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Feijoa: scientific research trends and its potential for technological application

ABSTRACT - Feijoa (*Acca sellowiana*) is a fruit native to Brazil that has been attracting increasing interest due to its bioactive and sensory properties. This study aimed to map the scientific production on the species over the last 20 years, identifying emerging trends, potential technological applications of its different parts, and knowledge gaps. A bibliometric analysis was performed using the results obtained from a search in the Web of Science platform using combinations of keywords and Boolean operators ("feijoa" OR "Acca sellowiana" OR "Acca sellowiana (O. Berg) Burret" OR "A. sellowiana" OR "Feijoa sellowiana") in the title, abstract, and keyword fields, excluding review articles. In total, 244 articles were identified, distributed across more than 40 research areas, with Brazil standing out, accounting for 95 publications. The applications described include the use of different fruit fractions to produce fermented beverages, jams, flours, and biodegradable films, as well as the extraction of pectin and essential oils, both of which exhibit antioxidant activity and a high content of phenolic compounds. The most established themes involve bioactive compounds, processing, and post-harvest quality, while terms such as "gut microbiota" and "silver nanoparticles" represent emerging trends. The mapping revealed gaps, particularly in the scarcity of in vivo studies, sensory analyses, and large-scale applications.

Index terms: *Feijoa sellowiana*, Brazilian native fruit, by-product valorization.

Feijoa: tendências de pesquisas científicas e seu potencial de aplicação tecnológica

RESUMO - A feijoa (*Acca sellowiana*) é uma fruta nativa do Brasil que tem despertado crescente interesse devido às suas propriedades bioativas e sensoriais. Este estudo teve como objetivo mapear a produção científica sobre a espécie nos últimos 20 anos, identificando tendências emergentes, potenciais aplicações tecnológicas de suas diferentes partes e lacunas do conhecimento. Foi realizada uma análise bibliométrica com base nos resultados obtidos na busca no Web of Science, utilizando-se combinações de palavras-chave e operadores booleanos ("feijoa" OR "*Acca sellowiana*" OR "*Acca sellowiana* (O. Berg) Burret" OR "A. sellowiana" OR "Feijoa sellowiana") nos campos de título, resumo e palavras-chave, excluindo artigos de revisão. Foram identificados 244 artigos, distribuídos em mais de 40 áreas de pesquisa, com destaque para o Brasil, responsável por 95 publicações. As aplicações descritas abrangem o uso de diferentes frações da fruta para elaborar bebidas fermentadas,

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geleias, farinhas, filmes biodegradáveis, além da extração de pectina e óleo essencial, ambos tendo atividades antioxidantes e elevado teor de compostos fenólicos. Os temas mais consolidados envolvem compostos bioativos, processamento e qualidade pós-colheita, enquanto termos como "*gut microbiota*" e "*silver nanoparticles*" representam tendências emergentes. O mapeamento evidenciou lacunas, especialmente aquelas relacionadas à escassez de estudos in vivo, análises sensoriais e aplicações em larga escala.

Termos para indexação: *Feijoa sellowiana*, fruta nativa brasileira, valorização de subprodutos.

INTRODUCTION

Fruit production in Brazil stands out for its remarkable biodiversity, which encompasses approximately 15% of all plant species worldwide (Morais et al., 2022). Although a large part of the country's fruit production is comprised of exotic species, there is a wide variety of native fruit species, primarily from the Myrtaceae family. These have significant economic and commercial potential and are a rich source of secondary metabolites involved in plant defense, such as polyphenols (Donado-Pestana et al., 2018).

One of the species in the Myrtaceae family is the feijoa [*Acca sellowiana* (O. Berg) Burret], which has sparked the interest of researchers and consumers in recent years (Gambin et al., 2023). Studies from different countries have highlighted the bioactive potential of feijoa and its by-products, including leaves and flowers (Mosbah et al., 2019; Montoro et al., 2020), as well as the fruit in its entirety, including pulp, peel, and seeds (Almeida et al., 2020; Guerra-Ramírez et al., 2021; Wanderley et al., 2022). Feijoa is classified as a pome-type pseudofruit, with an oval shape, ranging from 3 to 5 cm in diameter and 4 to 10 cm in length, and weighing between 20 and 250 g. The peel varies in shade from green to greenish-white and can be smooth, semi-wrinkled, or rough, while the pulp is icy white (Clerici & Carvalho-Silva, 2011).

In Brazil, since 1996, feijoa genetic improvement has been carried out by the Agricultural Research and Rural Extension Company of Santa Catarina (Epagri) with the aim of planting on a commercial scale and optimizing the fruit's characteristics, such as sensory aspects and pulp yield, mainly because genotypes from different locations show significant differences in the physical and chemical factors that are important for fresh consumption and processing (Sganzerla et al., 2020a). Promoting the use of these under-exploited species is essential for preserving Brazilian biodiversity. Recently, one of the strategies adopted to value, protect, and recognize the potential of feijoa is the promotion of feijoa-based food products, considering that, despite its rich bioactive composition, feijoa is a highly perishable fruit, and processing it is highly recommended to increase its shelf life. Products such as chutney, ice cream, jelly, wine and processed feijoa by-products are widely accepted because they retain the *terroir* flavor of the fruit, i.e., a sweet and highly aromatic taste (Amaral et al., 2019), and this fact creates an opportunity for the food processing industry.

Although the feijoa pulp and peel are the most widely used fractions in product development, other parts of the fruit, such as seeds, leaves, and flowers, also exhibit promising bioactive properties and potential for technological applications. Therefore, it is essential to understand how all fractions of the fruit, its derived products, and its compounds have been explored in the scientific literature to identify the state of the art in this research field and to define the objectives of future studies. Thus, it is possible to establish a solid foundation for advancing knowledge that enhances the value of feijoa and enables extending this knowledge from the academic world to the industrial sector.

Currently, exploration research using search tools is used in review studies to map the publication's profile and identify trends and emerging areas. Bibliometric analysis has become an important methodological tool for systematically mapping scientific production, allowing the identification of publication

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patterns, research trends, collaboration networks, and emerging topics within a given field. In addition to providing quantitative indicators of scientific activity, bibliometric approaches also support a deeper understanding of how knowledge evolves and which themes drive research development. This approach has already been applied to investigate scientific trends in several fruit species, such as *Syzygium malaccense* (Pazzini et al., 2021), *Eugenia pyriformis* (Sganzerla & Silva, 2022), *Psidium cattleyanum* (Santos et al., 2024), among others. However, despite the growing scientific interest in feijoa, no comprehensive bibliometric study has yet systematically mapped the evolution of research on this species and its technological applications.

Therefore, this study aims to perform a bibliometric analysis of the scientific literature on feijoa (*Acca sellowiana*), with the objective of identifying publication trends, research hotspots, and emerging themes related to this species. Based on this bibliometric mapping, the study also provides a critical synthesis of the technological applications reported in the retrieved studies, highlighting how different fractions of the fruit have been explored and identifying potential research gaps and future perspectives.

METHODOLOGY

The bibliometric analysis was conducted using an advanced search in the Web of Science© (WoS) database in February 2025. The search strategy involved combining keywords by using Boolean operators: "feijoa" OR "*Acca sellowiana*" OR "*Acca sellowiana* (O. Berg) Burret" OR "A. sellowiana" OR "Feijoa sellowiana", applied to the title, abstract, and keyword fields. A filter based on document type was applied to include only original research articles. Review papers, conference proceedings, book chapters, editorial materials, and other non-article documents were excluded to ensure analytical consistency and to focus exclusively on experimental studies reporting primary data related to *Acca sellowiana*. The initial search yielded 256 documents, from which duplicate records and those that did not directly address *Acca sellowiana* were removed, resulting in 244 articles selected for analysis. The data were extracted and processed using VOSviewer software (version 1.6.19), which was employed to create graphs of the co-occurrence of keywords and the collaboration network between countries.

Study limitations

This bibliometric analysis is subject to methodological constraints that should be acknowledged to ensure transparency and support a balanced interpretation of the results. First, the exclusive use of the Web of Science (WoS) database may introduce database-related selection bias, as studies indexed exclusively in other databases (e.g., Scopus, PubMed, or regional indexing systems) were not included in the dataset. The WoS database is widely recognized for its rigorous indexing standards, high-quality metadata, and structured citation records. Although it has been adopted as a sole data source in previous bibliometric investigations (Ampese et al., 2022; Rosa et al., 2022; Marinho et al., 2023), it is important to recognize that no single database ensures exhaustive coverage of global scientific output. Consequently, the findings should be interpreted within the scope of the selected indexing platform.

Second, the study is inherently influenced by search string sensitivity. Despite the inclusion of multiple taxonomic denominations, synonyms, and abbreviations for *Acca sellowiana*, variations in terminology, uncommon synonyms, spelling inconsistencies, or indexing inaccuracies may have limited the retrieval of some relevant publications. Bibliometric analyses are intrinsically dependent on database metadata quality, keyword standardization, and authors'

reporting practices, which may affect the comprehensiveness of the dataset.

Third, the time frame of the study (2005–2025) represents a methodological choice aligned with the technological focus of the present investigation. This period was deliberately defined to prioritize contemporary scientific production and to better capture recent advances in food technology, functional applications, and value-added product development involving *Acca sellowiana*. While this approach enhances the relevance of trend analysis in the context of technological development, it may have excluded earlier foundational or botanical studies that contributed to the scientific consolidation of the species.

Finally, it is important to note that the inclusion of the year 2025 corresponds to partial publication data (January–February 2025), reflecting the period in which the search was conducted. Therefore, publication counts for 2025 should be interpreted cautiously, as they do not represent the complete annual scientific output.

BIBLIOMETRIC ANALYSIS OF THE ARTICLES

Evolution of searches and keywords over time

Figure 1 illustrates the evolution of the number of publications since 2005, categorized by the leading Web of Science (WoS) research categories. There were fewer publications between 2005 and 2011, with an average of 5 per year, primarily in the categories of Plant Sciences, Horticulture, and Food Science and Technology. The central studies in these categories mainly focused on plant biotechnology

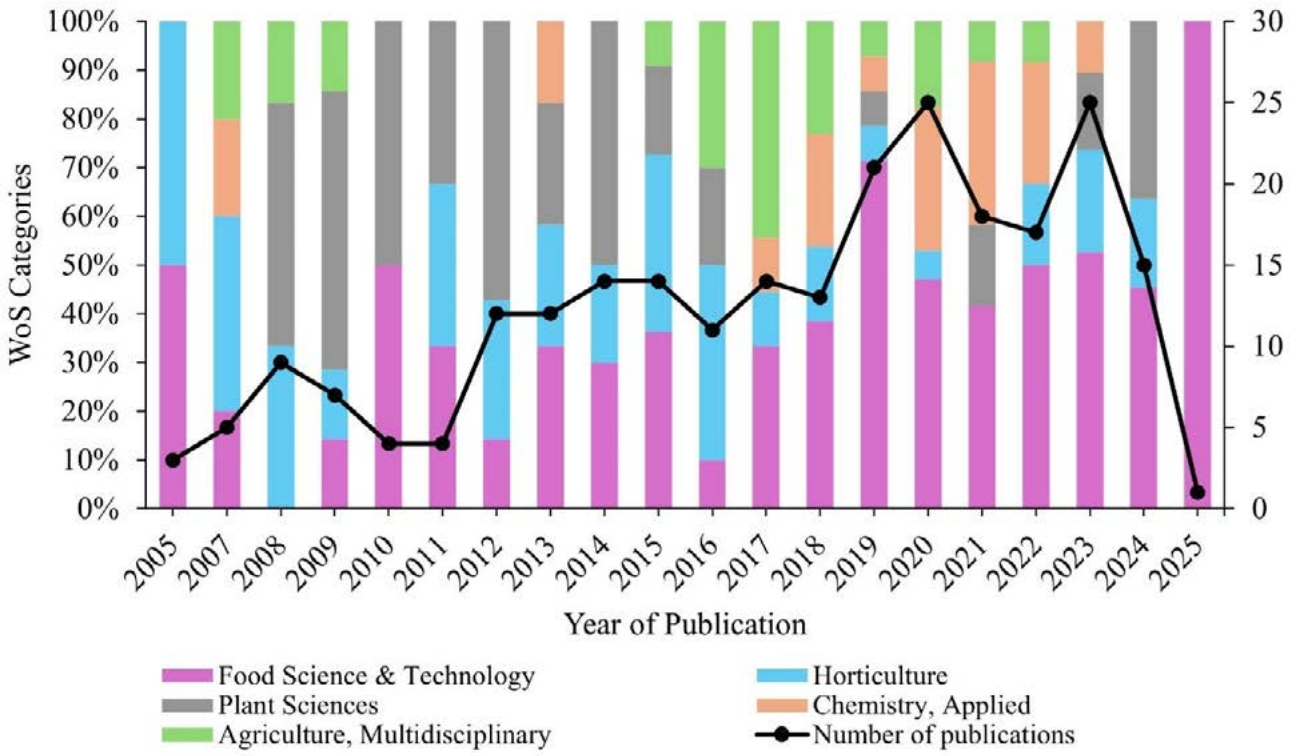


Figure 1. Annual evolution of publications on feijoa and their distribution in the five main categories of the Web of Science since 2005.

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and somatic embryogenesis, with the aim of genetic improvement and the production of higher-quality seeds (Cangahuala-Inocente et al., 2007; Correia & Canhoto, 2010). Other studies addressed fruit growth, as well as plant management and post-harvest technologies (East et al., 2009; Velho et al., 2011).

During the same period, several studies in the Food Science and Technology category have already explored the bioactive potential of feijoa, focusing on its antibacterial, antifungal, and anti-inflammatory properties (Rossi et al., 2007; Basile et al., 2010). From 2012 onwards, there was a significant increase in annual publications, followed by relative stability until 2018, with an average of 13 publications per year. Most publications from this period are distributed in the same categories as those from 2005 to 2011, with the Food Science and Technology category standing out, where studies have been conducted on the composition and bioactive potential of feijoa leaves and seeds (Andrade et al., 2012; Poodi et al., 2018). In addition, the first studies began to emerge, exploring feijoa juice and optimizing its shelf life by inactivating unwanted enzymes, as well as its application as a probiotic carrier and its sensory analysis with populations from different countries (Ngo et al., 2013; Duong et al., 2015; Valero-Cases et al., 2017). Additional studies have also emerged, focusing on the post-harvest aspects of the fruit (Castellanos et al., 2016).

In 2019, there was another significant increase in the number of publications, bringing the average to 20 per year between 2019 and 2024, with 2020 and 2023 standing out as having the highest volume of publications (n = 25). During this period, publications were distributed between the Food Science and Technology and Applied Chemistry categories. Within these categories, the most recent studies have explored characterization. Other studies published during this period explored the potential of feijoa by-products, such as the potential resulting from the extraction of pectin from the peel (Zhu et al., 2023) and the antimicrobial potential of the essential oil extracted from both the peel and leaves (Angane et al., 2024). Other studies have explored the fruit as a whole or the production of products with marketing potential using its pulp, such as feijoa jelly enriched with vitamin D (Melo et al., 2021).

Figure 2 shows the co-occurrence analysis of the most used keywords among the 244 documents retrieved in the search (Figure 2a) and the use of these words over the last 20 years (Figure 2b). This analysis aims to understand the evolution of themes over the years by grouping the most used keywords; in this case, for the 244 publications, this study used the criterion of using the keyword at least twice. Out of 840 keywords, 110 were linked to another word, and these words were grouped into 19 sets (Figure 2a).

In addition to the terms used in the search, such as "*Acca sellowiana*" and "feijoa", the most frequently used keywords in the publications were "antioxidant activity", "Myrtaceae", "pineapple guava", "phenolic compounds", "antimicrobial activity", and "bioactive compounds". Furthermore, the strongest themes associated with *Acca sellowiana* involve its bioactive composition, specifically "phenolic compounds" and "antioxidant activity". These terms are related to secondary terms that indicate the application of these compounds, such as "food conservation", "gut microbiota", "antimicrobial activity", and "silver nanoparticles".

In Figure 2b, the same network of terms is shown, colored according to the evolution of the publications, as indicated by the color scale (2012–2022). The results show that it is possible to identify the themes of the initial studies before 2015 (blue shades), which focused on the propagation of the species and its genetic improvement ("germination", "somatic embryogenesis", "epigenetics"), ripening time ("ripening", "ethylene inhibition", "carbon dioxide"), storage conditions and its chemical composition ("starch", "fatty acids"). It was observed that publications prior to 2015 were predominantly focused on agronomic and botanical aspects, including plant

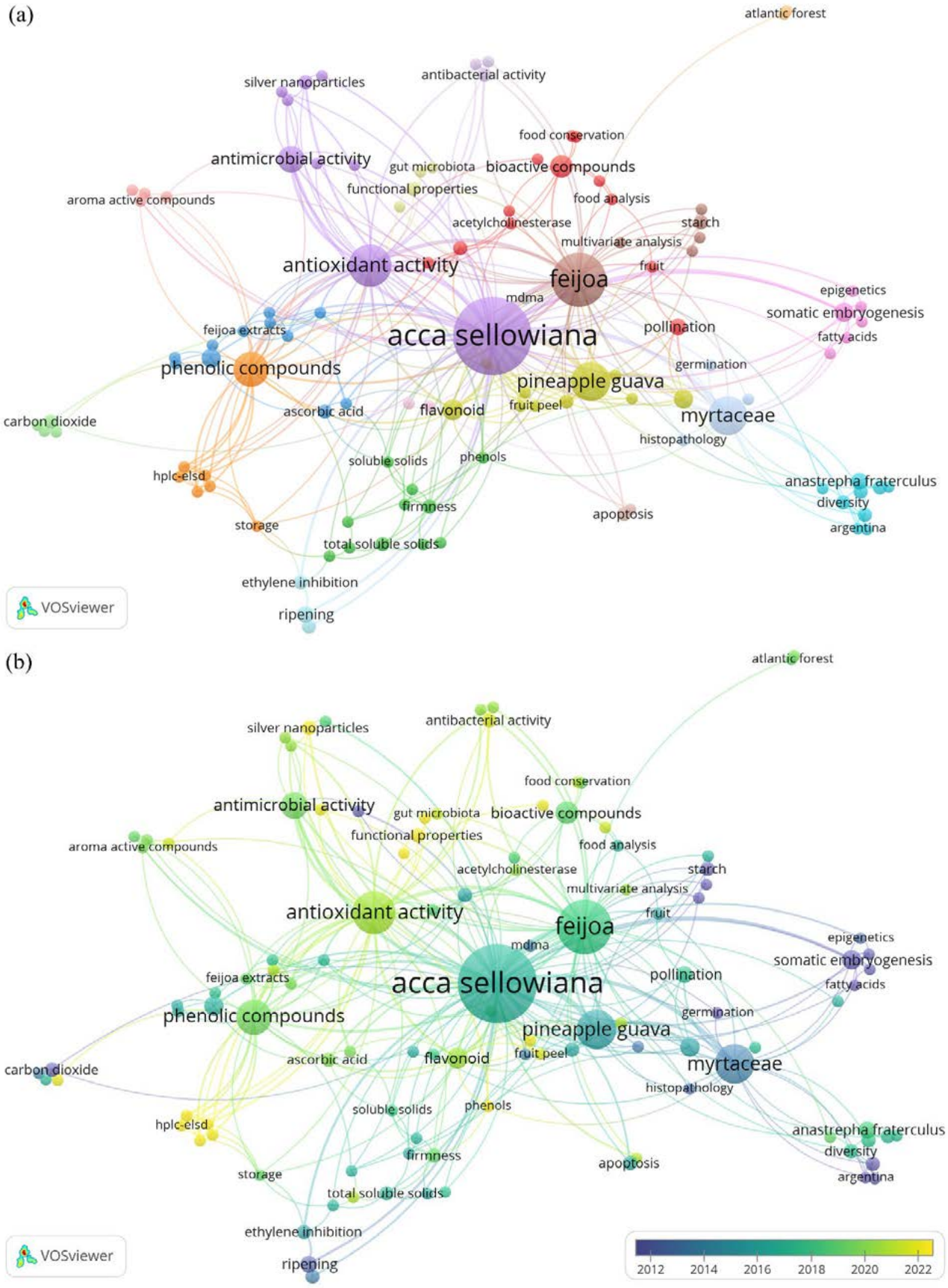


Figure 2. Co-occurrence of keywords used at least twice over time in publications on feijoa: (a) keywords used at least twice among the 244 publications; (b) use of keywords over the years.

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physiology, cultivation practices, and genetic characterization. The keywords present during this period were more strongly linked to plant development, fruit yield, and regional adaptation, reflecting fundamental research efforts.

In the papers published between 2016 and 2019 (greenish tones), there are still some themes related to the conservation of the species and post-harvest ("diversity", "*anastrepha fraterculus*", "storage", "firmness", "total soluble solids"), which are linked to the themes explored before 2015, but other studies have already begun to explore the fruit's bioactive compounds, as well as its antioxidant and antimicrobial properties ("feijoa extract", "flavonoid", "phenolic compounds", "antimicrobial activity", "aroma active compounds"). Therefore, between 2016 and 2019, a transition towards chemical characterization and bioactive compounds became evident. The use of terms related to antioxidant activity, phenolic compounds, extraction methods, and post-harvest quality has gained prominence, indicating a growing interest in the fruit's functional properties.

In the most recent research, following 2020 (yellowish tones), there is a trend towards new applications for feijoa and the use of more advanced technologies for its characterization ("HPLC-ELSD", "gut microbiota", "silver nanoparticles", "functional properties"). These data highlight the relevance of feijoa in functional foods and the development of products with added value as a natural source of antioxidants and a potential raw material for new food and pharmaceutical products. From 2020 onwards, research trends have increasingly shifted towards technological innovation and applied food science. In the overlay view, keywords associated with product development, functional foods, encapsulation, and sustainability appeared in more recent publications. This suggests a consolidation of technology and innovation-oriented research, aligning with global trends in functional food development and agro-industrial valorization. This temporal progression demonstrates a shift from foundational agronomic studies to a more application-driven, technology-oriented research landscape, highlighting the relevance of feijoa in functional foods and the development of products with added value as a natural source of antioxidants and as a potential raw material for new food and pharmaceutical products.

Collaboration between countries, primary affiliations, and authors

The international collaboration network between the most productive countries was analyzed through co-authored publications (Figure 3). Brazil stands out as the most productive country in the area with 95 documents, followed by New Zealand (n = 34), Italy (n = 28), Colombia (n = 24) and Iran (n = 19), which are also the leading countries that have established partnerships with each other.

This result is related to the fact that feijoa is native to Brazil, which encourages research in that area. Furthermore, other factors may strongly influence Brazil's leadership in this field of research, such as data from the long-term genetic improvement program collected by the Agricultural Research and Rural Extension Company of Santa Catarina (Epagri), which, since the 1990s, has played a central role in promoting the cultivation and scientific research of feijoa in Brazil. These initiatives have strengthened academic and institutional networks and stimulated applied research focused on fruit quality, post-harvest performance, and technological applications.

Besides that, incentive and development policies have resulted in a growing national interest in valuing native Brazilian fruits and underutilized species, such as those of the Arecaceae family (Morais et al., 2022), or specific species such as *Eugenia gracillima* (Feitosa et al., 2023), *Eugenia pyriformis* (Ferreira et al., 2024), *Passiflora caerulea* L. (Wanderley et al., 2024), and even pioneering studies with other species, such as *Plinia edulis* (Vell.) Sobral (Pazzini et al.,

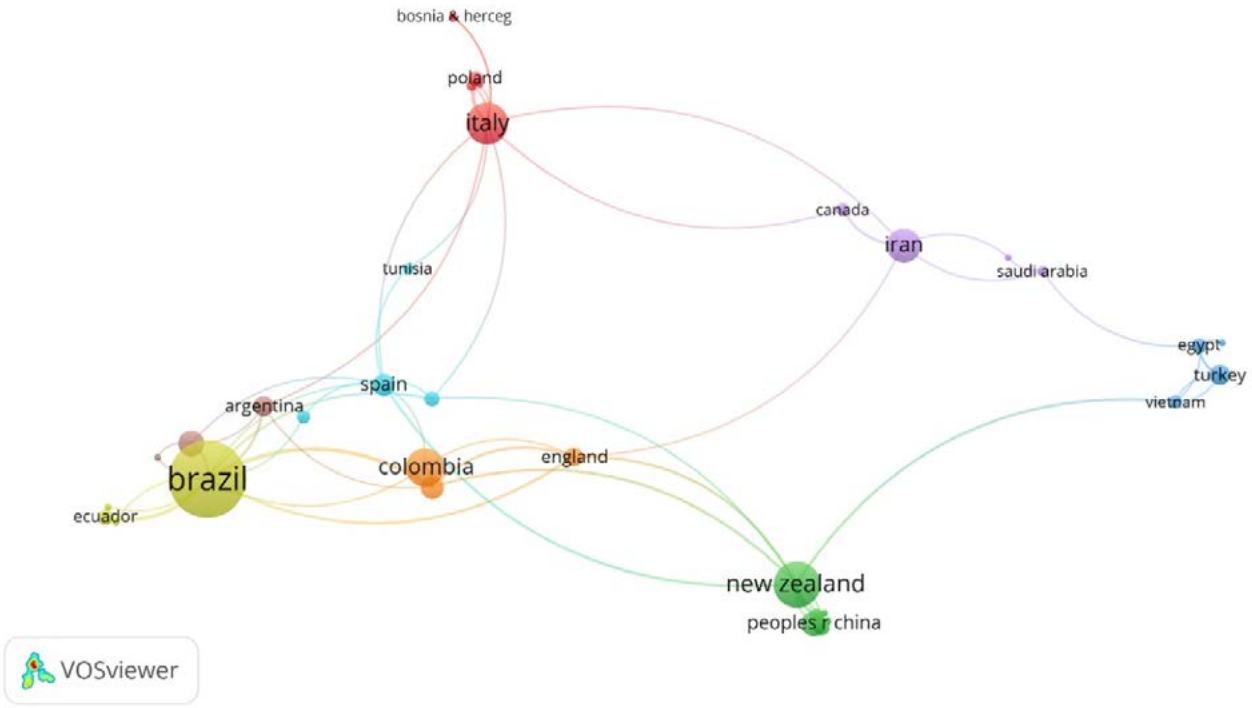


Figure 3. Collaboration network between countries based on co-authorship of feijoa publications.

2025), for example. This growing literature on native Brazilian fruits may also be one of the factors contributing to Brazil's prominence in feijoa research. Therefore, Brazil's leadership likely reflects a combination of biological origins, institutional support, initiatives aimed at genetic improvement, and broader movements toward valuing biodiversity and sustainable agro-industrial development.

Feijoa cultivation is already well established in New Zealand, with the country's annual production reaching 800 tons (Zhu, 2018). The fruit is also widely marketed and exported in Colombia (Moretto et al., 2021). Countries with fewer or smaller connections, such as Spain (n = 8) and Turkey (n = 7), represent opportunities to expand research through collaborations and/or investments.

Table 1 presents the 10 most prominent affiliations and the 10 authors with the highest number of publications. As shown in Figure 3, Brazil stands out in terms of the number of affiliations, with four universities represented in the ranking. In first place is the Federal University of Santa Catarina, which is also the affiliated institution of the two authors with the highest number of publications: Nodari, R. O., and Guerra, M. P., with 21 and 19 publications, respectively. These two authors maintain a strong collaboration, with 33 co-authored papers. The concentration of publications in institutions such as the Federal University of Santa Catarina (UFSC) and the University of São Paulo (USP) may be associated with consolidated research groups and long-standing institutional collaborations, as well as structured research programs in food science and agricultural sciences, since both universities appear together in affiliations of different studies (Cangahuala-Inocente et al., 2009, 2014; Pescador et al., 2012). Furthermore, feijoa cultivation is well adapted to southern and southeastern Brazil, which may facilitate field experimentation (Bokelmann, 2026). However, the concentration in these regions may also reflect regional research dynamics and potential geographical biases in scientific production, highlighting the importance of expanding collaborative networks to other regions and institutions.

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Table 1. Ranking of the main affiliations and authors in the 244 documents on feijoa.

Ranking	Affiliations	Publications	%(1)
1st	Federal University of Santa Catarina (Brazil)	47	19.26
2nd	University of São Paulo (Brazil)	17	6.97
3rd	University of Auckland (New Zealand)	16	6.55
4th	National University of Colombia (Colombia)	13	5.33
5th	Mazandaran University of Medical Sciences (Iran)	11	4.50
6th	University of the Republic of Uruguay (Uruguay)	11	4.51
7th	Santa Catarina State University (Brazil)	11	4.51
8th	Tehran University of Medical Sciences (Iran)	10	4.10
9th	Federal University of Rio Grande do Sul (Brazil)	9	3.69
10th	University of Naples Federico II (Italy)	9	3.69
Ranking	**Authors**	**Publications**	**%(1)**
1st	Nodari, R.O.	21	8.61
2nd	Guerra, M.P.	19	7.79
3rd	Amarante, C.V.T.	10	4.10
4th	Santos, K.L.	10	4.10
5th	Basile, A.	9	3.69
6th	Ducroquet, J.P.H.J.	9	3.69
7th	Ebrahimzadeh, M.A.	9	3.69
8th	Steffens, C.A.	9	3.69
9th	Donazzolo, J.	8	3.27
10th	Pescador, R.	8	3.27

(1)Percentage generated by Web of Science.

As shown in Figure 3, the universities that are part of the collaboration network between the countries are listed as the most prominent in the area, with the University of Auckland and the National University of Colombia standing out as the principal collaborators in the field. These partnerships can favor interdisciplinary approaches that help broaden the scope of feijoa studies. Applying the knowledge generated by these collaborations can lead to the development of new products and the improvement of fruit cultivation and processing strategies.

Most cited articles

Table 2 shows the 10 most cited articles in the area. The article Fungal Planet Description Sheets: 868-950, published in 2019 in *Persoonia – Molecular Phylogeny and Evolution of Fungi*, received 182 citations. The authors conducted the genetic sequencing of new species of fungi from different countries. Regarding fungi in feijoa, a new species of *Colletotrichum* was identified in Portugal, the *Colletotrichum feijoicola*, which was associated with reddish spots on the leaves of *Acca sellowiana* (Crous et al., 2019).

The second article in the ranking – Total Phenolic Compounds and Antioxidant Capacity of Leaf, Dry Fruit and Fresh Fruit of Feijoa (*Acca sellowiana*, Myrtaceae) –, published in the *Journal of Medicinal Plants Research*, received 110 citations. The authors found a high antioxidant potential in the methanolic extracts of the leaves, the dry fruit and the fresh fruit, and their

Table 2. Ten most cited articles among the 244 publications on feijoa.

Ranking	Title	Journal	Total citations	Reference
1st	Fungal Planet Description Sheets: 868–950	Persoonia – Molecular Phylogeny and Evolution of Fungi	182	Crous et al. (2019)
2nd	Total Phenolic Compounds and Antioxidant Capacity of Leaf, Dry Fruit and Fresh Fruit of Feijoa (Acca sellowiana, Myrtaceae)	Journal of Medicinal Plants Research	110	Beyhan et al. (2010)
3rd	Nutritional Bioactive Compounds and Technological Aspects of Minor Fruits Grown in Brazil	Food Research International	106	Clerici & Carvalho-Silva (2011)
4th	Investigating the Host-Range of the Rust Fungus Puccinia psidii Sensu Lato Across Tribes of the Family Myrtaceae Present in Australia	PLOS One	97	Morin et al. (2012)
5th	Feijoa sellowiana Derived Natural Flavone Exerts Anti-Cancer Action Displaying HDAC Inhibitory Activities	The International Journal of Biochemistry & Cell Biology	90	Bontempo et al. (2007)
6th	5-Azacytidine combined with 2,4-D Improves Somatic Embryogenesis of Acca sellowiana (O. Berg) Burret by means of Changes in Global DNA Methylation Levels	Plant Cell Reports	86	Fraga et al. (2012)
7th	Correlation between Sun Protection Factor and Antioxidant Activity, Phenol and Flavonoid Contents of Some Medicinal Plants	Iranian Journal of Pharmaceutical Research	86	Ebrahimzadeh et al. (2014)
8th	A New Subtribal Classification of Tribe Myrteae (Myrtaceae)	Systematic Botany	73	Lucas et al. (2019)
9th	Bioactive Food Packaging Based on Starch, Citric Pectin and Functionalized with Acca sellowiana Waste By-Product: Characterization and Application in the Postharvest Conservation of Apple	International Journal of Biological Macromolecules	68	Sganzerla et al. (2020c)
10th	Effect and Analysis of Phenolic Compounds during Somatic Embryogenesis Induction in Feijoa sellowiana Berg	Protoplasma	58	Reis et al. (2008)

potentials were comparable to those of standard antioxidants such as α-tocopherol. A peroxidation inhibition potential of more than 70% was also observed for the three extracts. The authors highlight the potential of feijoa as a source of natural antioxidants for the pharmaceutical industry (Beyhan et al., 2010).

The article Nutritional Bioactive Compounds and Technological Aspects of Minor Fruits Grown in Brazil ranked third with 106 citations. Published in *Food Research International*, the authors detailed the post-harvest characteristics of feijoa and the ideal storage conditions. In refrigerated storage (4°C), the shelf life of feijoa was estimated at 30 days, while at room temperature (around 20°C), it was reduced to five days (Clerici & Carvalho-Silva, 2011).

In fourth place, the article titled Investigating the Host-Range of the Rust Fungus *Puccinia psidii* Sensu Lato across Tribes of the Family Myrtaceae Present in Australia, published in PLOS One, received 97 citations. In this study, the authors focused on the fungus *Puccinia psidii*,

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which is known to be a pathogen in plants of the Myrtaceae family, prevalent on the Australian continent. It was observed that feijoa might have a potential for moderate resistance to contamination by this species of fungus, showing only the presence of small spots (Morin et al., 2012).

The article in fifth place, titled *Feijoa sellowiana* Derived Natural Flavone Exerts Anti-Cancer Action Displaying HDAC Inhibitory Activities, was published in The International Journal of Biochemistry & Cell Biology and received 90 citations. When analyzing the acetone extract of feijoa, the authors found an anti-cancer potential, indicating that the extract induces the death of cancer cells without showing toxicity. When the extract was purified, it was observed that, in addition to other components, the flavone was the compound responsible for inhibiting histone deacetylases. This inhibition is associated with the regulation of genes involved in cell death (Bontempo et al., 2007).

In sixth place, the article titled 5-Azacytidine combined with 2,4-D Improves Somatic Embryogenesis of *Acca sellowiana* (O. Berg) Burret by means of Changes in Global DNA Methylation Levels received 86 citations and was published in Plant Cell Reports. The authors investigated how the application of a DNA methylation inhibitor, in conjunction with a plant growth regulator, affects the ability of feijoa cells to form somatic embryos. It was observed that 2,4-D induces embryogenesis by increasing global methylation, while AzaC can both stimulate the formation of embryos and negatively affect their conversion to viable plants (Fraga et al., 2012).

The article in seventh place, titled Correlation between Sun Protection Factor and Antioxidant Activity, Phenol and Flavonoid Contents of some Medicinal Plants, which was published in the Iranian Journal of Pharmaceutical Research, received 86 citations. In this study, the sun protection potential of feijoa extract was tested. However, a low sun protection value was found (1.30). The authors suggest that there may be a correlation between the content of phenolic compounds and the sun protection factor, indicating feijoa extract as an additive in sunscreen formulations (Ebrahimzadeh et al., 2014).

In eighth place, published in Systematic Botany, the article A New Subtribal Classification of Tribe Myrteae (Myrtaceae), with 73 citations, discusses a proposal to reclassify the genus of feijoa/goiaba-serrana as *Feijoa sellowiana* (O. Berg) – this species belonged to the genus *Acca*. However, the authors' genetic analyses showed that *Acca* encompassed plants that were not closely related evolutionarily, not forming a natural group (Lucas et al., 2019).

The ninth most cited article, Bioactive Food Packaging Based on Starch, Citric Pectin and Functionalized with *Acca sellowiana* Waste By-Product: Characterization and Application in the Postharvest Conservation of Apple, was published in the International Journal of Biological Macromolecules and received 68 citations. In this study, the incorporation of feijoa peel into biodegradable films improved their physicochemical, antioxidant and antimicrobial properties. In addition, the packaging maintained the quality of apples stored at room temperature for 15 days (Sganzerla et al., 2020c).

Finally, in tenth place, with 58 citations, the article Effect and Analysis of Phenolic Compounds during Somatic Embryogenesis Induction in *Feijoa sellowiana* Berg, published in Protoplasma, explored the effect of the presence of different phenolic compounds on the somatic embryogenesis of feijoa. It was observed that caffeic acid, for example, increased embryo induction, while the presence of phlorizin can inhibit embryo development beyond the globular stage. Results like these are essential for contributing to the propagation of the species and optimizing cultivation systems (Reis et al., 2008).

Given these findings, feijoa has been studied in a wide variety of fields, ranging from

agronomy, biology, and food technology, to medicine, from its genetic improvement to the fungal pathogens that can attack the species, including the application of its by-products in innovative technologies and its bioactive potential against cancer cells, demonstrating the wide diversity of applications in which the fruit can be used.

TECHNOLOGICAL APPLICATIONS OF FEIJOA AND ITS BY-PRODUCTS

Research trends show that all parts of the feijoa fruit have interesting characteristics and different potential applications, so the utilization of feijoa by-products is also encouraged, as it generates technological products that can be applied in various areas of the food production chain and in other industries (Castelucci et al., 2020). As shown in Figure 1, in the last five years, most of the published articles belonged to the category of Food Science & Technology. Based on the dataset obtained through the bibliometric search strategy, the most relevant studies from the last five years were analyzed to synthesize the main technological applications reported for different fractions of the feijoa fruit and are discussed in this section. Figure 4 summarizes the main results of these studies, highlighting which products and by-products are derived from each part of the fruit studied, along with their main chemical characteristics. The technological applications described in the literature reflect the thematic evolution identified in the bibliometric analysis. Keywords such as “phenolic compounds”, “antioxidant activity”, “gut microbiota”, “silver nanoparticles”, and “functional properties” indicate that research on feijoa has progressively shifted from basic compositional studies toward the development of functional ingredients, innovative food products, and bio-based materials.

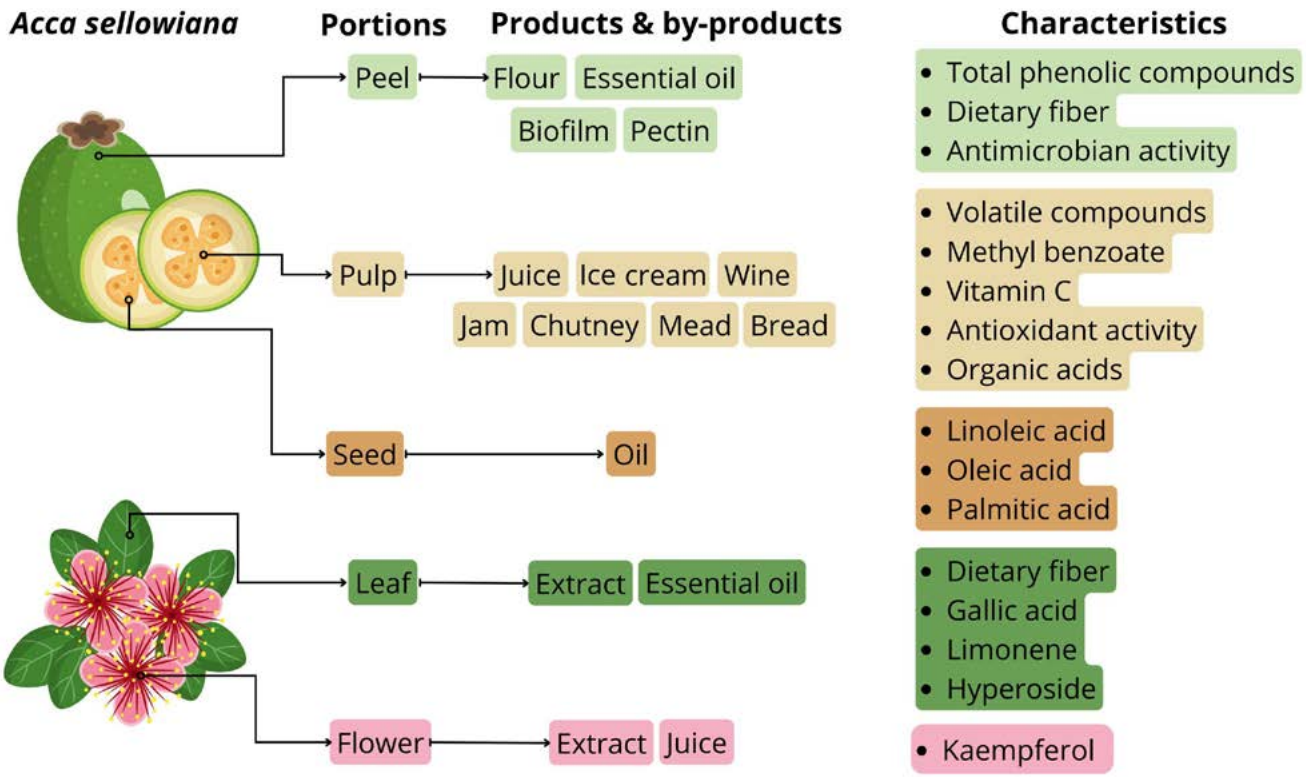


Figure 4. Main characteristics of feijoa derivatives and by-products.

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Pulp

The feijoa pulp, which is the central edible part of this fruit, has low yield, high perishability, and a tendency to enzymatic browning (Zhu, 2018). The development of new technological applications for feijoa must focus on overcoming these intrinsic challenges of this fruit. Processing for juice production stands out as the main alternative for adding value to the pulp. In this context, Schmidt et al. (2021) evaluated the influence of three enzyme complexes (Pectinex®, Lallzyme®, and Rohapect®) on the yield of juice extracted from feijoa pulp. The results indicated that the addition of Pectinex® (10 U/mL) during the pulping stage increased the juice yield by 26.60% compared to juice produced without the addition of this enzyme. This approach mitigates low pulp yield, but may also affect the economic viability of the process.

A crucial point in the industrialization of feijoa juice is the preservation of its sensory and nutritional attributes. Given this fact, and as shown in Figure 2, keywords like “aroma active compounds” may be related to the study by Peng et al. (2020), which determined the volatile composition of feijoa juices from four cultivars (Unique, Apollo, Wiki Tu, and Opal Star) using the HS-SPME-GC-MS technique. This approach identified 63 volatile compounds, with esters (25 compounds) and terpenes (5 monoterpenes and 20 sesquiterpenes) standing out as the main groups detected. Methyl benzoate was identified as the predominant component in the feijoa juices analyzed, followed by (3Z)-3-hexenyl acetate and ethyl butanoate. Even though this characterization is essential to product standardization, the stability of those volatile compounds during storage remains a scientific gap, and it is essential to ensure consumer satisfaction.

In this sense, Schmidt et al. (2022), by including direct links to the keywords “storage” and “ascorbic acid”, as shown in Figure 2, sought to fill this gap regarding processing methods and the stability of other important bioactive compounds. They observed that, over 90 days, there was a 75% reduction in the vitamin C content, and carotenoids were no longer detected after 30 days of storage. However, some phenolic compounds remained stable over time in the enzyme-treated and pasteurized juice. Although the stability of some phenolic compounds has been maintained, the sharp decline in essential antioxidants underscores the pressing need to investigate non-thermal processing technologies or more effective encapsulation methods to ensure the nutritional quality of the juice throughout its storage.

In addition to technological processing strategies and volatile compound characterization, other studies have explored the sensory attributes and culinary potential of feijoa pulp. Amaral et al. (2019) performed a physicochemical and sensory characterization of four feijoa cultivars and observed considerable differences between them, particularly in flavor profile and soluble solids content. This study might be directly connected with the keywords “total soluble solids” found in Figure 2. The Helena cultivar stood out for producing larger fruits, higher soluble solids content, and more intense floral and sweet sensory notes than the other cultivars. These attributes reinforce the unique sensory identity of feijoa, often described as having a *terroir*-like flavor profile. Beyond characterization, the authors also demonstrated the feasibility of incorporating feijoa into various gastronomic preparations, such as chutney, sorbet, compote, and spice powder, highlighting its versatility as a culinary ingredient. The study also indicated that processing techniques such as oven drying and osmotic dehydration might represent promising strategies for diversifying the use of feijoa pulp and extending its applications within gastronomy and small-scale agro-industrial production.

Similarly, still in the area of preservation and processing of feijoa pulp to extend its shelf life and directly linked to the words “ascorbic acid” and “phenolic compounds” shown in

Figure 2, Henao-Ardila et al. (2019) developed a method for producing feijoa pulp powder. This method involved a combination of freeze-drying and spray-drying processes. The results showed that the powdered pulp obtained had a high retention of polyphenols (25.95%) and vitamin C (47.28%). Freeze-drying is known for its ability to preserve thermolabile compounds, but it has disadvantages, such as high operating costs and long processing times. Spray drying, on the other hand, is faster and more economical, but the high temperatures can degrade nutrients. The combination of both techniques sought a balance between efficiency and quality.

On the other hand, Castro et al. (2023) investigated the effects of different convective drying conditions on slices of whole feijoa fruit. They observed that an average temperature (49.79 ºC), combined with a high air velocity (1 m/s), avoided significant losses in polyphenol content. Convective drying is a simpler and more industrially accessible method, but prolonged exposure to oxygen and heat can lead to nutritional losses and color changes.

When synthesizing the available evidence on technological processing strategies for feijoa pulp, several methodological and technological gaps become evident. The main challenges in processing feijoa pulp include low yield, high perishability, and susceptibility to enzymatic browning, all of which directly impede technological utilization. Key findings indicate that juice production is a major alternative for value addition, but studies focused on optimizing processing are scarce. Current research shows enzymatic treatments can improve juice yield, though their broad technological and economic impacts require further exploration. Studies have identified important aroma-active compounds in the volatile profile of feijoa juice, but knowledge of how these compounds degrade during storage remains limited. Evidence also shows that antioxidants such as vitamin C and carotenoids are substantially lost during storage, underscoring the need for research on non-thermal processing, improved preservation, or encapsulation to retain the nutritional and sensory qualities of feijoa-derived products.

Beyond pulp processing, preservation techniques such as drying have their own challenges. The main finding is a lack of direct comparative studies using the same raw material to evaluate nutrient retention, the bioavailability of bioactive compounds, and the sensory characteristics of reconstituted products. Additionally, there is limited research on the use of new, milder drying technologies, such as infrared or vacuum microwave drying, which may better preserve sensitive compounds.

Another emerging trend is the use of feijoa pulp as a substrate for fermentation processes, aiming to conserve it and add value. As shown in Figure 2, “gut microbiota” appears as an emerging keyword, reflected in studies such as that of Peng et al. (2024), which showed that enzymatic hydrolysis of feijoa juice, followed by fermentation with five commercial strains of probiotic bacteria, increased the concentration of organic acids, such as quinic acid and adipic acid, and also resulted in a significant increase in gallic acid content. This increase was positively correlated with improved antioxidant capacity of the beverage, especially for the *Bifidobacterium adolescentis* 68 (Bba68) strain, which showed the highest antioxidant activity in the DPPH, ABTS, and FRAP tests.

In addition to fermentation using probiotics, the production of alcoholic beverages is also being explored. Sartori et al. (2020) made an alcoholic fermented feijoa and, after 15 days of fermentation, obtained a feijoa wine with an alcohol content of 9.7%, with a total phenolic content of 104 mg of gallic acid equivalent/100 mL of beverage and with antioxidant activities ranging from 315 to 3.484 mg of Trolox equivalent/100 mL of beverage. In addition, Wanderley et al. (2022) observed that adding feijoa pulp to mead positively affected the composition of organic acids,

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which directly influenced the stability of the beverages produced. The authors emphasized that mead with feijoa pulp had a higher citric acid concentration than mead without added pulp. These studies demonstrate the versatility of feijoa across different fermented matrices, indicating that fermented feijoa can act as an effective vehicle for probiotics and for the flavor and functional composition of the final product.

In addition to beverages, feijoa can also be used as a fortification matrix. Melo et al. (2021) produced zein nanocapsules loaded with vitamin D3 and used feijoa jelly as a food matrix. The authors observed a low release of the vitamin under gastric conditions and a high release under intestinal conditions, concluding that 20 g of the enriched jelly contains around 60% of the recommended daily intake of vitamin D3. Furthermore, adding the nanocapsules did not alter the physicochemical characteristics of the jelly. This application highlights the potential of feijoa in nutrient delivery systems.

Guerra-Ramírez et al. (2021) evaluated the viability of feijoa pulp and peel in jelly production. During processing, a reduction in the antioxidant potential and vitamin C content of feijoa was observed. However, the authors found a total phenolic content of 186 mg of gallic acid equivalent/100 g, while Melo et al. (2021) obtained a content of 139 mg of gallic acid equivalent/100 g. When comparing the results obtained in both studies, it is possible to observe that Guerra-Ramírez et al. (2021) found a higher level of total phenolic compounds. These data corroborate the literature indicating that the peel is a rich source of bioactive compounds, and this suggests that using the whole fruit can maximize the nutritional value of processed products.

In addition to developing new fortified products, researchers have emphasized the incorporation of feijoa as a functional ingredient in foods. In the study conducted by Wang et al. (2023), the authors evaluated the effect of adding insoluble fiber from feijoa pulp in bread production. This study might be related to the keyword “functional properties” in the co-occurrence of keywords. The addition of 8% insoluble fiber resulted in a considerable increase in the content of total phenolic compounds (113.01 mg EAG/100 g). This application demonstrates the feasibility of using by-products from feijoa processing to enrich everyday foods, aligning with circular economy strategies and the development of functional foods.

These findings collectively highlight the technological versatility of feijoa pulp, which can be incorporated into a wide range of food systems, including culinary products, fermented beverages, fortified products, and functional ingredients in staple foods. Such applications demonstrate the potential of the fruit not only to enhance the nutritional and bioactive profile of food products but also to support innovative strategies for the valorization of underutilized fruits and processing by-products. Nevertheless, to fully translate this potential into commercially viable products, further efforts are required to improve preservation strategies, optimize processing conditions, and ensure the stability of key sensory and nutritional attributes. Advancing these aspects will be essential to support the broader industrial application of feijoa and to maximize its contribution to the development of functional and sustainable food products.

Peel

The feijoa peel accounts for approximately 60% of the fruit’s total weight and is generally not consumed, resulting in considerable discarded waste (Zhu, 2018). This topic is closely related to the results of the bibliometric analysis, as the keyword “fruit peel” appeared in Figure 2 as an emerging topic. Recently, studies have been conducted to valorize the technological properties found abundantly in this fraction of the fruit. In the study by Zhu et al. (2023), three different methods for extracting pectin from feijoa peel were evaluated using hot, acidic, and alkaline water. Notably, alkaline water (pH

10) extraction showed a significantly higher extraction yield, reaching 11.61%. In addition, this method showed higher levels of protein (4.06%), of total phenolic compounds (6.32%), and higher degree of acetylation (2.64%).

Zhu et al. (2024) observed that pectin extracted from feijoa peel in a water bath at 100 °C for 4 hours, *in vitro*, interacted with the intestinal microbiota and regulated its composition by increasing the presence of beneficial bacteria such as *Lactiplantibacillus* and *Bifidobacterium*, thus becoming a potential source of probiotics that promote intestinal health. This study also connects with the keywords “gut microbiota”, “feijoa extracts” and “functional properties”, found in the bibliometric analysis as emerging topics.

Regarding methods for pectin extraction from feijoa peel, alkaline extraction yields higher amounts and preserves acetyl groups and phenolic compounds, which enhance antioxidant activity. However, it may require more rigorous neutralization steps. While acid and hot extractions are conventional methods with lower operational costs, they produce lower yields (approximately 7-8%) and carry the risk of degrading heat-sensitive bioactive fractions. However, the pectin extracted by the hot method resisted digestive enzymes and reached the colon.

In the area of feijoa by-product processing, a study by Almeida et al. (2020) investigated the technological properties of flours produced from the mesocarp and epicarp of feijoa. Both flours proved to be rich in dietary fiber, with average contents of 45% and 48% respectively. In addition, the authors highlighted the bioactive potential of this by-product, as the flour obtained from the epicarp and mesocarp of feijoa had an average total phenolic compound content of 640 mg of gallic acid equivalent/100 g.

Considering this, feijoa peel flour has also been explored for purposes beyond food. Sganzerla et al. (2020c) identified the antimicrobial potential of biodegradable films containing feijoa peel flour. The study revealed that adding 4% of this flour resulted in a zone of inhibition against microorganisms such as *Escherichia coli*, *Salmonella typhimurium*, and *Pseudomonas aeruginosa*.

In another study, in line with the trend in food conservation observed in the bibliometric analysis, Sganzerla et al. (2021) investigated the application of biodegradable films functionalized with aqueous extracts of feijoa pulp and peel for lipid stabilization of meat, microbiological preservation of bread, and post-harvest preservation of grapes. The films showed stability of phenolic compounds during 30 days of release in a simulated aqueous and acidic food environment; this release began with contents ranging from 4.91 to 10.92 mg of gallic acid equivalent/g. In addition, the packaging stabilized lipid oxidation in meat for 6 months, inhibited mold and yeast in bread, and preserved grapes for 30 days.

Some of the applications of feijoa peel go beyond food science and technology. The emerging keywords “silver nanoparticles” connect directly to the studies by Hassan (2021), which used an extract rich in polyphenols from this by-product as an antimicrobial treatment for wool fabrics. The fabric treated with this extract exhibited improved hydrophilicity, yet reduced absorption of UV radiation and antioxidant activity. In the same vein, in another study, Hassan & Gupta (2024) used feijoa peel extract as a stabilizer for silver nanoparticles used to color and multifunctional wool fabrics. The studies mentioned above are also strongly linked to keywords such as “antibacterial activity”, “antimicrobial activity”, “feijoa extracts”, “phenolic compounds”, “food analysis”, and “antioxidant activity”, found in Figure 2. This shows that these studies might have a meaningful impact as drivers of new trends in future studies with feijoa peel.

Peng et al. (2019) optimized the method for extracting essential oil from the peels of

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five New Zealand feijoa cultivars, and the most effective extraction method was hydrodistillation, which enabled the detection of 158 compounds in all the cultivars. The major compound was β-caryophyllene, ranging from 95.64 to 173.74 mg/mL, followed by humulene, which can also be called α-caryophyllene, ranging from 41.12 to 112.77 mg/mL, and finally germacrene D, which ranged from 58.98 to 128.46 mg/mL. In the aromatic profile determined through an olfactory test, the terms fruity and honey-like were predominant among all the attributes.

Collectively, these studies demonstrate that feijoa peel represents a highly valuable by-product with diverse technological and functional applications. Research has highlighted its potential as a source of pectin, essential oils, and phenolic-rich extracts with antioxidant and antimicrobial properties. In addition, the peel has been successfully explored for the production of dietary fiber-rich flours, biodegradable active packaging materials, and multifunctional materials incorporating silver nanoparticles, and its applications were extended beyond food processing to encompass areas such as textile technology. The interaction of peel-derived compounds with the gut microbiota further reinforces its potential role as a functional ingredient. These findings illustrate how the valorization of feijoa peel can contribute to the development of innovative products, support sustainable processing strategies, and reduce agro-industrial waste, aligning with emerging research trends identified in the bibliometric analysis.

Seed

Feijoa seeds represent a fraction of the fruit whose technological potential is still poorly explored in scientific literature, which is reflected in the lower centrality of this term in the keyword co-occurrence analysis (Figure 2). In a study by Andrade et al. (2012), feijoa seed oil was obtained by a static maceration process with hexane. Analysis of the fatty acid profile revealed that linoleic acid (84.44%) was the predominant fatty acid identified, followed by oleic acid (7.21%) and palmitic acid (5.55%). A recent study by Guerra-Ramírez et al. (2021) examined oil extraction from feijoa seeds using the Soxhlet method. The results revealed a similar fatty acid composition, with linoleic acid (46.23%) being the most abundant, followed by palmitic acid (20.86%) and oleic acid (18.57%). It is worth noting that other fatty acids were identified in lower concentrations, including linolenic acid (3.69%), stearic acid (2.77%), docosanoic acid (0.91%), and palmitoleic acid (0.47%).

The discrepancy in linoleic acid content between studies (84% vs. 46%) suggests that, in addition to the extraction method, factors such as the geographical origin of the fruits and the storage conditions of the seeds can drastically influence oxidative stability and lipid yield. Thus, a methodological gap can be identified: the lack of studies on other methods of extraction, such as supercritical fluid extraction (CO_2), which could yield a purer oil, free of organic solvent residues. The predominance of unsaturated fatty acids, especially linoleic and oleic acids, makes feijoa seed oil a promising ingredient for the cosmetics and functional food industries. The transition from a merely descriptive analysis of the composition to product development, such as the development of nanoemulsion systems for different applications, constitutes the next logical step in the technological mapping of this species.

It is important to emphasize that studies that address the technological application of this fruit fraction have not yet fully explored the potential of feijoa seeds and their oil. Further investigation of these resources could open new perspectives on product development and additional research, contributing to the generation of value from these previously underutilized waste products.

Leaves

During the fruit production process, a significant amount of feijoa leaves accumulates, which are a by-product that often ends up being discarded. The studies cited below are strongly linked to different keywords presented in the bibliometric analysis ("silver nanoparticles", "antimicrobial activity", "phenolic compounds", "feijoa extracts"), indicating that, currently, leaves represent the most explored fraction of the plant in the scientific literature after the pulp, establishing themselves as a versatile raw material for the development of bioproducts.

From a compositional perspective, several studies have demonstrated that feijoa leaves contain significant levels of bioactive compounds, justifying the growing technological interest in them (Santos et al., 2021). The study conducted by Mosbah et al. (2019) revealed that *Acca sellowiana* leaves contain an average of 22.33 mg/100 g of insoluble dietary fiber and a low content of soluble dietary fiber, approximately 0.76 mg/100 g. These results highlight the potential of these leaves for food applications as sources of dietary fiber.

Although the fiber content itself may support potential food applications, most studies have focused on the extraction of phenolic compounds and volatile constituents, which appear to be the main drivers of technological exploitation. Poodi et al. (2018) observed that pre-leaching the leaves for 40 minutes, followed by ultrasound-assisted extraction, resulted in extracts rich in gallic acid (123.15 mg/g), catechin (56.10 mg/g), rutin (37.13 mg/g), ferulic acid (69.33 mg/g), quercetin (40.60 mg/g) and apigenin (46.30 mg/g). Ultrasound-assisted extraction offers advantages such as reduced extraction time and improved release of intracellular compounds, although its scalability and energy efficiency for industrial applications remain poorly explored in the context of feijoa leaves.

Mosbah et al. (2018) identified the volatile compound profile of *Acca sellowiana* leaves grown in Tunisia, revealing the presence of 31 volatile compounds, with limonene (36.2%), β-caryophyllene (27.8%), aromadendrene (12.5%) and α-copaene (6.6%) as the majority compounds. The authors highlighted the potential of these leaves for various technological applications, above all, due to limonene, which is used as an aromatic compound in a wide range of products.

Another study by El-Nashar et al. (2022) sought to chemically characterize the essential oil of feijoa leaves and stems and investigate its inhibitory potential against enzymes that act on aging factors. The chemical profiles of oils obtained by hydrodistillation and analyzed by gas chromatography, coupled with mass spectrometry, revealed that caryophyllene oxide (24.37%) predominated in the leaf essential oil, followed by linalool (7.99%) and spathulenol (6.69%). The essential oil of the stem also showed a predominance of caryophyllene oxide (38.14%), followed by α-zingiberene (10.18%) and humulene oxide II (6.02%). In addition, at a concentration of 10 µg/mL, the leaf and stem oil showed inhibitions of 72% and 79%, respectively, of the enzyme acetylcholinesterase, as well as significant inhibitions of the enzyme β-secretase, both of which are involved in the precursor of Alzheimer's disease. These findings highlight the pharmaceutical potential of leaf-derived compounds but also point to the need for comparative studies evaluating the efficiency and selectivity of different extraction techniques.

Beyond compound extraction, several studies have explored the direct application of feijoa leaf extracts in food systems. Miraballes et al. (2019) developed a strawberry jam enriched with feijoa leaf extract. The results showed that the incorporation of this extract led to a significant increase in the total phenolic compound content of the samples, in proportion to the amount of extract incorporated (between 467.50 and 1,090.50 mg of gallic acid equivalent/100 g). Beilke et al. (2021) evaluated the influence of adding aqueous feijoa leaf

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extracts from different genotypes on lactic fermentation with three different strains. The extracts showed total phenolic compound contents ranging from 94 to 138 mg of gallic acid equivalent/g. The addition of the extracts influenced the growth of the mixed culture of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*. At dilutions of 80% of the extracts, bacterial growth was inhibited, and it was necessary to reduce the content of phenolic compounds to avoid this inhibition. In addition, a predominance of *Streptococcus thermophilus* was observed, suggesting that the extracts can influence the development of different bacteria. This result illustrates a potential contradiction in literature: while phenolic compounds contribute to antioxidant activity and product functionality, they may also interfere with microbial fermentation processes depending on their concentration.

A particularly notable research trend identified in the bibliometric analysis is the emergence of the keyword "silver nanoparticles", reflecting the growing interest in nanobiotechnology applications of plant extracts. Hashemi et al. (2020) used feijoa leaf extracts prepared in methanol to synthesize silver nanoparticles and observed efficacy against Gram-positive and Gram-negative bacteria. In addition, the nanoparticles significantly reduced the viability of gastric adenocarcinoma and breast cancer cells at concentrations of 3.12 mg/mL and showed good free radical scavenging capacity. Furthermore, regarding silver nanoparticle synthesis, Fazli et al. (2024) explored the biosynthesis of these nanoparticles using feijoa leaf extract as a reducing agent to optimize the antibacterial activity of children's toothpastes. They obtained antifungal activity results against *Candida albicans* superior to those of toothpaste without the addition of nanoparticles.

In addition to biomedical applications, these nanoparticles have also been incorporated into active packaging materials. Sganzerla et al. (2020b) applied silver nanoparticles, synthesized from the aqueous extract of feijoa leaves, to biodegradable poly(ethylene oxide) films. The films showed up to 85 mg of gallic acid equivalent/g of total phenolic compounds and an antioxidant activity of 1,293 mg of Trolox equivalent/g for reduction of ferric ions. In light of the above, the versatility of application of this feijoa by-product has become evident, from its use in the formulation of jellies, dairy fermentations, and biodegradable films to the functionalization of toothpastes. However, further studies that optimize the extraction and stabilization processes of the bioactive compounds are needed, guaranteeing their efficiency and large-scale applicability, as well as studies with *in vivo* applications.

Flowers

Edible flowers have emerged as an innovative food category, primarily due to their aesthetic and aromatic appeal, as well as their nutraceutical profile, rich in phytochemicals (Teixeira et al., 2019). Although the technological application of feijoa flowers remains relatively underexplored compared to other plant fractions, recent studies suggest that they represent a promising source of bioactive compounds, particularly flavonoids and phenolic acids. This trend is consistent with the bibliometric analysis, where keywords such as "phenolic compounds", "flavonoid", "antioxidant activity", and "feijoa extracts" appear among the most recurrent terms associated with functional applications of plant-derived ingredients.

From a compositional perspective, several studies have focused on identifying the main phytochemicals present in feijoa flowers. Gil et al. (2023a) tested different methods for extracting flavonoids from edible feijoa flowers, identifying the highest concentrations of hyperoside, isoquercitrin, quercetin, and chrysanthemum by using the ultrasound-assisted extraction technique.

Magri et al. (2020) evaluated the content of phenolic compounds in feijoa flowers at different stages of development. Among the five stages evaluated, the petal opening period had the highest phenolic content (113.4 mg of gallic acid equivalent/100 g). This considerable value is related to the stress caused by flower development. The study by Montoro et al. (2020) investigated the bioactive potential of different fractions of feijoa flowers, including whole flowers, petals, and petal juice. All fractions exhibited similar phenolic profiles, differing only in their concentrations. For example, quercetin-3-O-galactoside had the highest concentration in the whole flower extract (12.4 ± 0.4 mg/L). The petals stood out for their higher kaempferol-3-O-hexoside content (25.6 ± 1.6 mg/L), and apigenin was the predominant compound found in the petal juice (3.4 ± 0.2 mg/L). These studies show the potential of feijoa flowers as a significant source of phytochemicals, highlighting their versatility for various purposes in the food and pharmaceutical industries.

As for the technological applications of the flowers, Gil et al. (2023d) investigated the effect of adding freeze-dried *Acca sellowiana* flowers to apple juice. This combination resulted in a higher content of organic acids, primarily oxalic and citric, and a higher concentration of phenolic compounds (274.40 mg/100 g wet weight), as well as higher antioxidant activity, when compared to apple juice supplemented with other plant materials. However, due to the low pH, the sample with added feijoa flowers received the lowest aroma and flavor ratings in the sensory analysis. In another study, Gil et al. (2023b) investigated the potential health benefits of smoothies made from strawberry tree fruits and apples with added feijoa flowers. Kaempferol-hexoside was one of the flavonoids explicitly found in the sample with feijoa flower, and this sample also showed the highest α-amylase enzyme inhibition activity. Nevertheless, regarding flower application, sensory acceptance proved to be a critical limitation, with samples containing feijoa flowers consistently receiving lower scores for flavor and aroma. These findings highlight another contradiction in the literature: while feijoa flowers contribute significantly to the bioactive profile of food products, their incorporation may negatively affect sensory acceptance depending on the formulation and concentration used.

Another important limitation relates to product stability during storage. When studying the effect of storage on the composition of the persimmon and apple smoothie – also containing feijoa flowers added – Gil et al. (2023c) again found that this sample received the lowest scores for flavor and aroma in the sensory analysis. However, the addition of the flowers resulted in a sample with the highest mineral content (0.52 g/100 g wet weight). Additionally, the content of phenolic compounds increased compared to the base smoothie, primarily hydroxybenzoic acids and polymeric procyanidins. Despite this, a significant decrease in all the parameters analyzed was observed after six months of smoothie storage, drawing attention to a research gap when investigating the best storage strategies for this sample type.

Overall, the available evidence suggests that feijoa flowers are a promising yet underdeveloped raw material for functional food applications. Most studies have focused primarily on chemical characterization and small-scale product formulations, while comparative evaluations of extraction techniques, optimization of sensory attributes, and strategies to improve storage stability remain limited. Addressing these challenges will be essential to fully exploit the technological potential of feijoa flowers in food and nutraceutical products.

Overall, the technological exploitation of feijoa follows distinct research pathways depending on the plant fraction considered. While pulp-based applications primarily focus on functional foods, fermented beverages, and ingredient fortification, peel valorization primarily focuses on pectin extraction, active packaging materials, and essential oil recovery.

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Seeds remain comparatively underexplored, although their lipid composition suggests potential applications in cosmetic and functional food formulations. Leaves have emerged as a versatile raw material for the extraction of phenolic compounds and for green nanotechnology approaches, particularly in the synthesis of silver nanoparticles. Finally, flowers have been increasingly investigated as sources of flavonoids and phenolic compounds for functional food formulations, although sensory acceptance and storage stability remain important challenges. Together, these research pathways reflect the trends identified in the bibliometric analysis and highlight the potential of feijoa as a multifunctional raw material for the development of sustainable bioproducts.

CHALLENGES AND PROSPECTS

The versatility of the feijoa is evident. Although it is not a widely known fruit species, it has the potential to be used in various products across different scientific fields: food science and technology, biotechnology, pharmacy, medicine, chemistry, and even textile science. The production of these derivatives is crucial for adding value to the fruit, introducing it to the market, and generating a new source of income for local producers.

This study provides the first comprehensive bibliometric overview of scientific research on feijoa over the last 20 years. The temporal evolution of publications demonstrates a significant increase in scientific output after 2019, reaching 25 publications per year in 2023, which indicates growing interest in the species. Research centers dedicated to feijoa are predominantly located in producing countries such as Brazil and New Zealand, underscoring the central role of these countries in advancing research and technological development on feijoa. Furthermore, these data reveal a potential emerging collaboration network between these two countries that could be further explored.

A keyword co-occurrence analysis revealed well-defined research themes focused on processing technologies, post-harvest quality, bioactive compounds, and antioxidant activity. Simultaneously, emerging topics such as silver nanoparticles, gut microbiota, and antimicrobial activity were linked to these well-established themes in the literature, indicating a research trend that explores the application of compounds present in feijoa across different technologies.

The keyword analysis showed that there are still few green technologies that exploit feijoa by-products more sustainably, supporting the efficient use of an underutilized natural resource. In addition, there are research gaps that still need to be filled, such as studies evaluating the behavior of these by-products and derivatives *in vivo*, optimizing the stability of extracts and products during storage, and the formulation and characterization of food products derived exclusively from feijoa, as well as consumers' sensory perception of these products, clinical trials, and the exploration of potential applications in the pharmaceutical and food industries.

To address these gaps, future research should employ more targeted methodologies. For example, *in vivo* experiments and clinical trials using standardized feijoa extracts or formulated products could help validate related biological activities *in vitro* and clarify their potential health benefits. Furthermore, accessible sensory studies involving broader consumer groups, including international markets or specific consumer segments, are essential for supporting the commercial vision for products exclusively related to feijoa.

Optimizing processing technologies and evaluating the stability and shelf life of feijoa-based products should remain a focus of future research. In addition, conducting pilot and industrial-scale studies to explore the valorization of feijoa by-products, such as peel, seeds, and leaves, could support the development of controlled processing chains that follow the principles of the circular economy.

Furthermore, genetic variation among feijoa cultivars must be taken into consideration during fruit processing, as processing can generate waste exceeding 50% of the total fruit mass. As explained in this paper, the feijoa peel and seeds possess significant nutritional and bioactive properties, similar to those of the edible part of the fruit. Managing this waste through the circular economy – a concept primarily aimed at the optimal use of natural resources – becomes an alternative for the better utilization of fruits such as feijoa, given the impact that such waste has on the economy and the environment (Villegas-Yarlequé et al., 2023).

In conclusion, this bibliometric analysis and review highlighted that few studies have yet investigated both the industrial-scale application and the sensory perception of consumers regarding products made exclusively from feijoa. However, it demonstrates the potential of feijoa and its by-products for various industrial and technological applications, due to their chemical, bioactive, and sensory characteristics, and highlights the relevance of this native Brazilian fruit in stimulating research in various areas, especially in agricultural sciences. Furthermore, this growing research trend promotes sustainable cultivation and the appreciation of feijoa and other native species.

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