Journal of Management and Sustainability; Vol. 13, No. 1; 2023
ISSN 1925-4725 E-ISSN 1925-4733
Published by Canadian Center of Science and Education

Plant Waste in the Production of New Materials in Brazil: A Scientometric Analysis from 1991–2021

Anielly M. de Melo[1], Brendon O. B. Santos[1], Guilherme S. Ribeiro[1], Karine B. Machado[1], Josana C. Peixoto[1], Leonardo L. Borges[1], & Joelma A. M. Paula[1]

[1] Campus of Exact and Technological Sciences "Henrique Santillo" (CCET), State University of Goiás (UEG), Anápolis, Brazil

Correspondent: Anielly Monteiro de Melo, Laboratory Research, Development & Innovation of Biodiversity Products (LRD&I Bio), State University of Goiás (UEG), Anápolis, Br 153, nº 3.105 — Farm Barreiro do Meio, Anápolis – GO, 75132-903, Brazil.

Received: December 12, 2022 Accepted: February 6, 2023 Online Published: February 15, 2023
doi:10.5539/jms.v13n1p58 URL: https://doi.org/10.5539/jms.v13n1p58

Abstract

Several plant residues can be generated during the stages of industrial processing, such as fruit peel, seeds and bagasse, and these can give rise to high-value products. The management and use of this waste is of global interest. The aim of this study was to evaluate the spatio-temporal evolution of scientific knowledge on the reuse of agroindustrial waste generated in Brazil through a scientometric analysis. To this end, a search was performed in the databases Scopus, Scielo, and Web of Science between the years 1991and 2021. The words used as indexers were *agribusiness waste*, *vegetable waste*, *fruit waste*, *biomass waste*, *plant residue*, and *chemical characterization*. The following selection criteria were adopted: search of indexers by title, scientific articles, articles in English and Portuguese, and articles on plant waste generated in Brazil. There was an increase in publications over the years, with a greater number of studies (21.46%) in the chemistry area, addressing mainly the physical-chemical characterization of materials. In Brazil, sugarcane (*Saccharum officinarum* L.) was the most studied species with a view to reusing its residues. We identified species from highly threatened Brazilian biomes, such as the Atlantic Forest and Cerrado, with the potential for transformation into new materials. The gaps in knowledge, evidenced in this analysis, suggest that more studies should be carried out on residues of native plant species which impact local communities. In particular, studies could focus on applicability in health and cosmetics, which are promising areas for plant materials and still little investigated.

Keywords: bioproduct, management, reuse, agroindustrial residue

1. Introduction

The world population has gradually increased. Producing food properly, sustainably and of a high quality is a challenge for humanity. Technological development has favored increased productivity, which has significantly intensified the need for sustainability in agriculture due to the environmental impacts associated with the use of fertilizers, pesticides, water and others (Lampridi, Sorensen, & Bochtis, 2019).

Because of their high content of vitamins, minerals and fiber, vegetables are key components for a healthy human diet (Nguyen et al., 2020). Thus, the consumption of fruit and vegetables has been stimulated as a form of disease prevention (Silva, Smith-Menezes, & Duarte, 2016). In the industrial production of vegetable products it is common to use, for example, the pulp of fruit and the disposal of the peel and seeds in significant quantities (Cangussu, Fronza, & Cavalcanti, 2020), with a consequent increase in waste generation (Barbosa & Conceição, 2016).

The residues generated in the processing of vegetables in the food industry, although they have antioxidant compounds and nutritional values, are often discarded at the end of the production process (Pereira, Firmo, & Coutinho, 2022). However, they could be used in new food sources, reducing food waste (Sousa, Vieira, & Lima, 2011), or be reused by the pharmaceutical and chemical industry (Saraiva et al., 2018). Studies have developed ways to convert plant waste into added value, such as in the production of vermicompost (Muthukumaravel, Amsath, & Sukumaran, 2008), biomethane (Jaiganesh, Nagarajan, & Geetha, 2014), bioactive compounds, bioethanol and organic acids (Sánchez et al., 2021).

Waste management and sustainable development are challenging topics for developing and industrialized countries (Patel, 2012). In this context, agroindustrial systems and forestry stand out because they demand a significant availability of biomass linked to the activities of these sectors (Santos, Nascimento, & Alves, 2017). The agricultural sector has challenges to face in the management and adequate food security of waste in order to reduce environmental and socioeconomic impacts (Esparza et al., 2020).

In Brazil there has been growing concern about the management of municipal solid waste, both related to its recovery and in order to reduce its environmental impact. However, initiatives in this direction are still insufficient (Prado et al., 2022). According to Silva, Rosas and Oliveira (2018), the prospects for a decrease in solid waste generation in Brazil are not positive. These authors, when analyzing the situation of the country after the creation of Law 12.305/2010 which instituted the National Solid Waste Policy (Brazil, 2010), pointed out that non-generation, reduction, reuse and, consequently, conscious consumption are still developing very slowly.

It is important, therefore, to investigate what researchers in Brazil have done in the field of scientific research on the reuse of agroindustrial waste so far as a way to assess current trends and direct future efforts. In this context, scientometric analysis can be a very useful tool. Review articles have the function of providing information about academic evolution and helping to monitor the development of science. They present the “state of the art” in a specific subject in order to improve the quality of research, guiding future work through evidence (Blümel & Schniedermann, 2020).

The objective of this study was to evaluate the spatio-temporal evolution of scientific knowledge on the reuse of plant waste generated by the agroindustrial sector in Brazil, with emphasis on the types of reuses proposed for plant residues, predominant areas of knowledge and plant species studied (origin, endemism, and phytogeographic domains).

2. Methods

The methodological basis of this study was based on scientometrics, a segment of the sociology of science that studies the quantitative aspects of scientific activities. Through indicators that detect the growth and trends of the subject addressed, it provides information on the orientation and scientific and technological dynamics of a country, as well as on its participation in science and technology worldwide (Macias-Chapula, 1998; Parra, Coutinho, & Pessano, 2019).

2.1 Collection of Scientometric Data

To compose the dataset of this work, the articles/papers were initially accessed in the databases of the Portal de Periódicos da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior—CAPES (http://www.periodicos.capes.gov.br/); *Scopus* (Elsevier) (https://www.scopus.com); *Scientific Electronic Library Online* (Scielo) (https://scielo.org/); and *Web of Science* (www.webofknowledge.com), between May and June 2022. All databases were searched for papers that presented in their title the following combination of terms: “agribusiness* waste*” OR “vegetable* waste*” OR “fruit* waste*” OR “Biomass* Waste*” OR “plant* residue*” OR “Chemical characterization”. The asterisk (*) was used to capture variations in the root of words or singular and plural, p. ex. “plant residues”.

2.2 Temporal Analysis of Publications

The selected time frame was from 1991 to 2021. As the platforms do not have the same standard for the refinement of searches, there was a need to carry out manual verification of all articles in order to exclude the titles that were not related to the reuse of plant waste.

During manual screening, duplicate file deletions and evaluation of titles and abstracts were performed. The application of these filters was carried out by organizing and reading the files in the programs Zotero 6.0.9 and Microsoft Excel. Review articles were excluded in order to consider only articles that investigated physical-chemical characteristics and the applicability of plant residues.

We obtained 14,084 studies, of which 12,072 were scientific papers. Among these, 144 scientific articles were selected for being published in Portuguese or English, produced in Brazil and addressing the theme “reuse of plant residues” (Figure 1).

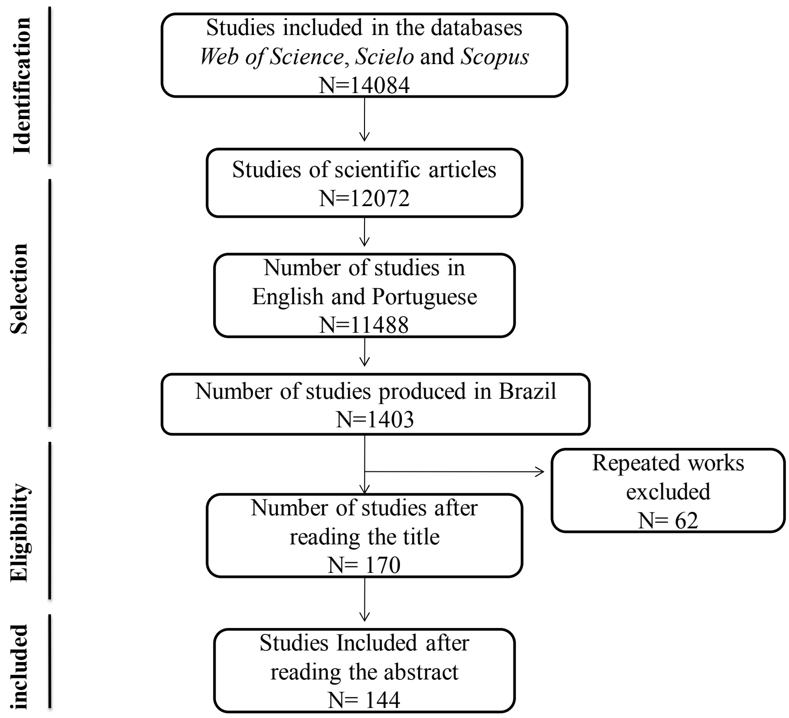

Figure 1. Diagram of identification and selection of articles for the scientometric analysis of scientific knowledge about the reuse of plant waste produced in Brazil, published from 1991 to 2021

2.3 Bibliometric Indicators

In order to meet the objectives of the scientometric analysis, the data collected in the 144 selected articles were as follows: year of publication; area of knowledge of the research/researchers; type of reuse; plant species cited in the study; and origin, endemism and phytogeographic domains of the species. The scientific names, origins, endemism and phytogeographic domains of the species were determined according to Flora e Funga do Brasil (2022).

2.4 Data Analysis

Data analysis was performed with the help of the Program R version 4.0.0 for Windows. Normality was checked by the Shapiro-Wilk test (p = 0.454), showing that the results do not differ from a normal distribution. In order to express the trend of the number of publications over the years, linear regression analysis and determination of (R^2) were performed. The images were generated by QGIS 3.26.0 and Microsoft Excel.

3. Results and Discussion

Although the search covered the period from 1991 to 2021, the first article on this subject was published only in 1994. Between 1994 and 2021 the number of publications increased linearly, indicated by the equation $y = 1.3846x + 2000$, $R^2 = 0.7525$ (Figure 2).

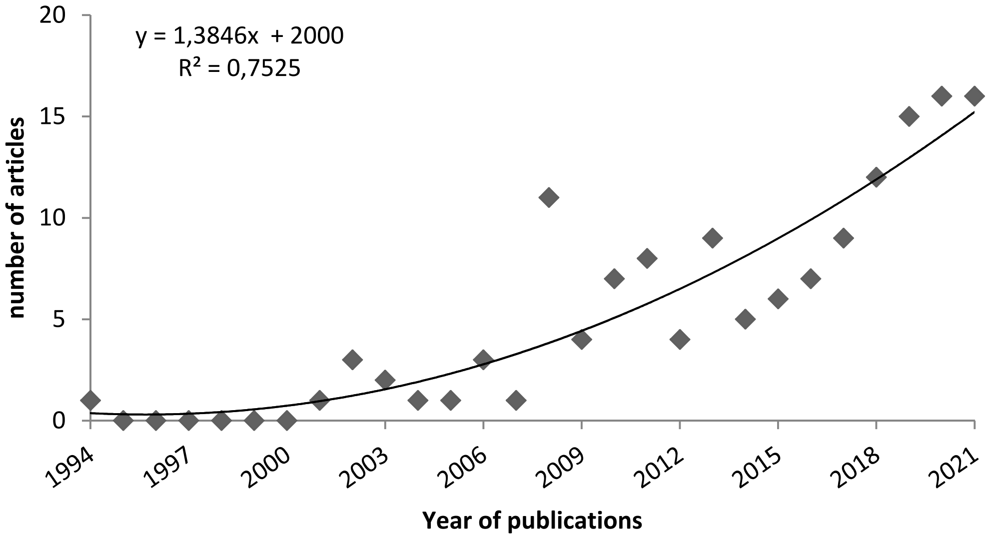

Figure 2. Regression analysis of articles published on the use of agroindustrial plant residues in Brazil between 1994 and 2021

Solid waste generation is considered a consequence of economic growth, which boosts the population's access to new products and consumer goods, such as energy recovery (Mannarino et al., 2016). The transformations arising from globalization that occurred in the 1990s contributed to the increase in information regarding the implications for the environment. Waste management has been incorporated in urban centers, most of which are in member countries of the Organization for Economic Cooperation and Development (OECD) (Demajorovic, 1995). Thus, it is possible that the beginning of scientific production on this subject from the year 1994 is related to the incorporation of the concept of sustainability in 1992 at the United Nations Conference on Environment and Development in Rio de Janeiro. At this event, documents were prepared that stipulated international commitment to actions that associate development and the environment. From that moment, the matter has become official in most governments in the world (Malheiros et al., 2008).

Although the growth in the number of publications in the first two decades of the evaluated period (1994–2014) may be related to the international agreements on the environment, to which Brazil is a signatory, it is important to note that the most significant increase in publications occurred in the later years (2010–2021). It is possible that this is related to the publication of Federal Law nº 12.305/2010, which establishes the National Solid Waste Policy in Brazil. This policy has as its guiding principle the protection of human health and sustainability in government actions in the field of waste management, with goals that seek to eradicate landfills and encourage environmental solutions considered appropriate for the final disposal of municipal solid waste (Brazil, 2010). It is important to note that according to Normative Instruction Ibama nº 13/2012, which establishes the Brazilian Waste List, residues from agriculture, horticulture, aquaculture, forestry, hunting and fishing are considered solid waste, as are residues from the preparation and processing of food products (Ibama, 2012).

In the same period between 2010 and 2019, the Brazilian Association of Public Cleaning Companies and Special Waste (Abrelpe, 2010) observed a considerable increase in the generation of municipal solid waste in Brazil, from 67 million to 79 million tons per year, in all regions of the country. In 2010, ABRELPE reported that 3,152 municipalities sought a selective collection initiative, and this number increased in the following decade to 4,070 municipalities.

Agribusiness is considered responsible for producing much of the organic waste today. The minimization or reuse of agroindustrial waste is an alternative to reduce the impacts caused by the inadequate disposal of these by-products, since they are a source of organic matter such as proteins, enzymes, essential oils and other chemical constituents (Ricardino, Souza, & Silva Neto, 2020). This has stimulated the development of methods and reuse and, consequently, led to an increase in the number of scientific publications in the area.

The concern with the need to produce more food due to the population increase, and the need to preserve natural resources challenge several areas of knowledge, especially the Natural, Exact and Earth Sciences. This was evidenced in the publications selected for this scientometric analysis. It was observed, as shown in Figure 3, that there were a greater number of publications in the areas of Chemistry, with 56 works, which corresponds to 21.46% of the publications and Agrarian Sciences, with 26 works representing 9.96% of the publications. Further, the areas of Agricultural Sciences (26 works; 9.96%), Chemical Engineering (21 works; 8.05%), Biological Sciences (13 works; 4.98%), and Agricultural Engineering (11 works, 4.21%) were included (Figure 3). Discussions related to socio-environmental issues in organizations have influenced the increase in research in different fields of knowledge, leading to the advancement of existing scientific information (Ferreira, Rosa & Borba, 2012).

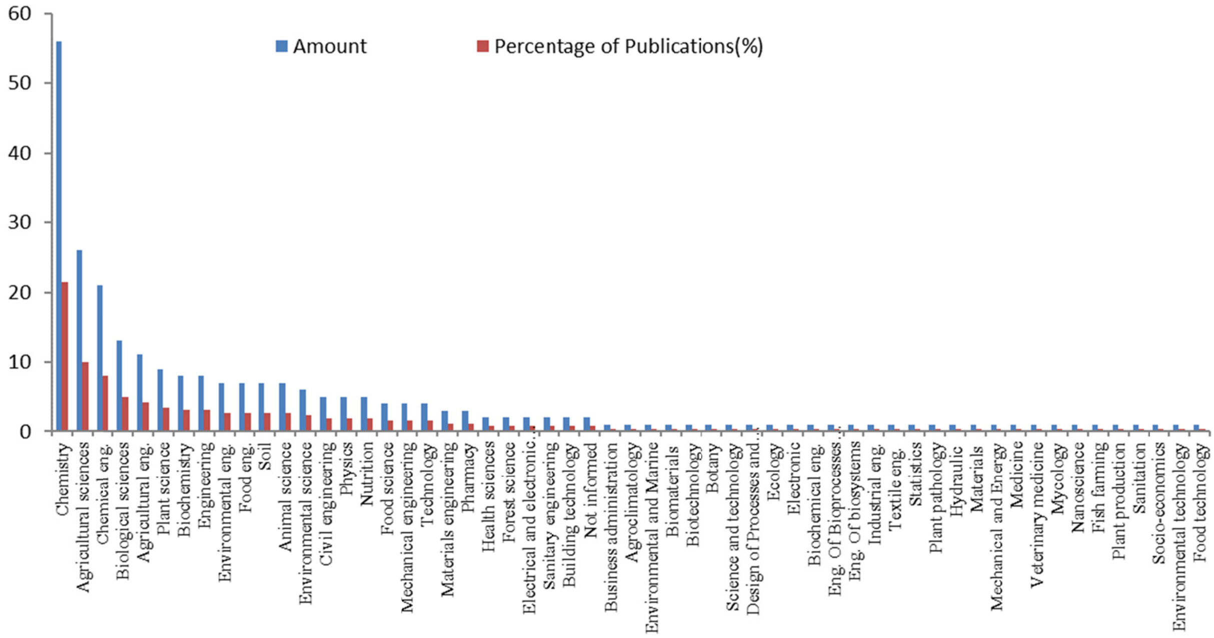

Figure 3. Research areas of researchers with the highest number of publications of articles on the use of agroindustrial plant waste in Brazil between 1994 and 2021

The greater number of studies in the chemistry area may be related to the fundamental importance of knowing details of the chemical composition of the products. The physical-chemical characterization of the materials takes into account use and applications, as well as the provision of relevant information that can lead to the development of new studies and products (Esmelindro et al., 2002).

The occurrence of a significant number of publications in the field of Agricultural Sciences may be closely related to a recurring challenge for this area of knowledge in recent decades, namely, agricultural sustainability. The science of agricultural sustainability, despite having a scientific community, still needs common theoretical assumptions related to the concept of sustainability and methodological designs (Salas-Zapata, Ríos-Osorio, & Cardona-Arias, 2017). When reviewing the concepts and methods applied to agricultural sustainability, Lampridi, Sorensen and Bochtis (2019) identified an increase in the number of review articles on the subject in the years 2016–2018. However, the assessment of sustainability in the field of agricultural practices involves different variables specific to each case to be considered. The existing variability in policy making is based on and supported by academic knowledge (Binder, Feola, & Steinberger, 2010).

Another area of knowledge with a significant number of publications was Engineering. Educators in the field of Engineering have sought to integrate environmental engineering in education since mid-1994, having recognized issues of environmental efficiency for engineers. Efforts have been applied to implement questions about sustainability and sustainable development in the curricula of engineering courses, reflecting an increase in the literature on the subject (Thürer et al., 2018). An example is research that seeks resources to minimize air pollution, as well as the exploitation of natural resources for asphalt (Pouranian & Shishehbor, 2019).

Table 1 (Appendix A) shows the plant species cited in the studies, accompanied by their origin, endemism and Brazilian phytogeographic domains in which they can be found, as well as the type of reuse of their residues mentioned in the studies.

Of the 153 plant species described in the papers (Table 1), the most cited were sugarcane (*Saccharum officinarum* L.)—18 papers; corn (*Zea mays* L.)—14 papers; rice (*Oryza sativa* L.)—13 papers; oats (*Avena strigosa* Schreb.)—11 papers; and (*Passiflora* spp)—9 papers. Brazil is considered a major sugarcane producer and exporter in global agribusiness, and 68% of Brazilian production is exported, which represents 5.7% of the total revenue of exports made by the country (Satolo et al., 2016). About 11 million tons of bagasse ash and 14 million tons of sugarcane straw ash can be generated annually. These data show that reusing this waste sustainably has become a necessity and has motivated research in recent years (Berenguer et al., 2020).

Bibliographic data demonstrate trends in the development of innovative materials from sugarcane waste with applications in construction (Silva et al., 2021), in wastewater treatment (Lebre et al., 2022), and in power generation (Silva et al., 2019), among others. These data are corroborated by Tessmann et al. (2021), who identified, by scientometric analysis, the use of sugarcane residues such as bagasse, molasses, straw, cake and vinasse in the production of bioproducts such as lactic acid and flour.

Corn is another major crop on the world stage, ranking third in world exports, and is the second most significant crop in Brazilian agriculture (Silva et al., 2021). Corn processing generates cob and straw, residues that can be used in the production of bioethanol (Gupta & Verma, 2015) and which are considered viable as a complement to sugarcane ethanol (Silva & Castaneda-Ayarza, 2021). In addition, corn silk, often discarded during the corn processing stages, has the potential to become health products (Gasparoti & Paula, 2021).

Rice is one of the most consumed and produced grains in the world and is considered a staple food. In Brazil, rice has economic and social relevance. The need to adapt rice farming systems in order to improve productivity and ensure sustainability has been the subject of recent discussions (García et al., 2021). The by-products of rice crops are generated in significant quantity. Among them are bran, chirera, bark and ashes of burnt bark (Silva et al., 2021). The most frequent use of rice residues is as a fertilizer additive and in plants in the production of thermal and electrical energy (Abaide et al., 2019). Applications of residues were also found in the coproduction of furfural, furfuryl alcohol and formic acid (Santos et al., 2021), fertilizer (Jakelaitis et al., 2010), milk coagulation enzymes (Alecrim et al., 2015), flour (Ascheri et al., 2016) and vermicomposting (Vione et al., 2018).

Oat is considered an important winter crop in Brazil. The area of cultivation of oats grew around 8% from 2019 to 2020, an increase of about 429.7 thousand hectares, and consequently its production has risen (Azevedo et al., 2022). Oats have different uses, such as in the production of grains for human and animal consumption, production of cosmetics and inputs for the chemical industry, green fertilization, pasture formation or preparation of hay and silage, among others (Mori, Fontaneli, & Santos, 2012). This justifies the search for methods that reuse oat residues, produced in the stages of raw material processing, to obtain fertilizer (Dias et al., 2003; Paredes Filho, Silva, & Florentino, 2020) and for the conservation (Panachuki et al., 2015) and improvement of soil quality (Franchini, Gonzalez-Vila, & Rodriguez, 2002).

Fruit and vegetables are among the most important waste generators in the food processing industry, supermarkets and homes, and waste may exceed 25% of the initial product (Sánchez et al., 2021). This fact is attributed to the regular growth in the use of fruits and vegetables in diets due to the population's search for natural and healthy foods (Brito et al., 2020).

In Brazil, passion fruit is a widely consumed fruit. It is estimated that about 60% of the cultivation is intended for fresh consumption, while the rest of the production is used in juices and concentrates in processing. The increase in consumption of this fruit may be related to its nutritional characteristics, such as high levels of vitamins, carotenoids and phenolic compounds. Research has been carried out with the objective of evaluating the chemical composition and the physical-chemical characteristics of. the agroindustrial residues of passion fruit, due to the increase in the availability of these materials (Santos et al., 2021). In addition, the residues have also been studied for use as flour (Mendes et al., 2019) in the production of methane (Edwiges et al., 2018), animal feed (Pereira et al., 2020) and biosorbent (Pavan et al., 2008).

Several fruits whose residues were studied in the studies collected here, although less cited, are important in the Brazilian and global scenario. Sustainable reuse can contribute to the bioeconomy and to the fulfillment of the 2030 Agenda for sustainable development, launched by the United Nations (UN) (United Nations, 2017). Bioeconomy is understood as the use of innovative and biotechnological processes for the conversion of biomass into bioproducts (food, biofuels, biochemists, forage, etc.), either as raw material or final product. In this type of economy the production bases, such as materials, chemical compounds and energy, are derived from renewable biological resources (Bueno & Torres, 2022). This new approach to the economy is consistent with the need to preserve and value the biodiversity of Brazilian biomes, of which some of them, such as the Cerrado and the Atlantic Forest, are already highly threatened (Myers et al., 2000; Mittermeier et al., 2005). In view of this, we sought to establish the main phytogeographic domains of the coverage of plant species surveyed in this work.

Figure 4 shows the map of Brazil with the distribution of species in the different phytogeographic domains. The Atlantic Forest, the Cerrado and the Amazon stand out in a number of species. It should be remembered that the same species can occur simultaneously in different phytogeographic domains. For 71 species, no information was found on their predominant occurrences in the Brazilian phytogeographic domains, according to the Flora e Funga do Brazil (2020).

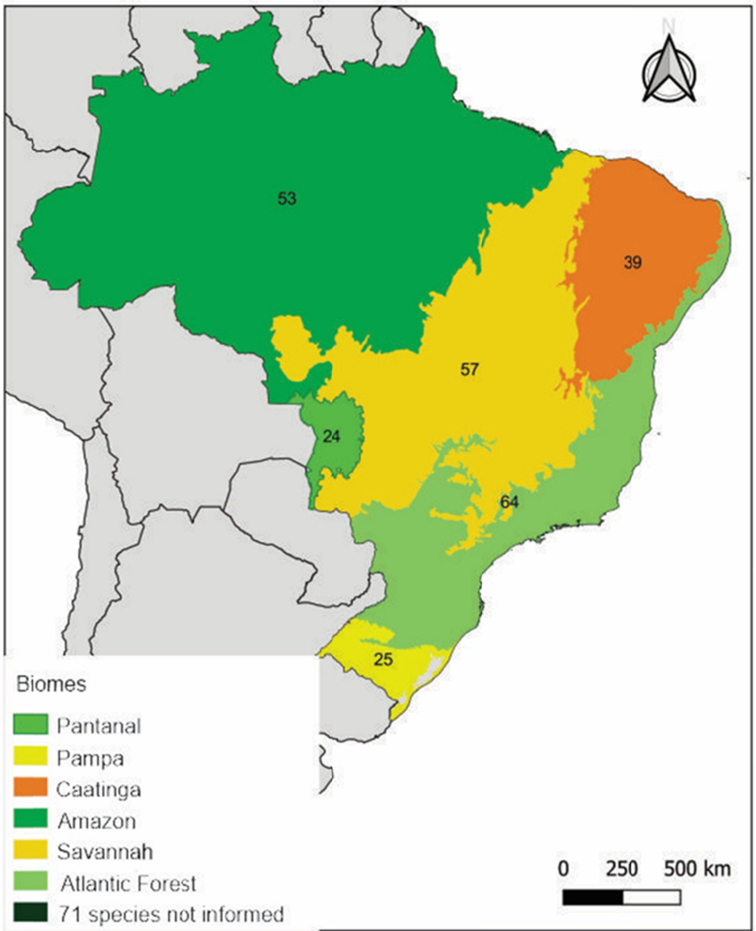

Figure 4. Map of Brazil highlighting the number of species by phytogeographic domain cited in articles published between 1994 and 2021

Of the 153 plant species described in the studies (Table 1) only 5 are native and endemic to Brazil: *Arachis pintoi, Attalea speciosa* (babaçu), *Campomanesia pubescens* (gabiroba), *Passiflora alata* (maracujá) and *Spondias tuberosa* (umbu). These species can be found in different Brazilian phytogeographic domains. It is noteworthy that most are frequently found in the Atlantic Forest and the Cerrado, biomes with high endemism and among the most threatened in the world and therefore considered priority areas in the preservation of world biodiversity (Mittermeier et al., 2005; Myers et al., 2000).

The Atlantic Forest and the Cerrado have undergone accelerated deforestation throughout history. In the Cerrado approximately two million km^2 were deforested, which represents 22% of the total area of Brazil. More than half of the native vegetation of the Cerrado has been turned into agricultural land (Nearing et al., 2017). This fact is evidenced in the data collected in this work, since 50% of the most studied species in the articles can be found in the Cerrado, most of which are cultivated, such as *Saccharum officinarum* (sugarcane), *Oryza sativa* (arroz), *Cenchrus americanus* (millet), *Musa* L. (banana), *Crotalaria juncea* (crotalaria), *Raphanus sativus* (fodder radish), *Citrus × aurantium* (orange), *Attalea speciosa* (babaçu), and *Psidium guajava* (guava). Although *Zea mays* (corn) does not have its phytogeographic domains defined in the reference consulted (Flora e Funga do Brasil, 2022), it is known that the Midwest region, which covers much of the Brazilian Cerrado, is one of the major corn producers in Brazil (Conab, 2020).

About 30% of the species surveyed in the studies (Table 1) are native to Brazil, and 20%, in addition to being native, are common fruits in the Cerrado and with potential in Brazilian agroindustry. The processing of native fruits seeks to add commercial and nutritional value. In addition, fruit exploitation can strengthen its commercial use, minimize waste, generate products, increase income generation and employment for local populations and favor industrial expansion (Reis & Schmiele, 2019).

The sustainable management and reuse of plant residues from the Cerrado can assist in the conservation of this savanna. Residues generated in the processing of native fruits found in the Cerrado have been evaluated as substrates for protein enrichment. Factors such as good adaptability, rapid growth and high protein conversion of the species Bocaiuva (*Acrocomia aculeata* (Jacq.) Lodd. ex Mart.), pequi (*Caryocar brasiliense* Cambess.), guavira (*Campomanesia pubescens* Mart ex DC. O. Berg) and araticum (*Annona crassiflora* Mart.) establish them as competitive against traditional species (Silva et al., 2014).

Through physical-chemical characterizations post processing of agroindustrial residues of Cerrado species such as pequi (*Caryocar brasiliense*), murici (*Byrsonima crassifolia*), passion fruit (*Passiflora alata*) (Araujo et al., 2018), rice (*Oryza sativa*) (Ascheri et al., 2016), and gabiroba (*Campomanesia adamantium*) (Alves et al., 2013), the maintenance of nutritional qualities that enable them to be used as food has been observed. In addition, other residues of Cerrado species have applications such as fertilizer (millet or *Cenchrus americanus*) (Silva et al., 2008) and as biosorbent (babassu or *Attalea speciosa*) (Nascimento, Oliveira, & Leite, 2019), among others.

Among the different applications for agroindustrial plant residues investigated in the articles (Table 1) the most frequent ones were identified and summarized in Figure 5. Usage as foodstuff was most frequently found (21 works), followed by fertilizer (24 works), biofuel (14 works), activated carbon (13 works), and construction (5 works), while 12 studies did not contain the specified application and 33 other applications were cited less. The articles that mentioned the terms methane and biogas were considered as biofuel in the present work.

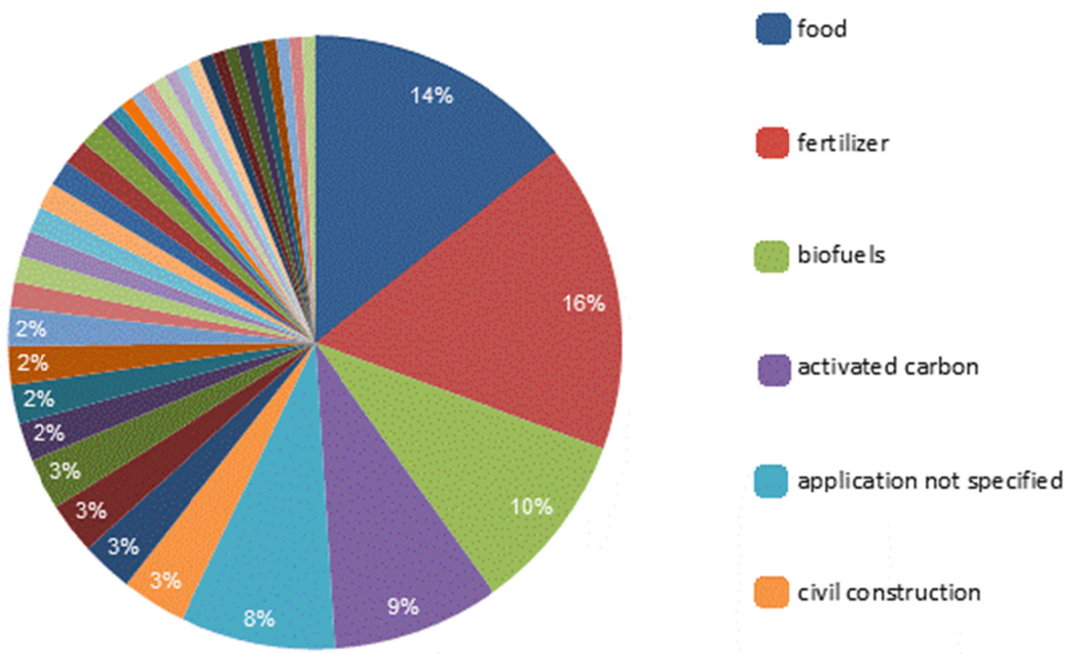

Figure 5. Types of reuse of plant waste produced in Brazil and cited in articles published between 1994 and 2021

According to Verruck (2021), although plant residues are predominantly from the food area, they can also give rise to value-added raw materials for other sectors given their varied characteristics and applicability. The fermentation of fruit residues can be used in the production of biofuels (Tahir & Amin, 2013). A focus of many countries today is the modernization of biogas for the large-scale production of renewable energy systems, which encourages the valorization of biofuel in the energy system, both economically and environmentally (Angelidakia et al., 2018).

For biogas production, husks, bagasse and fruit seeds are used as biomass in renewable methods such as anaerobic digestion. It is used as a direct energy source in boilers and biogas turbines (Sousa & Rizzatto, 2022). Reis et al. (2019) used residues of açaí, cocoa, coconut, cupuaçu and Brazil nut to evaluate the combustion properties and create renewable energy alternatives for the industry of the Amazon region of Brazil. Similarly, residues of species such as tomato, squash, carrot, and potato were used for the treatment of plant solid waste and the development of scientific knowledge on the kinetics of hydrolysis in anaerobic codigestion systems (Leite et al., 2021).

Plant residues were used long before the Christian age as green fertilization was applied to agricultural systems. Nowadays, they are reemerging as alternatives to conventional forms of agricultural production. They present benefits such as improving the physical-chemical and biological properties of the soil and fertility, providing nutrients for following crops, erosion control and plant protection (Abranches et al., 2021). In this context, in 2009, Carvalho et al. already considered the plant residues of the species Cajanus *Cajanus cajan* (L.) Huth, *Mucuna pruriens* (L.) DC. and *Pennisetum glaucum* (L.) R.Br. as suitable species for soil cover and *Canavalia brasiliensis* Mart. ex Benth, *Helianthus annuus* L. and *Raphanus sativus* L. as green fertilizers due to their faster recycling. Sarfaraz et al. (2020) used the residues (straw) of rice, soybean and corn crops for the production of suitable biochar to increase soil fertility.

Biochar can also be produced by different materials containing carbon such as wood, coal and coconut shell, with numerous applications in different areas, but mainly in the environmental area, as one of the adsorbents in water and effluent treatment (Bhatnagar et al., 2013). Studies have shown the use of plant residues in this, such as *Ceiba speciosa* (A.St.-Hil.), Ravenna, in the adsorption of synthetic phenolic effluent (Franco et al., 2021), sugarcane bagasse, coconut shell and babassu coconut endocarp in the removal of 2,4-D herbicide from water (Brito et al., 2020), and *Passiflora edulis* residue in methylene blue biosorption (Pavan et al., 2008).

In addition, plant waste has been used in construction based on tests making mortar with waste from *Pinus caribaea* (Stancato, Burke, & Beraldo, 2005) as a mineral additive to partially replace cement from the biomass residue of sugarcane (Anjos et al., 2013) and complementary cementation material resulting from the calcination of elephant grass biomass (Martínez□Ramírez et al., 2019). The quality of the concrete is related to the quality of the aggregates used, and the concrete is based on the dosed and homogeneous mixture between aggregates, cement and water (Silva et al., 2022). The use of agroindustrial plant residues in the production of cement and construction derivatives reduces the extraction of mineral resources, which has direct impact on the preservation of natural resources (Pacheco-Torgal & Jalali, 2011).

Different applications of plant residues were little mentioned by the works in the searches. Among them, articles were found that aimed to evaluate residues for the production of compounds of interest to the pharmaceutical industry and polymer production (Branco et al., 2010), chitosan films for food packaging (Mesquita et al., 2020) and cellulose nanocrystals from rice husk (Hafemann et al., 2020). In addition, vegetable waste can be raw materials with the potential to provide solutions in the future for science's demand for biomedical materials (Pelegrini et al., 2019).

The development of products originating from plant waste can reduce the negative socioeconomic and environmental impacts caused by food waste (Esparza et al., 2020). The strategies to valorize residues of vegetable origin are still relatively scarce due to the small amount of knowledge, but the development of biotechnologies can help in this valorization, improving the yield, quality and economic viability (Ganesh, Sridhar, & Vishali, 2022). In this way, research is needed that proposes new applications for plant waste, in order to expand the range of options for the producer market.

4. Conclusions

Waste management means adopting a set of appropriate actions at all stages of the manufacturing process of a product, from the collection of raw material to the final product. The reuse of agroindustrial plant waste follows the precepts of sustainable development, and seeks to minimize waste production, aiming at the preservation of public health and the quality of the environment.

This scientometric analysis evaluated the trends in publications about the reuse of plant waste in Brazil between

1991 and 2021. An exponential increase was seen in the number of articles published on this subject over the years, starting in 1994. The largest number of publications addressed the areas of chemistry, agricultural sciences, chemical engineering, biological sciences and agricultural engineering.

The residues most investigated for reuse were (*Saccharum officinarum*), corn (*Zea mays*), rice (*Oryza sativa*), oat (*Avena strigosa* Schreb.) and passion fruit (*Passiflora edulis*, *Passiflora alata*). Regarding the distribution of species in different Brazilian phytogeographic domains, it was found that the Atlantic Forest, the Cerrado and the Amazon are the most investigated. Publications with residues of species occurring in the Atlantic Forest and Cerrado, two highly threatened Brazilian biomes, may reveal a concern with the conservation and preservation of these biomes.

A significant number of studies investigated the use of plant waste from large crops, due to their commercial importance combined with the great environmental impact that such crops potentially generate. A small number of studies investigated residues of native plant species. These findings open the prospect that research for the use of plant residues from the most threatened biomes, even if generated on a smaller scale from local species in cooperatives and communities, could contribute to the strengthening of the entire production chain. This strengthening, in turn, could be reflected in the greater engagement of communities in actions for the conservation of species, whose residues are confirmed to be useful. Therefore, this is a gap in knowledge in a field where scientific investigations are still insufficient.

The authors evaluated agroindustrial plant waste more frequently, with the objective of generating potential products for food, fertilizer, biofuel, activated carbon, and construction, but 12 papers did not contain the specified application and 33 other applications were less cited. Among the less cited applications, it is worth mentioning those that focused on health (human and animal) and cosmetics, demonstrating that there is another gap in knowledge to be explored here, since plant residues can be sources of pharmacologically active chemical compounds.

Acknowledgments

We are grateful to the University of Goiás, Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the financial support provided.

References

Abaide, E. R., Tres, M. V., Zabot, G. L., & Mazutti, M. A. (2019). Reasons for processing of rice coproducts: Reality and expectations. *Biomass and Bioenergy*, *120*, 240–256. https://doi.org/10.1016/j.biombioe.2018.11.032

Abranches, M. O., Silva, G. A. M., Santos, L. C., Pereira, L. F., & Freitas, G. B. (2021). Contribution of green fertilization to the chemical, physical and biological characteristics of the soil and its influence on the nutrition of vegetables. *Research, Society and Development*, *10*(7), e7410716351. https://doi.org/10.33448/rsd-v10i7.16351

Abrelpe. (2020). *Panorama dos Resíduos Sólidos no Brasil 2020*. Retrieved July 12, 2022, from https://abrelpe.org.br/panorama-2020/

Alecrim, M. M., Palheta, R. A., Teixeira, M. F. S., & Oliveira, I. M. A. (2015). Milk-clotting enzymes produced by Aspergillus flavo furcatis strains on Amazonic fruit waste. *International Journal of Food Science and Technology*, *50*(1), 151–157. https://doi.org/10.1111/ijfs.12677

Alves, A. M., Alves, M. S. O., Fernandes, T. O., Naves, R. V., & Naves, M. M. V. (2013). Caracterização física e química, fenólicos totais e atividade antioxidante da polpa e resíduo de gabiroba. *Revista Brasileira de Fruticultura*, *35*(3), 837–844. https://doi.org/10.1590/S0100-29452013000300021

Angelidaki, I., TREU, L., Tsapekos, P., Luo, G., Campanaro, S., Wenzel, H., & Kougias, P. G. (2018). Biogas upgrading and utilization: Current status and perspectives. *Biotechnology Advances*, *36*(2), 452–466. https://doi.org/10.1016/j.biotechadv.2018.01.011

Anjos, M. A. S., Martinelli, A. E., Melo, D. M. A., Renovato, T., Souza, P. D. P., & Freitas, J. C. (2013). Hydration of oil well cement containing sugarcane biomass waste as a function of curing temperature and pressure. *Journal of Petroleum Science and Engineering*, *109*, 291–297. https://doi.org/10.1016/j.petrol.2013.08.016

Araújo, A. M. A., Menezes, E. G. T., Terra, A. W. C., Dias, B. O., Oliveira, E. R., & Queiroz, F. (2018). Bioactive compounds and chemical composition of Brazilian Cerrado fruits' wastes: pequi almonds, murici, and sweet passion fruit seeds. *Food Science and Technology*, *38*(1), 203–214.

https://doi.org/10.1590/fst.19417

Ascheri, D. P. R., Cavalcante, L. H., Ascheri, J. L. R., & Carvalho, C. W. P. (2016). Physical-chemical characterization of pre-cooked mixed rice flour and barley bagasse. *Ciências de Alimentos*, *37*(2), 737–750. https://doi.org/10.5433/1679-0359.2016v37n2p737

Azevedo, C. F., Nascimento, M., Carvalho, I. R., Nascimento, A. C. C., Almeida, H. C. F., Cruz, C. D., & Silva, J. A. G. (2022). Updated knowledge in the estimation of genetics parameters: a Bayesian approach in white oat (Avena sativa L.). *Euphytica*, *218*(43). https://doi.org/10.1007/s10681-022-02995-0

Barbosa, N. P., & Conceição, E. C. (2016). Aproveitamento de Resíduos Industriais de Alimentos com Potencial Aplicação em Cosméticos Naturais. *Revista Processos Químicos*, *9*, 127–131. https://doi.org/10.19142/rpq.v10i20.357

Berenguer, R. A., Capraro, A. P., Medeiros, M. H. F., Carneiro, A. M. P., & Oliveira, R. A. (2020). Sugar cane bagasse ash as a partial substitute of Portland cement: Effect on mechanical properties and emission of carbon dioxide. *Journal of Environmental Chemical Engineering*, *8*(2), 103655. https://doi.org/10.1016/j.jece.2020.103655

Bhatnagar, A., Hogland, W., Marques, M., & Sillanpää, M. (2013) An overview of the modification methods of activated carbon for its water treatment applications. *Chemical Engineering Journal*, *2019*(1), 499–511. https://doi.org/10.1016/j.cej.2012.12.038

Binder, C. R., Feola, G., & Steinberger, J. K. (2010). Considering the normative, systemic and procedural dimensions in indicator-based sustainability assessments in agriculture. *Environmental Impact Assessment Review*, *30*(2), 71–81. https://doi.org/10.1016/j.eiar.2009.06.002

Blümel, C., & Schniedermann, A. (2020). Studying review articles in scientometrics and beyond: a research agenda. *Scientometrics*, *124*, 711–728. https://doi.org/10.1007/s11192-020-03431-7

Branco, A., Santos, J. D. G., Pimentel, M. M. A. M., Osuna, J. T. A., Lima, L. S., & David, J. M. (2010). d-Mannitol from Agave sisalana biomass waste. *Culturas e Produtos Industriais*, *32*(3), 507–510. https://doi.org/10.1016/j.indcrop.2010.06.025

Brasil. (2010, 2 de agosto). *Política Nacional de Resíduos Sólidos*. Lei nº 12.305. Presidência da República, Departamento da Casa Civil. Brasília. Retrieved October 12, 2022, from https://www.planalto.gov.br/ccivil_03/_ato2007-2010/2010/lei/l12305.htm

Brito, G. M., Roldi, L. L., Schetino Jr., M. A., Freitas, J. C. C., & Coelho, E. R. C. (2020). High-performance of activated biocarbon based on agricultural biomass waste applied for 2,4-D herbicide removing from water: adsorption, kinetic and thermodynamic assessments. *Journal of Environmental Science and Health*, *55*(9), 767–782. https://doi.org/10.1080/03601234.2020.1783178

Brito, T. B. N., Ferreira, M. S. L., & Fai, A. E. C. (2020). Utilization of Agricultural By-products: Bioactive Properties and Technological Applications. *Food Reviews International*, *38*(6), 1305–1329. https://doi.org/10.1080/87559129.2020.1804930

Bueno, A. M. C., & Torres, D. A. P. (2022). *Objetivos de Desenvolvimento Sustentável da Agenda 2030 e Bioeconomia: Oportunidades e potencialidades para a atuação da Embrapa. Brasília: Embrapa* (21ª ed., pp. 1–104).

Cangussu, L. B., Fronza, P., & Cavalcanti, W. M. (2020). Fiber-rich powders of tropical fruits by-products: a bibliographic review on their bioactive compounds. *Research, Society and Development*, *9*(9), e80996803. https://doi.org/10.33448/rsd-v9i9.6803

Carvalho, A. M., Bustamante, M. M. C., Alcântara, F. A., Resck, I. S., & Lemos, S. S. (2009). Characterization by solid-state CPMAS 13C NMR spectroscopy of decomposing plant residues in conventional and no-tillage systems in Central Brazil. *Soil and Tillage Research*, *102*(1), 144–150. https://doi.org/10.1016/j.still.2008.08.006

Conab-Companhia Nacional de Abastecimento do Brasil. (2020). *Acompanhamento da safra brasileira: grãos*. Retrieved August 7, 2022, from https://www.conab.gov.br/

Demajorovic, J. (1995). Da política tradicional de tratamento do lixo à política de gestão de resíduos sólidos as novas prioridades. *Revista de Administração de Empresas*, *35*(3), 88–93. https://doi.org/10.1590/S0034-75901995000300010

Dias, A. C. B., Pavan, M. A., Miyazaw, M., & Zocoler, D. C. (2003). Plant Residues: Short Term Effect on

Sulphate, Borate, Zinc and Copper Adsorption by an Acid Oxisol. *Brazilian Archives of Biology and Technology*, *46*(2), 199–202. https://doi.org/10.1590/S1516-89132003000200010

Edwiges, T., Frare, L., Mayer, B., Lins, L., Triolo, J. M., Flotats, X., & Costa, M. S. S. M. (2018). Influence of chemical composition on biochemical methane potential of fruit and vegetable waste. *Waste Management*, *71*, 618–625. https://doi.org/10.1016/j.wasman.2017.05.030

Esmelindro, M. C., Toniazzo, G., Waczuk, A., Dariva, C., & Oliveira, D. (2002). Caracterização físico-química da erva-mate: influência das etapas do processamento industrial. *Ciência e Tecnologia de Alimentos*, *22*(2), 193–204. https://doi.org/10.1590/S0101-20612002000200016

Esparza, I., Jiménez-Moreno, N., Bimbela, F., Ancín-Azpilicueta, C., & Gandía, L. M. (2020). Fruit and vegetable waste management: Conventional and emerging approaches. *Journal of Environmental Management*, *265*(1). https://doi.org/10.1016/j.jenvman.2020.110510

Ferreira, D. D. M., Rosa, C. A., & Borba, J. A. (2012). Panorama e potencialidades para publicação de artigos científicos na área ambiental. *Administração: Ensino e Pesquisa*, *13*(4), 673–705. https://doi.org/10.13058/raep.2012.v13n4.78

Flora e Funga do Brasil (2020). *Jardim Botânico do Rio de Janeiro*. Retrieved September 7, 2022, from http://floradobrasil.jbrj.gov.br/.

Franchini, J. C., Gonzalez-Vila, F. J., & Rodriguez, J. (2002). Decomposition of plant residues used in no-tillage systems as revealed by flash pyrolysis. *Journal of Analytical and Applied Pyrolysis*, *62*(1), 35–43. https://doi.org/10.1016/S0165-2370(00)00210-2

Franco, D. S. P., Georgin, J., Schadeck Netto, M., Allasia, D., Oliveira, M. L. S., Foletto, E. L., & Dotto, G. L. (2021). Highly effective adsorption of synthetic phenol effluent by a novel activated carbon prepared from fruit wastes of the Ceiba speciosa forest species. *Journal of Environmental Chemical Engineering*, *9*(5), 105927. https://doi.org/10.1016/j.jece.2021.105927

Ganesh, K. S., Sridhar, A., & Vishali, S. (2022). Utilization of fruit and vegetable waste to produce value-added products: Conventional utilization and emerging opportunities-A review. *Chemosphere*, *287*(3), 132221. https://doi.org/10.1016/j.chemosphere.2021.132221

García, R. R. M., Giannetti, B. F., Agostinho, F., Almeida, C. M. V. B., Sevegnani, F., Pérez, K. M. P., & Velásquez, L. (2021). Assessing the sustainability of rice production in Brazil and Cuba. *Journal of Agriculture and Food Research*, *4*, 100152. https://doi.org/10.1016/j.jafr.2021.100152

Gasparoti, P. S., & Paula, J. A. M. (2021). Composição fitoquímica e potencial farmacológico do estigma de Zea mays L. (Poaceae): uma revisão de escopo. *Movimenta*, *14*(2), 320–340.

Gupta, A., & Verma, J. P. (2015). Sustainable bio-ethanol production from agro-residues: A review. *Renewable and Sustainable Energy Reviews*, *41*, 550–557. https://doi.org/10.1016/j.rser.2014.08.032

Hafemann, E., Battisti, R., Bresolin, D., Marangoni, C., & Machado, R. A. F. (2020). Enhancing Chlorine□Free Purifcation Routes of Rice Husk Biomass Waste to Obtain Cellulose Nanocrystals. *Waste and Biomass Valorization*, *11*, 6595–6611. https://doi.org/10.1007/s12649-020-00937-2

Ibama—Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis. (2012, December 18). *Instrução Normativa Ibama nº 13, Lista Brasileira de Resíduos Sólidos*. Retrieved January 12, 2022, from https://servicos.ibama.gov.br/phocadownload/legislacao/in_13_18dez2012_ibama_lista_brasileira_residuos.pdf

Jaiganesh, V., Nagarajan, P. K., & Geetha, A. (2014). Solid state bio methane production from vegetable wastes Currentstate and perception. *Renewable and Sustainable Energy Reviews*, *40*, 432–437. https://doi.org/10.1016/j.rser.2014.07.016

Jakelaitis, A., Santos, C. L., Borchartt, L., Valadão, F. C. A., & Pittelkow, F. K. (2010). Effects of plant residues and herbicides on weed control and common bean yield. *Revista Caatinga*, *23*(1), 45–53. https://www.researchgate.net/publication/287942896

Lampridi, M. G., Sorensen, C. G., & Bochtis, D. (2019). Agricultural Sustainability: A Review of Concepts and Methods. *Sustainability*, *11*(18), 5120. https://doi.org/10.3390/su11185120

Lebre, D. T., Thipe, V. C., Cotrim, M. E. B., & Bustillos, J. O. V. (2022). Use of Sugar Cane Bagasse as Solid Extraction Phase Sorbent to Analyze Hormones from Industrial Effluent. *ACS OMEGA*, *7*, 10069. https://doi.org/10.1021/acsomega.1c06064

Leite, V. D., Ramos, R. O., Silva, P. M. U., Lopes, W. S., & Sousa, J. T. (2021). Kinetic models describing the hydrolytic stage of the anaerobic co-digestion of solid vegetable waste and anaerobic sewage sludge. *Biomass Conversion and Biorefinery*. https://doi.org/10.1007/s13399-021-01574-y

Macias-Chapula, C. A. (1998). O papel da informetria e da cienciometria e sua perspectiva nacional e internacional. *Ciência da Informação*, *27*(2), 134–140. https://doi.org/10.1590/S0100-19651998000200005

Malheiros, T. F., Phlippi Jr, A., & Coutinho, S. M. V. (2008). National Agenda 21 and Sustainable Development Indicators: The Brazilian context. *Saúde e Sociedade*, *17*(1), 7–20. https://doi.org/10.1590/S0104-12902008000100002

Mannarino, C. F., Ferreira, J. A., & Gandolla, M. (2016). Contribution to the development of municipal solid waste management in Brazil based on European experience. *Engenharia Sanitária e Ambiental*, *21*(2), 379–385. https://doi.org/10.1590/s1413-41522016146475

Martínez□Ramírez, S. M., Frías, M., Nakanishi, E. Y., & Savastano, J. R. H. (2019). Pozzolanic Reaction of a Biomass Waste as Mineral Addition to Cement Based Materials: Studies by Nuclear Magnetic Resonance (NMR). *International Journal of Concrete Structures and Material*, *13*(31), 1–8. https://doi.org/10.1186/s40069-019-0342-3

Mendes, N. S., Favre, L. C., Rolandelli, G., Ferreira, C. S., Gonçalves, E. C. B. A., & Buera, M. P. (2019). Flour from 'fruits and vegetables' waste with addition of a South-American pepper (Capsicum baccatum) proposed as food ingredient. *Food Science & Technology*, *55*, 1230–1237. https://doi.org/10.1111/ijfs.14358

Mesquita, L. M. S., Martins, M., Maricato, E., Nunes, C., Quinteiro, P. S. G. N., Dias, A. C. R. V., … Ventura, S. P. M. (2020). Ionic Liquid-Mediated Recovery of Carotenoids from the Bactris gasipaes Fruit Waste and Their Application in Food-Packaging Chitosan Films. *ACS Sustainable Chemistry & Engineering*, *8*, 4085–4095. https://doi.org/10.1021/acssuschemeng.9b06424

Mittermeier, R. A., Robles, P., Hoffmann, M., Pilgrim, J., Brooks, T., Mittermeier, C. G., … Fonseca, G. B. (2005). *Hotspots Revisited: earth's biologically richest and most endangered ecoregions* (pp. 1–200). Mexico City: Conservation International.

Mori, C., Fontaneli, R. S., & Santos, H. P. (2012). *Aspectos econômicos e conjunturais da cultura da aveia. Embrapa Trigo, Passo Fundo, RS*. Retrieved July 12, 2022, from http://www.cnpt.embrapa.br/biblio/do/p_do136.html.

Muthukumaravel, K., Amsath, A., & Sukumaran, M. (2008). Vermicomposting of Vegetable Wastes Using Cow Dung. *E-Journal of Chemistry*, *5*(4), 810–813. https://doi.org/10.1155/2008/572431

Myers, N., Mittermeier, R. A., Mittermeier, C. G., Fonseca, G. A. B., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, *403*, 853–858. https://doi.org/10.1038/35002501

Nascimento, J. M., Oliveira, J. D., & Leite, S. G. F. (2019). Chemical characterization of biomass flour of the babassu coconut mesocarp (Orbignya speciosa) during biosorption process of copper ions. *Environmental Technology & Innovation*, *16*. https://doi.org/10.1016/j.eti.2019.100440

Nearing, M. A., Xie, Y., Liu, B., & Ye, Y. (2017). Natural and anthropogenic rates of soil erosion. *International Soil and Water Conservation Research*, *5*(2), 77–84. https://doi.org/10.1016/j.iswcr.2017.04.001

Nguyen, T. T., Rosello, C., Bélanger, R., & Ratti, C. (2020). Fate of Residual Pesticides in Fruit and Vegetable Waste (FVW) Processing. *Foods*, *9*(10), 1468. https://doi.org/10.3390/foods9101468

Pacheco-Torgal, F., & Jalali, S. (2011). Cementitious building materials reinforced with vegetable fibres: A review. *Construction and Building Materials*, *25*(2), 575–581. https://doi.org/10.1016/j.conbuildmat.2010.07.024

Panachuki, E., Bertol, I., Sobrinho, T. A., Oliveira, P. T. S., & Rodrigues, D. B. B. (2015). Effect of soil tillage and plant residue on surface roughness of an oxisol under simulated rain. *Revista Brasileira de Ciências do solo*, *39*(1), 268–278. https://doi.org/10.1590/01000683rbcs20150187

Paredes Filho, M. V., Silva, A. B., & Florentino, L. A. (2020). Solubilization of Araxá natural phosphate and decomposition of plant residues by bacterial isolates. *Ciência e Agrotecnologia*, *44*, e008420. https://doi.org/10.1590/1413-7054202044008420

Parra, M. R., Coutinho, R. X., & Pessano, E. F. C. (2019). Um breve olhar sobre a cienciometria: origem, evolução, tendências e sua contribuição para o ensino de ciências. *Revista Contexto & Educação*, *34*(107), 126–141. https://doi.org/10.21527/2179-1309.2019.107.126-141

Patel, S. (2012). Potential of fruit and vegetable wastes as novel biosorbents: summarizing the recent studies. *Environmental Science and Bio/Technology*, *11*, 365–380. https://doi.org/10.1007/s11157-012-9297-4

Pavan, F. A., Lima, E. C., Dias, S. L. P., & Mazzocato, A. C. (2008). Methylene blue biosorption from aqueous solutions by yellow passion fruit waste. *Journal of Hazardous Materials*, *150*(3), 703–712. https://doi.org/10.1016/j.jhazmat.2007.05.023

Pelegrini, B. L., RÉ, F., Oliveira, M. M., Fernandes, T., Oliveira, J. H., Oliveira Junior, A. G., & Girotto, E. M. (2019). Cellulose Nanocrystals as a Sustainable Raw Material: Cytotoxicity and Applications on Healthcare Technology. *Macromolecular Materials and Engineering*, 304, 1–32. https://doi.org/10.1002/mame.201900092

Pereira, A. A., Alcântara, R. S., Moura, A. S., Griep Júnior, D. N., Vieira, G. M. N., & Almeida, J. R. S. (2020). Passion fruit waste in diets for quail in the laying phase. *Acta Scientiarum*, *42*, e48281. https://doi.org/10.4025/actascianimsci.v42i1.48281

Pereira, L. F. A., Firmo, W. C. A., & Coutinho, D. F. (2022). The importance of reusing waste from the food industry: the case of fruit processing. *Research, Society and Development*, *11*(12), e38111234089. https://doi.org/10.33448/rsd-v11i12.34089

Pouranian, M. R., & Shishehbor, M. (2019). Sustainability Assessment of Green Asphalt Mixtures: A Review. *Environments*, *6*(6), 73. https://doi.org/10.3390/environments6060073

Prado, K. S., Barrios, C. C., Fernandes, A. P., & Paiva, J. M. F. (2022). Municipal solid waste as source of renewable energy in Brazil: current overview and future perspectives. *Revista Virtual de Química*, *14*(1), 26-30. https://doi.org/10.21577/1984-6835.20210093

Reis, A. F., & Schmiele, M. (2019). Characteristics and potentialities of Savanna fruits in the food industry. *Brazilian Journalof Food Technology*, *22*, e2017150. https://doi.org/10.1590/1981-6723.15017

Reis, J. S., Araujo, R. O., Lima, V. M. R., Queiroz, L. S., Costa, C. E. F., Pardauil, J. J. R., … Souza, L. K. C. (2019). Combustion properties of potential Amazon biomass waste for use as fuel. *Journal of Thermal Analysis and Calorimetry*, *138*, 3535–3539. https://doi.org/10.1007/s10973-019-08457-5

Ricardino, I. E. F., Souza, M. N. C., & Silva Neto, I. F. (2020). Vantagens e Possibilidades do Reaproveitamento de Resíduos Agroindustriais. *Alimentos: Ciência, Tecnologia e Meio Ambiente*, *1*(8).

Salas-Zapata, W. A., Ríos-Osorio, L. A., & Cardona-Arias, J. A. (2017). Methodological characteristics of sustainability science: a systematic review. *Environment, Development and Sustainability*, *19*, 1127–1140. https://doi.org/10.1007/s10668-016-9801-z

Sánchez, M., Laca, A., Laca, A., & Díaz, M. (2021). Value-Added Products from Fruit and Vegetable Wastes: A Review. *Clean – Soil, Air, Water*, *49*, 2000376. https://doi.org/10.1002/clen.202000376

Santos, D., Iop, G. D., Mello, P. A., Flores, E. M. M., & Bizzi, C. A. (2021). Biomass waste valorization assisted by microwaves: a feasible approach for the co□production of value□added products. *Biomass Conversion and Biorefnery*. https://doi.org/10.1007/s13399-021-02104-6

Santos, G. H. F., Nascimento, R. S., & Alves, G. M. (2017). Biomass as Sustainable Energy in Brazil. *Revista UNINGÁ Review*, *29*(2), 6–13.

Santos, O. V., Vieira, E. L. S., Soares, S. D., Conceição, L. R. V., Nascimento, F. C. A., & Teixeira-Costa, B. E. (2021). Utilization of agroindustrial residue from passion fruit (Passiflora edulis) seeds as a source of fatty acids and bioactive substances. *Food Science and Technology*, *41*(1), 218–225. https://doi.org/10.1590/fst.16220

Saraiva, B. R., Vital, A. C. P., Anjo, F. A., Cesaro, E., & Pintro, P. T. (2018). Valorization of agro-industrial waste: sources of nutrients and bioactive compounds for human consumption. *Pubsaúde*, *1*, a007. https://doi.org/10.31533/pubsaude1.a007

Sarfaraz, Q., Silva, L. S., Drescher, G. L., Zafar, G., Severo, F. F., Kokkonen, A., … Solaiman, Z. M. Characterization and carbon mineralization of biochars produced from different animal manures and plant residues. *Scientific Reports*, *10*, 955. https://doi.org/10.1038/s41598-020-57987-8

Satolo, E. G., Hiraga, L. E. M., Goes, G. A., & Lourenzani, W. L. (2016). Lean production assessment in a sugarcane agribusiness: a case study in Brazil. *Independent Journal of Management & Production* (IJM&P). *7*(3), 937–952. https://doi.org/10.14807/ijmp.v7i3.471

Silva, A. L., & Castaneda-Ayarza, J. A. (2021). Macro-environment analysis of the corn ethanol fuel development in Brazil. *Renewable and Sustainable Energy Reviews*, *135*, 110387. https://doi.org/10.1016/j.rser.2020.110387

Silva, C. A. A., Lacerda, M. P. F., Leite, R. S. R., & Fonseca, G. G. (2014). Physiology of Lichtheimiaramosa obtained by solid-state bioprocess using fruit wastes as substrate. *Bioprocess Biosyst Eng.*, *37*, 727–734. https://doi.org/10.1007/s00449-013-1043-y

Silva, E. C., Muraoka, T., Buzetti, S., Espinal, F. S. C., & Trivelin, P. C. O. (2008). Utilization of nitrogen from corn plant residues and green manures by corn. *Revista Brasileira de Ciência do Solo*, *32*, 2853–2861. https://doi.org/10.1590/S0100-06832008000700032

Silva, F. M. A., Smith-Menezes, A., & Duarte, M. F. S. (2016). Consumption of fruits and vegetables associated with other risk behaviors among adolescents in Northeast Brazil. *Revista Paulista de Pediatria*, *34*(3), 309–315. https://doi.org/10.1016/j.rppede.2015.09.004

Silva, J. E., Calixto, G. Q., Almeida, C. C., Melo, D. M. A., Melo, M. A. F., Freitas, J. C. O., & Braga, R. M. (2019). Energy potential and thermogravimetric study of pyrolysis kinetics of biomass wastes. *Journal of Thermal Analysis and Calorimetry*, *137*, 1635–1643.https://doi.org/10.1007/s10973-019-08048-4

Silva, K. C., Rosas, L. S. P., & Oliveira, S. R. N. (2018). Gestão dos Resíduos Sólidos do Brasil evolução e desafios a caminho: Uma Revisão Integrativa. *Scientia Amazonia*, *7*(2), 1–15.

Silva, L. A., Santos, I. F. S., Machado, G. O., Tiago Filho, G. L., & Barros, R. M. (2021). Rice husk energy production in Brazil: An economic and energy extensive analysis. *Journal of Cleaner Production*, *290*(25), 125188. https://doi.org/10.1016/j.jclepro.2020.125188

Silva, M. E. A., Nunes, L. M. C., Passos, I. S., Cordeiro, D. R., Caldas, A. M. J., Ogorodnik, M. E. A., … Silva, E. M. (2022). Reuse of solid waste in partial replacement to binding industry in the civil construction industry: a review. *Brazilian Journal of Development*, *8*(7), 50690–50709. https://doi.org/10.34117/bjdv8n7-133

Silva, R. G., Bortoletto, M., Bigotto, S. A. M., Akasaki, J. L., Soriano, L., & Tashima, M. M. (2021). Effect of wastes from sugar cane industry on the mechanical and hydraulic properties of pervious concrete. *Road Materials and Pavement Design*, 1981–1998. https://doi.org/10.1080/14680629.2021.1927156

Sousa, A. L., & Rizzatto, M. L. (2022). Biogás production from organic waste: a review. *Scientific Electronic Archives*, *15*(2), 72–77. https://doi.org/10.36560/15220221511

Sousa, M. S. B., Vieira, L. M., & Lima, A. (2011). Total phenolics and in vitro antioxidant capacity of tropical fruit pulp wastes. *Brazilian Journal of Food Technology*, *14*(3), 202–210. https://doi.org/10.4260/BJFT2011140300024

Stancato, A. C., Burke, A. K., & Beraldo, A. L. (2005). Mechanism of a vegetable waste composite withpolymer-modified cement (VWCPMC). *Cement & Concrete Composites*, *27*(5), 599–603. https://doi.org/10.1016/j.cemconcomp.2004.09.011

Tahir, M., & Amin, N. S. (2013). Advances in visible light responsive titanium oxide-based photocatalysts for CO2 conversion to hydrocarbon fuels. *Energy Conversion and Management*, *76*, 194–214. https://doi.org/10.1016/j.enconman.2013.07.046

Tessmann, M. S., Tessmann, C., Lima, L. S., Quintão, M. B., & Bandeira, M. L. S. F. (2021). Bioproducts from agro-industrial plant residues: opportunities for sustainable reuse. *Brazilian Journal of Development*, *7*(9). https://doi.org/10.34117/bjdv7n9-208

Thürer, M., Tomasevic, I., Stevenson, I., QU, M. T., & Huisingh, D. (2018). A systematic review of the literature on integrating sustainability into engineering curricula. *Journal of Cleaner Production*, *181*(20), 608–617. https://doi.org/10.1016/j.jclepro.2017.12.130

United Nations. (2017). *Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development*. Retrieved July 23, 2021, from https://unstats.un.org/sdgs/indicators/indicators-list

Verruck, S. (2021). Avanços em ciência e tecnologia de alimentos. In C. V. Alves, G. S. Lima, W. Dorvil, V. M. Santos, I. B. Lima, F. H. Xavier-Júnior, F. Humberto & T. C. M. Stamford (Eds.), *Sustentabilidade da produção de alimentos através da valorização do potencial de resíduos vegetais – Uma revisão* (1st ed., pp. 591–604). Editora científica digital. https://doi.org/10.37885/978-65-87196-95-4

Vione, E. L. B., Silva, L. S., Cargnelutti Filho, A., Aita, N. T., Morais, A. F., & Silva, A. A. K. (2018). Caracterização química de compostos e vermicompostos produzidos com casca de arroz e dejetos animais. *Revista Ceres*, *65*(1), 65–73. https://doi.org/10.1590/0034-737X201865010009

Appendix A

Table 1. Plant species cited in articles published between 1994 and 2021, with the number of articles in which they were cited, common name, scientific name, origin, endemism, Brazilian phytogeographic domains and type of reuse

Number of articles in which they were cited	**Common name**	**Scientific name**	**Origin ***	**Endemism***	**phytogeographic domains ***	**Type of reuse investigated in the articles**
1	avocado	*Persea americana* Mill.*	naturalized	non-endemic	Atlantic Forest	methane production
1	pineapple	*Ananas comosus* (L.) Merril*	native	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Pampa and Swampland	bioenergy
4	pumpkin	NI	NI	NI	NI	biogas production
2	açai	*Euterpe oleracea* Mart.	native	non-endemic	Amazon and Savannah	methane production, biomass conversion, production of milk coagulation enzymes and biofuels
1	watercress	*Rorippa nasturtium-aquaticum* (L.) Hayek*	cultivated	non-endemic	NI	methane production
1	poplar	*Populus deltoids* W. Bartram ex Marshall*	cultivated	non-endemic	NI	ANE
1	albizia	*Albizia julibrissin* Durazz	cultivated	non-endemic	NI	green manure
1	artichoke	*Cynara cardunculus* L.*	cultivated	non-endemic	Savannah, Atlantic Forest, Pampa	biogas production
4	lettuce	*Lactuca sativa* L.	cultivated	endemic	NI	flour, biogas production and production of 2,3-butanediol
2	cotton	*Gossypium barbadense* L.*	naturalized	non-endemic	Amazon, Caatinga, Atlantic Forest	bioenergy
2	plum	*Prunus domestica* L.*	cultivated	non-endemic	NI	methane production and production of 2,3-butanediol
1	almond	*Prunus dulcis* (Mill.) D. A. Webb*	cultivated	non-endemic	NI	mushroom fertilization
1	andiroba	*Carapaguianensis* A ubl.	native	non-endemic	Amazon	biomass conversion
1	Arachis pintoi	*Arachis pintoi* Krapov. & W. C .Greg.	native	endemic	Caatinga, Savannah, Atlantic Forest	decomposition and mineralization of N from organic plant materials
1	araticum	*Annona crassiflora* Mart.	native	non-endemic	Amazon, Savannah, Swampland	growth and production of lipases of the fungus
13	rice	*Oryza sativa* L.*	cultivated	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Pampa, Swampland	biocatalyst, coproduction of value-added products, fertilizer, nanocrystals, production of milk coagulation enzymes, polyurethane foam, construction, flour, production of compounds

						and vermicomposts.
1	asparagus	*Asparagus officinalis* L.	cultivated	non-endemic	NI	flour enrichment
11	oat	*Avenastrigosa* Schreb.	cultivated	non-endemic	Atlantic Forest, Pampa	soil conservation, waste decomposition, identifying low molecular weight organic acids, fertilizer, Surface Applied Lime Mobility, organic acid production, absorption of cations in latosol, improvement in fertility and soil correction.
1	olive	*Olea europaea* L.	cultivated	non-endemic	NI	biochar
1	bacuri	*Platonia insignis* Mart.	native	non-endemic	Amazon, Savannah	development of bioproducts
6	Cavendish banana	*Musa* L.	naturalized	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest	bioproducts production, biogas production, absorption of heavy metals from water and additives in elephant grass silage
1	baru	*Dipteryxalata* Vogel	native	non-endemic	Savannah	bioproducts
1	potato	*Solanum tuberosum* L.*	cultivated	non-endemic	NI	methane production
1	sweet potato	*Ipomoea batatas* (L.) Lam.*	naturalized	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Pampa, Swampland	methane production
1	eggplant	*Solanum melongena* L.*	cultivated	non-endemic	NI	methane production and production of 2,3-butanediol
3	beet	*Beta vulgaris* L.	cultivated	non-endemic	Atlantic Forest	meat preservative and biogas production.
1	birch	NI	NI	NI	NI	ANE
1	bocaiuva	*Acrocomia aculeata* (Jacq.) Lodd. ex Mart.	native	non-endemic	Savannah, Atlantic Forest	growth and the production of lipases of the fungus and substrate
1	falso-plátano	*Acer pseudoplatanus* L.*	cultivated	non-endemic	NI	ANE
2	grass - Brachiaria - Decumbens	*Urochloadecumbens* (Stapf) R. D. Webster	naturalized	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Pampa, Swampland	green manure and decomposition of waste
1	broccoli	*Brassica oleracea* L.*	cultivated	non-endemic	NI	methane production and production of 2,3-butanediol
1	buriti	*Mauritia flexuosa*L.f.	native	non-endemic	Amazon, Caatinga, Savannah	bioenergy
1	cocoa	*Theobroma cacao* L.	native	non-endemic	Amazon, Atlantic Forest	biosorbents and biofuels
1	coffee marata	*Coffea* L.*	naturalized	non-endemic	Amazon, Atlantic Forest	biofuels and activated carbon
1	cajanus	*Cajanus cajan* (L.) Huth	naturalized	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Pampa, Swampland	green manure
1	cashew	*Anacardium* L.*	native	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Pampa, Swampland	methane production

1	NI	*Calopogoniummucunoides*Desv.	native	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Swampland	decomposition and mineralization of N from organic plant materials
18	sugarcane	*Saccharum officinarum* L.*	cultivated	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Pampa, Swampland	coproduction of value-added products, biofuels, synthesis of gasification, production of bioproducts, substrate, bioenergy, construction, chemical input, composting, activated carbon and biofertilizer.
1	Canavalia b.	*Canavalia brasiliensis* Mart. ex Benth.	native	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest	green manure
1	cânhamo	*Crotalaria juncea* L.	naturalized	non-endemic	Amazon, Savannah, Atlantic Forest, Pampa, Swampland	green manure
1	grass	NI	NI	NI	NI	co-production of value-added products
2	capimBrachiaria	*Urochloabrizantha* (Hochst. ex A.Rich.) R.D.Webster	naturalized	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Pampa, Swampland	construction and fertilizer
2	elephant grass	*Cenchrus purpureus* (Schumach.) Morrone	naturalized	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Swampland	additives in elephant grass silage and construction.
2	persimmon	*Diospyros kaki* L.f.	cultivated	non-endemic	NI	production of methane and fertilizer
1	Brazil nut	*Bertholletiaexcelsa* Bonpl.	native	non-endemic	Amazon	biofuels
2	onion	*Allium cepa* L.*	cultivated	non-endemic	NI	biogas production
1	ceiba	*Ceiba speciosa* (A.St.-Hil.) Ravenna	native	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Pampa, Swampland	activated carbon for removal of phenol from water
6	carrot	*Daucus carota* L.*	cultivated	non-endemic	Atlantic Forest, Pampa	production of 2,3-butanediol, flour, biogas and human food
1	rye	*Secale cereale* L.	cultivated	non-endemic	Atlantic Forest	Mobility of Surface Applied Lime
2	barley	*Hordeumvulgare* L.*	cultivated	non-endemic	NI	flour
2	chayote	*Sicyosedulis* Jacq.	naturalized	non-endemic	NI	biogas production
1	citrus	NI	NI	NI	NI	soil conservation
1	coconut	*Cocos nucifera* L.	naturalized	non-endemic	Atlantic Forest	biosorbents and magnetic activated carbons
1	coconut	NI	NI	NI	NI	Biofuels, activated carbon and substrate
4	babassu	*Attalea speciosa* Mart. ex Spreng.*	native	endemic	Amazon, Savannah	activated carbon, biosorbents and biogas
1	cocona	*Solanum sessiliflorum* Dunal	native	non-endemic	Amazon	functional food and food additives
1	courgette	*Cucurbita pepo* L.	cultivated	non-endemic	NI	flour
1	cauliflower	*Brassica oleracea* var. botrytis L.*	cultivated	non-endemic	NI	methane production
6	crotalaria	*Crotalaria juncea* L.	naturalized	non-endemic	Amazon, Savannah, Atlantic Forest, Pampa, Swampland	green manure and decomposition of waste
1	cumaru	*Amburana acreana* (Ducke) A.C.Sm.	native	non-endemic	Amazon	food preservative

3	cupuaçu	*Theobroma grandiflorum* (Willd. ex Spreng.) K.Schum. in Mart.	native	unknown	Amazon	Production of milk coagulation enzymes, conversion of biomass and biofuels.
2	yerba mate	*Ilex dumosa* Reissek	native	non-endemic	Caatinga, Savannah, Atlantic Forest, Pampa	co-production of value-added products and confection of sweets
2	common vetch	*Vicia sativa* L.	naturalized	non-endemic	Atlantic Forest, Pampa	organic acid production and soil correction
1	spinach	*Spinacia oleracea* L.	cultivated	non-endemic	Atlantic Forest	flour
2	eucalyptus	*Eucalyptus grandis* W. Hill	cultivated	non-endemic	NI	biosorbents and fuel of boiler
3	eucalyptus	*Eucalyptus urophylla* S. T. Blake	cultivated	non-endemic	NI	biosorbents and fuel of boiler
2	eucalyptus	*Eucalyptus*L'Hér	cultivated	non-endemic	NI	ecological firewood
2	eucalyptus	NI	NI	NI	NI	Bioenergy production and soil conservation
1	pigeon pea	*Cajanus cajan* (L.) Huth	naturalized	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Pampa, Swampland	absorption of cations in latosol
1	velvet bean	*Mucuna pruriens* (L.) DC.	native	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest	green manure
1	green bean	*Vigna unguiculata* (L.) Walp.	cultivated	non-endemic	NI	ANE
1	wild bean	*Canavalia brasiliensis* Mart. ex Benth	native	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest	green manure
1	jack bean	*Canavalia ensiformis* (L.) DC.	cultivated	non-endemic	NI	green manure
3	bean	*Phaseolus vulgaris* L.	cultivated	non-endemic	NI	Production of methane, bioenergy and production of 2,3-butanediol
2	fig	*Ficus carica* L.*	cultivated	non-endemic	NI	fish nutrition
7	fruits and vegetables	NI	NI	NI	NI	evaluation of COD and C/N ratio, production of compounds, biogas, vermicomposting and anaerobic biodegradation
1	gabiroba	*Campomanesia adamantium* (Cambess.) O. Berg	native	non-endemic	Cerrado, Atlantic Forest	ANE
2	gabiroba	*Campomanesia pubescens* (Mart. ex DC.) O.Berg	native	endemic	Caatinga, Savannah, Atlantic Forest	substrate and growth and the production of lipases of the fungus
4	sunflower	*Helianthus annuus* L.	cultivated	non-endemic	NI	green manure
4	guava	*Psidium guajava* L.*	naturalized	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Pampa	meat preservative, methane production and fish nutrition
3	pigeon pea	*Cajanus cajan* (L.) Huth	naturalized	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Pampa, Swampland	green manure
1	guapeva	*Pouteria gardneriana* (A.DC.) Radlk	native	non-endemic	Caatinga, Savannah, Atlantic Forest	feed
1	mint	*Mentha* L.	naturalized	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest	flour

1	inajá	*Attalea maripa* (Aubl.) Mart.	native	non-endemic	Amazon	bioenergy
1	inga	*Inga edulis* Mart	native	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest	green manure
1	jambo	*Syzygium jambos* (L.) Alston*	naturalized	non-endemic	Savannah, Atlantic Forest	antioxidant, natural dye in food and enrichment of diets
1	jatobá	*Hymenaeacourbaril* L.	native	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Swampland	super-activated charcoal
1	juçara	*Euterpe edulis* Mart.	native	non-endemic	Savannah, Atlantic Forest	meat preservative
6	orange	*Citrus ×aurantium* L.	cultivated	non-endemic	Savannah, Atlantic Forest	fish nutrition, ice cream, methane and flour production
1	leucena	*Leucaena leucocephala* (Lam.) de Wit	naturalized	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest	Mobility of Surface Applied Lime
1	Lupinus albus	*Lupinus albus* L.	cultivated	non-endemic	NI	breakdown of waste
1	apple	*Malus pumila*Mill.*	cultivated	non-endemic	NI	methane production, production of 2,3-butanediol, co-production of value-added products and biofuels
1	pine wood	*Pinus caribaea* Morelet	naturalized	non-endemic	Savannah, Atlantic Forest	civil construction
3	papaya	*Carica papaya* L.*	naturalized	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest	biogas and flour production
2	castor bean	*Ricinus communis* L.	naturalized	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Pampa, Swampland	composting and production of bioproducts
3	cassava	*Manihot esculenta* Crantz	native	non-endemic	Amazon, Savannah	bioenergy and production of methane
2	manduvirá	*Crotalaria juncea* L.	naturalized	non-endemic	Amazon, Savannah, Atlantic Forest, Pampa, Swampland	green manure
5	mango	*Mangifera indica* L.*	cultivated	non-endemic	NI	bioactive compounds, additives in elephant grass silage and methane production
4	passion fruit	*Passiflora edulis* Sims	native	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Pampa, Swampland	flour, biosorbent, production of hydrolytic and oxidative enzymes
4	passion fruit	NI	NI	NI	NI	additives in the ensiling of elephant grass, methane production and feeding Japanese quail
1	sweet passion fruit	*Passiflora alata* Curtis	native	endemic	Amazon, Savannah, Atlantic Forest, Pampa	industrial processing of juices
3	watermelon	*Citrullus lanatus* (Thunb.) Matsum. &Nakai	cultivated	non-endemic	NI	flour and production of biogas
2	melon	*Cucumis melo* L.	cultivated	non-endemic	NI	biogas production

8	millet	*Cenchrus americanus* (L.) Morrone	naturalized	non-endemic	Savannah, Atlantic Forest	Fertilizer, soil correction, water interception and storage, desiccation speed, soil cover, solar radiation interception and surface runoff
14	corn	*Zea mays* L.	cultivated	non-endemic	NI	green fertilizer, foodstufffeed, bioenergy, production of 2,3-butanediol, bromatological characteristic, tillage and soil correction, water interception and storage, desiccation speed, soil cover, solar radiation interception and surface runoff
1	strawberry	*Fragaria ×ananassa* Duchesne ex Rozier *	cultivated	non-endemic	NI	methane production
3	mucuna	*Mucuna bennetti* F. Muell.	native	non-endemic	NI	Mobility of Surface Applied Lime, absorption of cations in latosol and fertilizer
4	mucuna	*Mucuna pruriens* var. utilis (Wall. ex Wight) Baker ex Burck	cultivated	non-endemic	Savannah, Atlantic Forest	green manure
1	murici	*Byrsonima* Rich. ex Kunth	native	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Swampland	industrial processing of juices
6	fodder radish	*Raphanus sativu*s L.	naturalized	non-endemic	Caatinga, Savannah, Atlantic Forest, Pampa	Identifying low molecular weight organic acids, fertilizer, soil correction, organic acid production.
1	neem	*Azadirachta indica* A.Juss.	cultivated	non-endemic	NI	biofertilizers
1	pecan nut	*Carya illinoinensis* (Wangenh.) K.Koch	cultivated	non-endemic	NI	production of compounds
1	nuts	*Bertholletiaexcelsa* B onpl.	native	non-endemic	Amazon	biomass conversion
1	palm	*Archontophoenixalex andrae* (F.Muell.) H.Wendl. &Drude	cultivated	non-endemic	NI	ANE
2	palm heart	*Euterpe edulis* Mart.	native	non-endemic	NI	Production Cellulose and cellulose pulp
1	NI	*Cenchrus americanus* (L.) Morrone	naturalized	non-endemic	Savannah, Atlantic Forest	green manure
2	cucumber	*Cucumis sativus* L.	cultivated	non-endemic	Atlantic Forest	flour and production of biogas
7	pequi	*Caryocar brasiliense* Cambess.	native	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest	industrial processing of juices, flour, nematode control, growth and production of fungus lipases, substrate and functional foods
1	pear	*Pyrus* L.*	cultivated	non-endemic	NI	production of 2,3-butanediol
2	peach	*Prunus persica* (L.) Batsch *	cultivated	non-endemic	NI	Production of methane and flour

1	pepper	*Capsicum baccatum* L. var. baccatum	native	non-endemic	Savannah, Atlantic Forest, Swampland	flour
4	pepper	NI	NI	NI	NI	methane production and production of 2,3-butanediol
1	chili	*Capsicum annuum* L.	cultivated	non-endemic	Amazon	production of 2,3-butanediol
1	NI	*Pinus taeda* L.	naturalized	non-endemic	Atlantic Forest	ecological firewood
1	pitaia	*Selenicereusundatus* (Haw.) D.R. Hunt	naturalized	non-endemic	NI	applicability not specified
1	pupunha	*Bactris gasipaes* Kunth	native	non-endemic	Amazon	food packaging
1	okra	*Abelmoschus*Medik.	Cultivated	non-endemic	NI	methane production
4	radish	*Raphanus sativus* L.	Naturalized	non-endemic	Caatinga, Savannah, Atlantic Forest, Pampa	soil correction, absorption of cations in latosol, fertilizer
3	cabbage	*Brassica oleracea* L.	Cultivated	non-endemic	NI	production of 2,3-butanediol and methane
2	arugula	*Eruca vesicaria* (L.) Cav.	Cultivated	non-endemic	NI	production of methane and flour
1	NI	*Sargassum filipendula* C. Agardh	Native	unknown	NI	silver absorption
1	seriguela	*Spondiaspurpurea* L.	Cultivated	non-endemic	NI	growth and production of lipases of fungus
2	sisal	*Agave sisalana Perrine* ex Engelm.	Naturalized	non-endemic	Caatinga	polymers and bioproducts
4	soy	NI	NI	NI	NI	green manure, added value material, feed, soil cover, water interception and storage, desiccation speed, solar radiation interception and surface runoff
4	soy	*Glycine max* (L.) Merr.	Cultivated	non-endemic	NI	green manure
4	sorghum	*Sorghum bicolor* (L.) Moench	Naturalized	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Swampland	green manure
1	mucuna	*Mucuna*Adans.	Native	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest	decomposition and mineralization of N from organic plant materials
2	Stylosanthes	*Stylosanthes guianensis* (Aubl.) Sw. var. guianensis	Native	non-endemic	Amazon, Caatinga, Savannah, Atlantic Forest, Swampland	green fertilizer and N decomposition and mineralization of organic plant materials
1	tamarind	*Tamarindus indica* L.	Cultivated	non-endemic	NI	human consumption
1	taro	*Colocasia esculenta* (L.) Schott	Cultivated	non-endemic	NI	flour
3	tomato	*Solanum lycopersicum* L.*	Cultivated	non-endemic	NI	biogas production
1	blue lupin	*Lupinus angustifolius* L.	Cultivated	non-endemic	NI	green manure
1	white lupin	*Lupinus albus* L.	Cultivated	non-endemic	NI	green manure
1	crimson clover	*Trifolium incarnatum* L	Cultivated	non-endemic	NI	green manure
2	wheat	*Triticum aestivum* L.	Naturalized	non-endemic	NI	green fertilizer and Surface Applied Lime Mobility
1	wheat	NI	Ni	NI	NI	production of hydrolytic and oxidative enzymes
3	wheat	*Triticum aestivum* L.	Cultivated	non-endemic	NI	fertilizer and correction of the soil

1	tucumã	*Astrocaryumtucuma* Mart	Unknown	desconhecido	NI	production of bioproducts
1	umbu	*Spondias tuberosa* Arruda	Native	endemic	NI	feed
5	grape	NI	NI	NI	NI	coproduction of value-added products, fish nutrition, methane production, oil source with nutritional, cosmetic and pharmaceutical applications
1	grape	*Vitis labrusca* L.	Cultivated	non-endemic	NI	breakfast cereal
1	grape	*Vitis vinifera* L.	Cultivated	non-endemic	NI	ANE
1	saconadi	*Virolaelongata* (Benth.) Warb.	Native	non-endemic	Amazon	plant drug

* data obtained in the Flora e Funga do Brazil (2022). NI – not informed. ANE – applicability not specified.