>100.0%</b>

Source: Authors.

This study also analyzed the relationships between authors and institutions, represented by Figure 3, in which the VOS generated a map that included 194 institutions. Applying a filter of a minimum of 3 documents per organization, resulted in 39 items, of which 33 are correlated and divided into 6 clusters, 92 links and total link strength 210. Cluster 1, indicated by the red color, corresponds to groups and institutions in Rio Grande do Sul (Unicruz, Univ. Fed. Pampas, UFRGS, Univ Fed. Santa Maria); Santa Catarina (UFSC), Paraná (PUC-PR) and the University of Brasília, which although belonging to the Midwest region, are more closely related to this group. Cluster 2 indicated by the color green is representatively listed by the Brazilian Agricultural Research Corporation (Embrapa) of national scope and 4 institutions in the state of Paraná.

**Figure 3** – Network of relationship between authors and institutions with publications on genus *Campomanesia*.



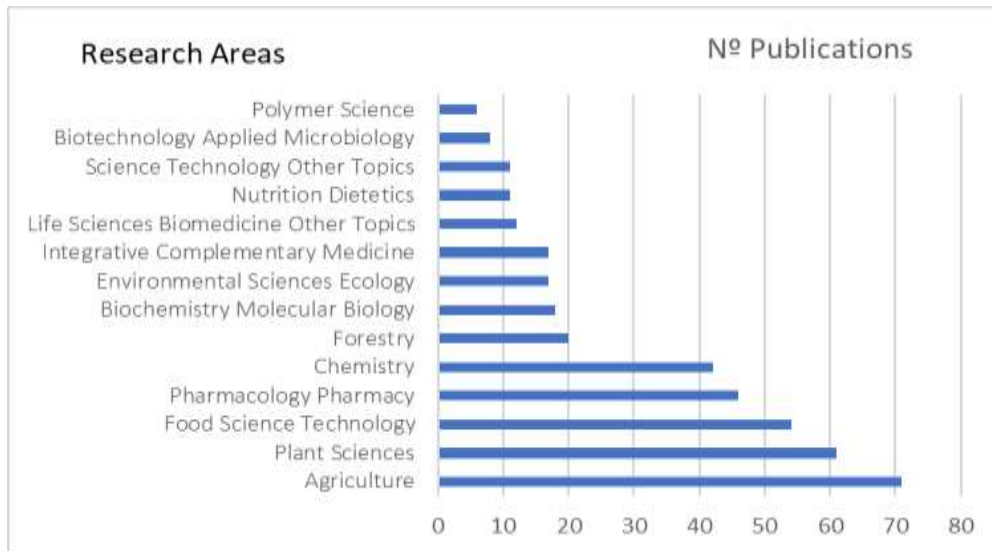
Source: Authors.

### 3.1.2 Journals, Impact Factor and research fields

Figure 4 graphically illustrates the relationship between the number of publications by research area, the most representative being: Agriculture, Plant Sciences, Food Science Technology, Pharmacology Pharmacy and Chemistry, indicating research trends for application in the field of agricultural sciences, food and nutrition and applications of pharmacological interest. Below, Table 3 and Figure 5 which respectively illustrate the ranking of journals with 5 or more publications and their

respective Impact Factor according to the Incites Journal Citation Reports (JCR) belonging to Clarivate Analytics and the network map involving the relationships of co-citation between journals, based on the strength of term density. The data presented lead to the reflection that titles with a higher Impact factor achieve greater relevance in terms of impact on citations than, for example, the journal with the highest number of publications, despite having a smaller number of publications. In the case of this study, the Food Research International and the Journal of Ethnopharmacology are the journals with higher impact, with an Impact Factor of 6,475 and 4,360 respectively.

**Figure 4** – Number of publications by research areas.



Source: WoS.

**Table 3** – Number of publications and percentage from journals with 5 or more publications and their respective impact factor (JCR).

Titles of Publications	Count	% of 302	Impact Factor - JCR (2020)
REVISTA BRASILEIRA DE FRUTICULTURA	16	5,3%	0.912
JOURNAL OF ESSENTIAL OIL RESEARCH	11	3,7%	1.963
JOURNAL OF ETHNOPHARMACOLOGY	11	3,7%	4.360
ACTA BOTANICA BRASILICA	6	2,0%	1.268
BRITTONIA	6	2,0%	0.863
CIENCIA FLORESTAL	6	2,0%	0.574
FOOD RESEARCH INTERNATIONAL	6	2,0%	6.475
BRAZILIAN JOURNAL OF PHARMACOGNOSY	6	2,0%	2.010
ACTA HORTICULTURAE	5	1,7%	Not found in JCR
CIENCIA RURAL	5	1,7%	0.803
NATURAL PRODUCT RESEARCH	5	1,7%	2.861

Source: Authors.





**Table 4** – Top 10 most cited articles by year, authorship, total citations and evolution of citation in the last 5 years.

Average Citations per Item		9,38	Citations last 5 years					Total
h-index		27	249	330	326	520	463	2834
TOTAL								
Title	Year	Authors	2017	2018	2019	2020	2021*	All years
Characterization and Antioxidant Potential of Brazilian Fruits from the Myrtaceae Family	2012	Pereira, M.C.; Steffens, R.S.; Jablonski, A.; Hertz, P.F.; Rios, A.O.; Vizzotto, M.; Flores, S.H.	7	9	19	21	14	<b>86</b>
Plants popularly used for loosing weight purposes in Porto Alegre, South Brazil	2007	Dickel, M.L.; Kuze-Rates, S.M.; Ritter, M.R.	6	4	3	4	5	<b>78</b>
Reproductive-Biology of 8 Sympatric Myrtaceae from Central Brazil	1994	Proença, C.E.B.; Gibbs, P.E.	4	8	0	5	4	<b>73</b>
Preliminary studies on <i>Campomanesia xanthocarpa</i> (Berg.) and <i>Cuphea carthagenensis</i> (Jacq.) JF Macbr. aqueous extract: weight control and biochemical parameters	2004	Biavatti, MW; Farias, C; Curtius, F; Brasil, LM; Hort, S; Schuster, L; Leite, SN; Prado, SRT	1	3	4	7	4	<b>58</b>
Antiulcerogenic effects of <i>Campomanesia xanthocarpa</i>	2004	Markman, BEO; Bacchi, EM; Kato, ETM	5	5	2	8	2	<b>56</b>
Indigenous and inoculated yeast fermentation of gabirola ( <i>Campomanesia pubescens</i> ) pulp for fruit wine production	2009	Duarte, W.F.; Dias, D.R.; Melo Pereira, G.V.; Gervasio, I.M.; Schwan, R.F.	6	2	4	2	2	<b>55</b>
Assessment of antioxidant and antiproliferative activities and the identification of phenolic compounds of exotic Brazilian fruits	2013	Malta, L.G.; Tessaro, E.P.; Eberlin, M.; Pastore, G.M.; Liu, R.H.	6	9	5	2	6	<b>46</b>
Total fenolics and condensed tanins in native fruits from brazilian savanna	2011	Rocha, W.S.; Lopes, R.M.; Silva, D.B.; Vieira, R. F.; Silva, J.P.; Agostini-Costa, T.S.	8	2	10	10	4	<b>46</b>
Volatile components and antioxidant activity from some myrtaceous fruits cultivated in Southern Brazil	2008	Marin, R.; Apel, M.A.; Limberger, R.P.; Raseira, M.C.B.; Pereira, J.F.M.; Zuanazzi, J.A.S.; Henriques, A.T.	2	5	4	3	4	<b>45</b>
Anti-inflammatory and antinociceptive activities of <i>Campomanesia adamantium</i>	2013	Ferreira, L.C.; Grabe-Guimarães, A.; Paula, C.A.; Michel, M.C.P.; Guimarães, R.G.; Rezende, S.A.; Souza Filho, J.D.; Saude-Guimarães, D.A.	8	10	4	2	1	<b>43</b>

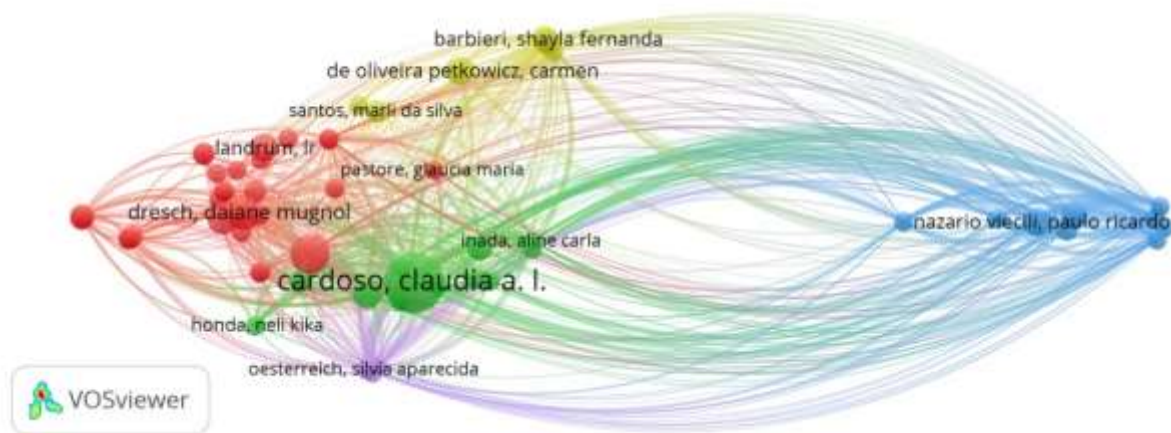
Source: Authors.

The co-occurrence analysis of keywords in the database on the *Campomanesia* genus is described in Figure 6. The genus' database generated a total of 1507 keywords. It was limited the minimum number of occurrences per word to 5, which generated 75 items divided into 6 clusters, 857 links, with 1608 being the total strength of the link. The overlay view displays keywords by publication time, which allows inferences about current research trends on the topic. It is observed that the term Myrtaceae appears more significantly because it is the family to which the genus belongs and may also reveal the interest of researchers in the family that houses numerous species of interest in the most diverse areas (Farias *et al.*, 2020). The *Campomanesia xanthocarpa* species also appears relevantly (34 occurrences, 45 links) linked to words that denote potential biological activities, such as inflammation, oxidative stress, bioactive compounds, obesity, cytokines and nitric oxide (Salmazzo *et al.*, 2021; Souza *et al.*, 2019). It is noted that the terms related to antioxidant activity are yellow, indicating that they are the most recent research, as well as the term savannah (16 occurrences, 29 links), suggesting a research trend towards biological activity with species from this Brazilian biome. *Campomanesia adamantium* was also a relevant term (13 occurrences, 22 links), in lilac color, which indicates older research that may be related to the traditional use linked to antimicrobial activity, but also related to words that indicate antioxidant and anti-microbial activity, but also related to words that indicate antioxidant and anti-inflammatory activities in recent research (Oliveira *et al.*, 2016). The term “antimicrobial activity” had 11 hits and 35 links, while the term “antioxidant activity” comes up with 51 hits and 57 links.



Figure 7 presents the relationship map of bibliographic coupling between authors, in which it can be seen different clusters of authors. Bibliographic coupling occurs when 2 or more citing articles are related through the same retrospectively cited articles. The research limited to authors with 3 or more publications and who received at least 1 citation, thus generating the map with 59 items, divided into 5 clusters, 1164 links and 34,318 the total strength of the link. Coupling strength is determined by the number of quotes they share. The greater the coupling force, the stronger the relationship between authors. It is observed that research involving the *Campomanesia* genus is restricted to a few groups, with a strong relationship between them, and that the authors Cardoso, Claudia AL (green cluster) and Vieira, Maria DC (red cluster) are the most productive with 8.3 % and 4.3% of publications respectively.

**Figure 7** - relationship map of bibliographic coupling between authors.

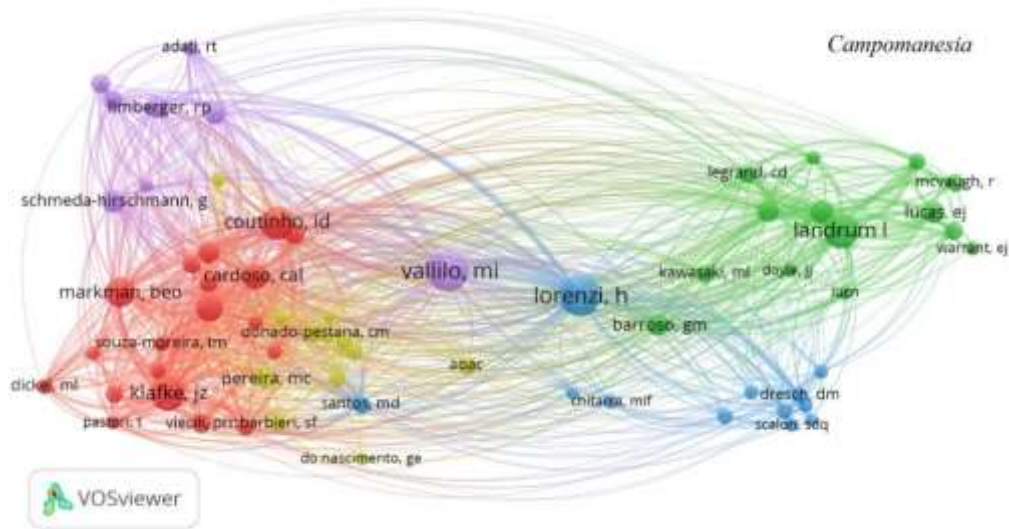


Source: Authors.

### 3.1.6 Co-citation networks and cited references - theoretical pillars

The analysis of the co-citation network, together with the cited references, indicate the theoretical pillars that underlie the database research on the *Campomanesia* genus. Figure 8 represents this network of connections and was built in the VOS, limiting to a minimum of 10 cited references. Therefore, the analysis of the 7,737 cited references that make up the database for the *Campomanesia* genus, limited to a minimum of 10, generated 65 items, divided into 5 clusters, 1,039 links and 5,132 link strength. Klafke, J.Z. , belonging to cluster 1, in red, was cited 66 times, with 52 links and 529 total link strength. Cluster 2, in green, has as main reference Landrum, L with 69 citations, 51 links and 419 the strength of the link. Lorenzi, H. and Vallilo, MI (from clusters 3 and 4 respectively) are the most cited authors, both with 90 citations, but they differ in the number of links (59 and 64 respectively) and the strength of the link (524 and 575 respectively), which gives Vallilo, MI leadership as a theoretical reference for research on the studied genus.

**Figure 8** - Co-citation map and cited references.



Source: Authors.

### 3.2 Most researched and researched species of the campomanesia genus in the last 5 years

For the analysis of the most searched species in the WoS database, it was added a filter with the name of each of the 38 species with names accepted by The Plant List platform (theplantlist.org), considering synonymous terms, then it was selected species with 10 or more publications. The species *C. xanthocarpa* and *C. adamantium* lead the ranking with 120 and 70 species respectively. Table 6 illustrates the 6 species with the total number of publications; the number of publications from 2017 to September 2021 and the representative percentage of studies in the last 5 years. It is observed that the species *C. guazumifolia*, from this list, is the one with the fewest studies, but the majority (80%) occurred in the last 5 years, suggesting a recent interest in its potential. On the other hand, *C. lineatifolia* presented only 1 study in the last 5 years, more specifically in 2021.

**Table 6** – Species of the *Campomanesia* genus with 10 or more studies in WoS, total publications, publications in the last 5 years and the percentage they represent for each species.

Species of <i>Campomanesia</i>	Total of publications	Publications 2017 - 2021	% of publications in last 5 years
<i>C. xanthocarpa</i>	120	59	49,2%
<i>C. adamantium</i>	70	32	45,7%
<i>C. pubescens</i>	33	13	39,4%
<i>C. phaea</i>	25	17	68,0%
<i>C. lineatifolia</i>	21	1	4,8%
<i>C. guazumifolia</i>	10	8	80,0%

Source: Authors.

#### 3.2.1 *Campomanesia xanthocarpa*

*C. xanthocarpa* (Mart) O.Berg, a native and non-endemic species of Brazil, is a semi-deciduous tree, with a tall, dense, pyramidal crown that measures from 4m to 20m in height; vegetation type Seasonal Semideciduous Forest, Ombrophilous Forest and Mixed Ombrophilous Forest; common in the Pampa and Atlantic Forest phytogeographic domains. The fruit, popularly known as gabirolba, has a greenish-yellow color, measures approximately 3 cm in diameter, has a firm, succulent pulp and a sweet taste, being highly appreciated for fresh consumption, in liqueurs, juices, ice cream and jellies (Fern, 2014a; Oliveira, M. I. U.; Costa, I. R.; Proença, 2020) It is a plant of pharmacological interest due to its anti-inflammatory properties (Cardozo et al., 2018; Silva et al., 2016; Vicili et al., 2014); antihypercholesterolemic (Klafke et al., 2010); antioxidant (Oliveira et al., 2016;

Salmazzo *et al.*, 2021); antidiabetic (Vinagre *et al.*, 2010); antiulcerogenic (Markman *et al.*, 2004), antinociceptive (Leandro *et al.*, 2020); anti-obesity (Biavatti *et al.*, 2004; Dickel *et al.*, 2007); antidiarrheal (Souza-Moreira *et al.*, 2011); antimicrobial (Capeletto *et al.*, 2016), among others.

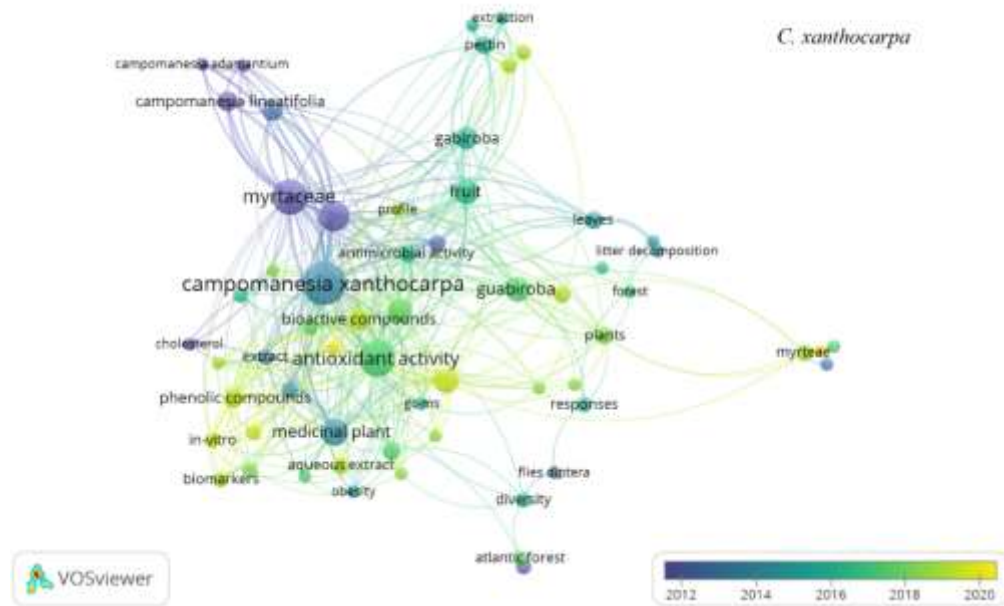
### 3.2.1.1 *Campomanesia xanthocarpa* – Bibliometric Analysis

The search for the term *C. xanthocarpa* in WoS, the most researched species of the genus in this database, resulted in 120 publications, 108 articles, 8 review articles, 4 early access documents and 4 meeting abstracts. The two years with the most indexed searches were 2020 with 22 publications (18.3%) and 2021, which until the month of September registered 12 publications. Most publications in these 2 years were 27 of the article type and only 4 reviews, which indicates that the research, with all the difficulties imposed by the Covid-19 pandemic, has not stopped. The country that most investigates the species is Brazil (115/120 = 95.8%), followed by the USA (6/120 = 5%) and Sweden (3/120 = 2.5%); The authors who published the most were: Cardoso C.A.L (13/120 = 10.8%); Viecili P.R.N. (7/120 = 5.8%); Klafke J.Z. and Re-Poppi N (6/120 = 5% each). Most authors are affiliated with the Federal University of Paraná (UFPR – 27/120 = 22.5%); State University of Mato Grosso do Sul (UEMS – 16/120 = 13.3%) and Federal University of Rio Grande do Sul (UFRGS – 15/120 = 12.5%), which indicates the interest of institutions in studying in plants from their own region. The journals with the highest number of publications were: Journal of Essential Oil Research and Journal of Ethnopharmacology with 7 publications each (5.8%); Forestry Science (5/120 = 4.2%) and Natural Product Research (4/120 = 3.3%). The most researched areas were: Food Science Technology (25/120 = 20.8%); Chemistry (24/120 = 20%); Pharmacology Pharmacy (21/120 = 17.5%); Plant Science and Agriculture (19/120 = 15.8%). These analyzes suggest Brazil's growing interest in investigating the potential of native species such as *C. xanthocarpa*, in the field of food and nutrition, agriculture and cultivation, and as a potential pharmacological application.

### 3.2.1.2 *C. xanthocarpa* – Co-occurrence network analysis by keywords

The co-occurrence relationship of words in research on the species shows the main keywords, and the relationship between them, which allows for the identification of the main themes addressed by the articles. For the construction of the VOS map, shown in Figure 8, we selected the All Keywords option and limited it to 3 occurrences per word, which generated 772 words in 61 items, divided into 7 clusters, 380 links, with a total link strength of 680. Figure 9 shows the overlay map visualization, indicating the use of terms over the years, which may suggest current research trends. It is observed that cluster 1, in green, presents the relevance of the keyword “Antioxidant activity”, which is also related to cluster 3 with the word “Oxidative stress” in yellow, both are linked to related terms such as “polyphenols”, “phenolic compounds”, “atherosclerosis”, “quercetin”, among others, indicating a strong research tendency of the species for this activity. Other words related to biological activities that appear relevantly are: “antimicrobial activity”, “obesity” and “cholesterol”.

**Figure 9** – Scientometric mapping of keywords co-occurrences – *C. xanthocarpa*



Source: Authors.

### 3.2.2 *Campomanesia adamantium*

*C. adamantium* (Cambess.) The Berg, popularly known as “guabiroba do campo”, is a native and non-endemic species in Brazil with geographic distribution in the Brazilian Midwest (Federal District, Goiás, Mato Grosso do Sul, Mato Grosso); Southeast (Minas Gerais, São Paulo) and South (Paraná, Santa Catarina) in the Cerrado and Atlantic Forest phytogeographic domains. It presents itself as a variable shrub that grows from 50 to 150 centimeters. Its fruits are also variable in size, color and degree of astringency. They have a succulent pulp with an acid-sweet flavor and are generally harvested in the field and consumed fresh (Oliveira; Costa & Proença, 2020). Among the main biological activities investigated in the species are: antimicrobial activity (Sá *et al.*, 2018), antioxidant (Coutinho *et al.*, 2010), anti-inflammatory and anti-nociceptive (Viscardi *et al.*, 2017).

#### 3.2.2.1 *C. adamantium* – Bibliometric Analysis

The search for the term *Campomanesia adamantium* in WoS resulted in 70 publications, 65 articles, 2 reviews, 2 corrections and 1 meeting summary. The most productive years were 2016 and 2017 with 11 and 9 publications (15.7% and 12.9%) respectively, followed by 2019 and 2018 (7/70 = 10% each). Brazil is the country that most contributes to research with 98.6% of publications and USA and Colombia, 1.4%. The research areas with the most publications were Agriculture (17/70 = 24.3%), Pharmacology Pharmacy (13/70 = 18.6%) and Food Science Technology (11/70 = 15.7%), indicating interest in cultivation and agriculture, pharmacological and food. The most productive authors were: Cardoso C.A.L with 11 publications (16.9%); followed by Vieira M.D. and Dresch D.M. with 13.8% and 10.8% of publications respectively. The main affiliations of the authors are: Federal University of Grande Dourados (UEGD – 29/70 = 41.4%); Federal University of Mato Grosso do Sul (UFMS – 16/70 = 22.9%); State University of Mato Grosso do Sul (UEMS – 13/70 = 18.6%); Federal University of Goiás (UFG – 11/70 = 15.7%) and University of São Paulo (USP – 10/70 = 14.3%). It is observed that the state of Mato Grosso do Sul contributes with more than 80% of the researches.









### 3.2.5 *Campomanesia lineatifolia* Ruiz & Pav.

*C. lineatifolia* is an evergreen tree, which can grow from 5 to 10m in height. It is geographically distributed in the west range of South America, comprising the center and north of Brazil, Peru, Colombia and Ecuador. Its natural habitat is primary growth forests in non-flooded areas. Its fruits, harvested locally and consumed fresh or in the form of sweets, ice cream and jellies, are popularly known as “guabiraba” or “champa”. From the leaves, volatile compounds used in the manufacture of perfumes are extracted (Canteiro & Lucas, 2019; *The Plant List*, 2013).

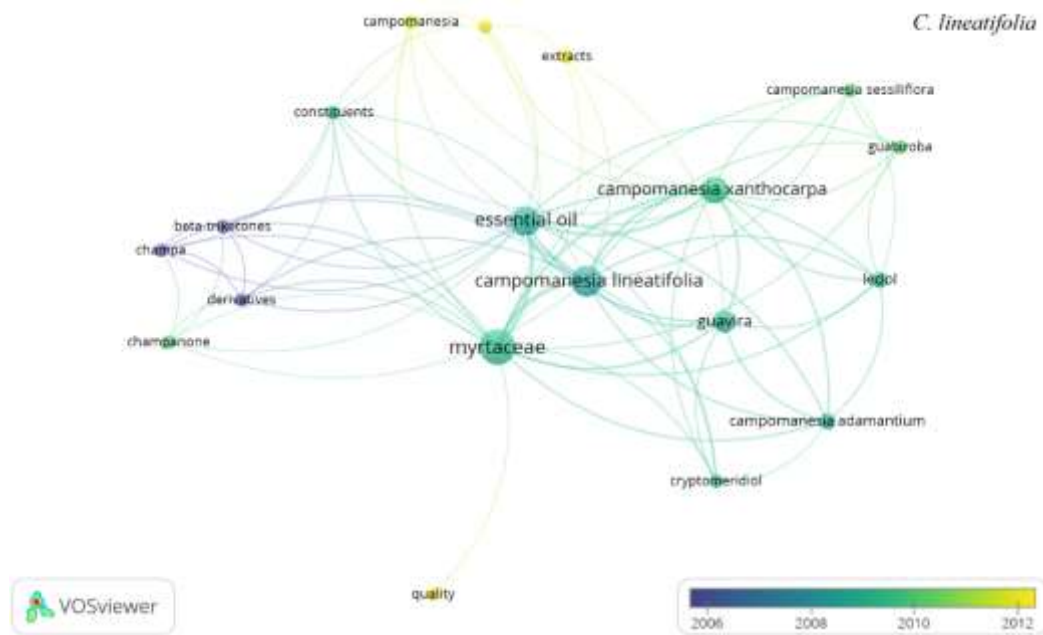
#### 3.2.5.1 *C. lineatifolia* – Análises Bibliométricas

Bibliometric analyzes in WoS indicate that the most productive years were 2009, 2012 and 2010 with respectively 5, 4 and 3 publications. Brazil was the country that published the most, although in a less hegemonic way compared to other species (12/21 = 57.1%). Colombia, a country that is also home to this species, comes in second with 8 out of 21 publications (38.1%). The most productive authors were Re-poppi N. (7/21 = 33.3%), Cardoso C.A.L. (5/21 = 23.8%) and Balaguera-lopés H.E. (4/21 = 19.0%). The first 2 authors did not research specifically on the species, these species being mentioned only in the Keywords Plus, but the 4 publications by Balaguera-lopés HE, affiliated researcher at the Universidad Nacional de Colombia, with a total of 20 publications and Híndex 4, are specifically about the species, as its name appears in the title of the 4 publications. The main areas of research were: Chemistry (9/21 = 42.9%); Food Science Technology (7/21 = 33.3%); Agriculture (6/21 = 28.6%); Pharmacology Pharmacy and Plant Science (both with 3/21 = 14.3%).

#### 3.2.5.2 *C. lineatifolia* – Co-occurrence network analysis by keywords

The VOS analyzes in the *Campomanesia lineatifolia* species database, limited to 2 occurrences per word, out of 108 words, resulted in 19 items linked in a network, divided into 5 clusters, 77 links and 183 the total strength of the link. Figure 13 represents the network of keyword co-occurrence links, highlighting the terms Myrtaceae (which represents the family) linked to other species of the genus *Campomanesia*, *xanthocarpa* (8 occurrences, 12 links), *adamantium* (3 occurrences, 7 links) and *sessiflora* (2 occurrences, 6 links), suggesting that they were searched together. The term “essential oil” (9 occurrences, 16 links) linked to terms that denote chemical composition such as “beta triketones” (in lilac), “champane” and cryptomeridiol (in green), show the evolution of substances found in the composition of the oil. essential oil of the plant. The group of  $\beta$ -triketones, among which the champanones, the main constituent of the volatile compounds of Champa and one of the most responsible for the intense and pleasant odor, are rare structures in compounds of natural origin and can be found in other species of Myrtaceae, especially of the genus *Eucalyptus*, *Kunzea* and *Leptospermum*. Champanones A, B and C, are yellow pigments found in champseeds, to which antimicrobial, anthelmintic and insecticidal activities have been attributed. There are commercially synthetic  $\beta$ -triketones used as herbicide and due to the considerable presence of these compounds in *C. lineatifolia*, studies report a potential use of the species as an insect repellent (Bonilla *et al.*, 2005; Osorio *et al.*, 2006).

**Figure 13** - Scientometric mapping of keywords co-occurrences – *C. lineatifolia*.



Source: Authors.

### 3.2.6 *Campomanesia guazumifolia* (Cambess.) O.Berg

*C. guazumifolia* is a native species, not endemic to Brazil, with phytogeographic domain Cerrado, Atlantic Forest and Pampa, geographically distributed in the following South American countries: Argentina, Paraguay and Brazil. In Brazil, it has been confirmed in the Northeast (Bahia), Midwest (Mato Grosso do Sul), Southeast (Espírito Santo, São Paulo, Minas Gerais and Rio de Janeiro) and South (Paraná, Rio Grande do Sul and Santa Catarina) regions. Popularly known as “Sete-capotes”, because of the layers of cork-like bark that naturally detach from the trunk in layers (capotes or capes). It is a deciduous tree with an open crown that can grow from 3 to 8 m in height. The fruits, although edible, are not unanimous in approving the sweet-sour flavor (Oliveira; Costa & Proença, 2020). It is popularly used in the treatment of liver disorders (Dorigoni *et al.*, 2001) and diarrhea (Brandão, 1991).

#### 3.2.6.1 *C. guazumifolia* – Análises Bibliométricas

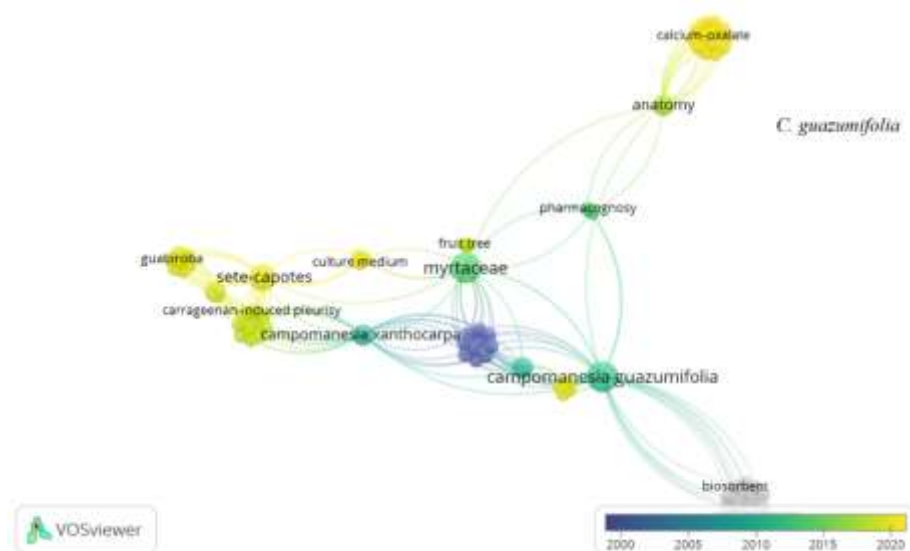
The first study involving *C. guazumifolia* indexed in WoS, dated 2001 and investigated the chemical composition of the essential oil of some species of Campomanesia. In *C. guazumifolia*, the main constituents found were Spathulenol (27.7%) and 1 $\beta$ -caryophyllene oxide (29%) (Limberger *et al.*, 2001). The second WoS publication came in 2013 and sought to understand the leaf and stem morphoanatomy of the species and indicated the presence of calcium oxalate and phenolic compounds in the leaves and also in the stem (Arruda *et al.*, 2013). In 2018, there were 2 publications, one of which sought to morphologically characterize the development of fruits, seeds and seedlings, aiming at the commercial production of seedlings (Souza *et al.*, 2018). The other study from 2018 investigated the anti-inflammatory activity and toxicological profile of the infusion of leaves in mice, in which anti-inflammatory potential with low toxicity was evidenced (Catelan *et al.*, 2018). In 2019, there were 3 publications. For the first time, antioxidant and antimicrobial potential of *C. guazumifolia* essential oil were reported and the main compounds identified by GCxGC/qMS were bicyclogermacrene (15%), globulol (5%) and spathulenol (5%). Sesquiterpene hydrocarbons (29 compounds) and oxygenated sesquiterpenes (20 compounds) were the most representative class of terpenes (Santos *et al.*, 2019). Another 2019 study investigated the infestation of fruit fly species infesting *C. guazumifolia* fruits (Almeida

et al., 2019). The third study from 2019 reported an increase in Sun Protection Factor (SPF) in formulations containing Octyl Methoxycinnamate in association with *Campomanesia* extracts (*C. guazumifolia*, *C. sessiliflora*, *C. xanthocarpa* and *C. adamantium*) alone or in association. All combinations were effective in increasing the SPF, and the combination of *C. xanthocarpa* and *C. adamantium* obtained higher SPF rates (Catelan *et al.*, 2019). Until October 2021, there were 3 publications and none of them with potential clinical application. One of them dealt with the morphoanatomical differences of parts of the ovary and pericarp of some species of *Campomanesia* native to Brazil (Pittarelli *et al.*, 2021). Another study investigated the viability of this species and sought to elucidate aspects of pollen germination (Guollo *et al.*, 2021) and the third proposed an alternative for the treatment of effluents in the pharmaceutical industry that produces ketoprofen, using acid-treated “sete-capotes” tree bark sulfuric acid (Preigschadt *et al.*, 2021).

### 3.2.6.2 *C. guazumifolia* – Co-occurrence network analysis by keywords

As there are only 10 publications about *C. guazumifolia*, all 87 words were considered for keyword co-occurrence analysis, which resulted in 72 items, 7 clusters, 436 links and 439 the total strength of the link. In Figure 14, which schematically presents these keyword co-occurrence relationships, it can be seen that in cluster 4, in dark blue, representing terms that appear in the first publications on the species, the words (e)-nerolidol, alpha-pinene, bicyclogermacrene, globulol, linalool, spathulenol may indicate chemical composition studies. Terms indicative of biological activities such as “antioxidant activity”, “solar protection factor”, “cytotoxic activities” and “biological activity” in colors ranging from yellowish-green to yellow suggest research trends for these approaches. The xanthocarpa species appears in 2 occurrences, suggesting that they were investigated simultaneously.

**Figure 14** - Scientometric mapping of keywords co-occurrences – *C. guazumifolia*.



Source: Authors.

## 4. Final Considerations

The analyzes of publications indexed in WoS, using bibliometric and scientometric mapping tools, suggest a growing interest in herbal medicines and medicinal plants native to Brazil with potential pharmacological applicability, without losing focus on sustainability and better use of our rich biodiversity, opening up thus a vast field of research that can investigate biological activities for species of the *Campomanesia*. New studies involving native Brazilian plants are welcome, so that they

can both support their traditional use by communities and to open up new possibilities for identification and isolation of compounds for research on new drugs.

## Acknowledgments

This work has been supported by the following Brazilian research agencies: CAPES, CNPq and FAPEG.

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