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Chapter

Beekeeping in Brazil: A Bibliographic Review

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Abstract

Brazil presents favorable conditions for beekeeping, having a suitable climate; native flowering plants with great potential for the production of honey, pollen, propolis, and royal jelly; and bees adapted to our conditions, tolerant to the main apicultural diseases and highly productive. Through the meliponiculture, the conservation of mainly native forest areas is allowed; therefore, they are the best environments for the creation of native bees and production of by-products of the beehive with quality. The stingless bees are very sensitive to any disturbance due to anthropogenic action. A systematic bibliographical review was carried out in different electronic databases, through descriptors referring to beekeeping in Brazil. The identification of articles and their inclusion occurred between January 2018 and April 2018. The bibliographic research was conducted in the following electronic databases: (1) Scientific Electronic Library Online (SciELO), (2) Public Library of Science (PLOS) Biology, and (3) ScienceDirect. In order to help in the process of standardization of bee products and traceability of the production chain, it was possible to draw a profile of the main bioactive substances of the beehive products of Brazil. It was also possible to relate the benefits of an adequate management of beekeeping and meliponiculture in Brazil.

Keywords: beekeeping management, meliponiculture, beehive products, propolis

1. Introduction

Bee products such as honey, beeswax, pollen, royal jelly, and propolis have a wide range of use. In addition to human nutrition, bee products can be used in traditional medicine [1].

Brazil has favorable conditions for bees and has a great variety of vegetation from which bees can collect resins, which cause a great chemical diversity among bee

products collected in different regions and different seasons [2]. The chemical diversity aspect of bee products demonstrates that prior to their use they must be chemically standardized to ensure quality, efficacy, and safety, and thus it is possible to correlate the type of product with its therapeutic application [3].

Several studies point to health-related benefits in propolis use. In the Brazilian Northeast, studies demonstrate, the benefits of the use of red propolis in renal lesions include beneficial alterations in the histopathological aspect of the renal tissue and potential clinical benefits in the use of this propolis to protect the kidneys against ischemic acute renal failure [4]. *Tetragonisca angustula* is a stingless bee distributed widely in Brazil and Mexico. The biological activity of *Tetragonisca angustula* honey, particularly its antimicrobial activity, has been well documented and studied, demonstrating good antimicrobial activity against *Staphylococcus aureus* bacteria [5, 6]. Honey produced in the Eastern Amazon, Brazil, was reported with the total content of phenolic compounds higher than those already reported in the literature, as well as high antioxidant activity [7].

Brazilian vegetation offers a large amount of chemical compounds through its diversity in which products of apicultural origin can offer great potential in the quality of hive products produced in the country, since Brazil has some of the largest biomes in terms of biodiversity and total area. In the neotropics, the flora through the biodiversity existing in them is incomparable in relation to the other existing biomes, being the flora existing in Brazil extremely rich with diverse floral morphology which attracts a great amount of pollinators. The Amazon stands out as being the main maintainer of the planet's greatest diversity [8].

Most conservation decisions occur at national or regional spatial scales, where information becomes useful at such decision-making scales, which is essential to guide conservation practice. Conservation practices such as meliponiculture tend to aid the conservationist effect of the sustainable use of Brazilian vegetation. It is also worth noting that Brazil is one of the most biodiverse countries in the world and, consequently, use and conservation decisions have impacts on these local populations [9].

Through the meliponiculture the conservation of mainly native forest areas is allowed; therefore, they are the best environments for the creation of native bees and production of by-products of the beehive with quality. The stingless bees are very sensitive to any disturbance due to anthropogenic action.

The Management of beekeeping identifies measures against the specific risks in this activity is very important for increasing productivity, income, and production and promoting beekeeping [10]. In this context, a systematic bibliographical review was carried out in different electronic databases, through descriptors referring to beekeeping in Brazil.

2. Body: research methods

Study design: the study of systematic bibliographic review in different scientific electronic databases is through descriptors referring to beekeeping in Brazil. The identification of articles and their inclusion occurred between January and April 2018.

Electronic databases: the bibliographic research was conducted in the following electronic databases: (1) Scientific Electronic Library Online (SciELO), (2) Public Library of Science (PLOS) Biology, and (3) ScienceDirect. Additional information was obtained from the manual search based on the references listed in the articles included in the review.

Search strategy: the searches were conducted using descriptors cataloged in the Health Sciences Descriptors (DeCS) and in the Medical Subject Headings (MeSH), in Portuguese and English contained in the title or in the summaries of the studies. The combination of terms used together or separately in the respective databases (SciELO, PLOS Biology, ScienceDirect) were *gestão de apicultura* (beekeeping

management), *meliponicultura* (meliponiculture), *produtos da colméia* (products of the hive), and *própolis* (propolis).

Selection and analysis of publications: for the selection of articles, a personal study form was prepared with the following information: author and year, title, study development period, federative unit, city and area of research, study design, descriptor used to locate the publication, objective, and main results. An inclusion criterion was used in which the selected articles had to be original, published in international or national journals, in English or Portuguese, between 2013 and 2018, from the subareas of health sciences, medicine and health sciences, research articles, and open articles accessed and indexed in one of the bases previously mentioned. Papers containing data on beekeeping in Brazil were selected for review.

Sampling: a total of 10,645 scientific papers on apiculture were identified in Brazil and in the world, searched in the databases and with the descriptors mentioned above. Of the total of articles published between the years 2013 and 2018, 4149 works were related to the subject of beekeeping. Articles were repealed because they were repeated in other languages, and products from Brazil were not evaluated. For the present revision of the scientific literature, 25 papers were selected.

3. Results

Only articles containing beekeeping studies in Brazil between the years 2013 and 2018 were selected for review. As can be seen in **Figure 1**, the number of published papers on beekeeping is relevant. However, we can see below the index

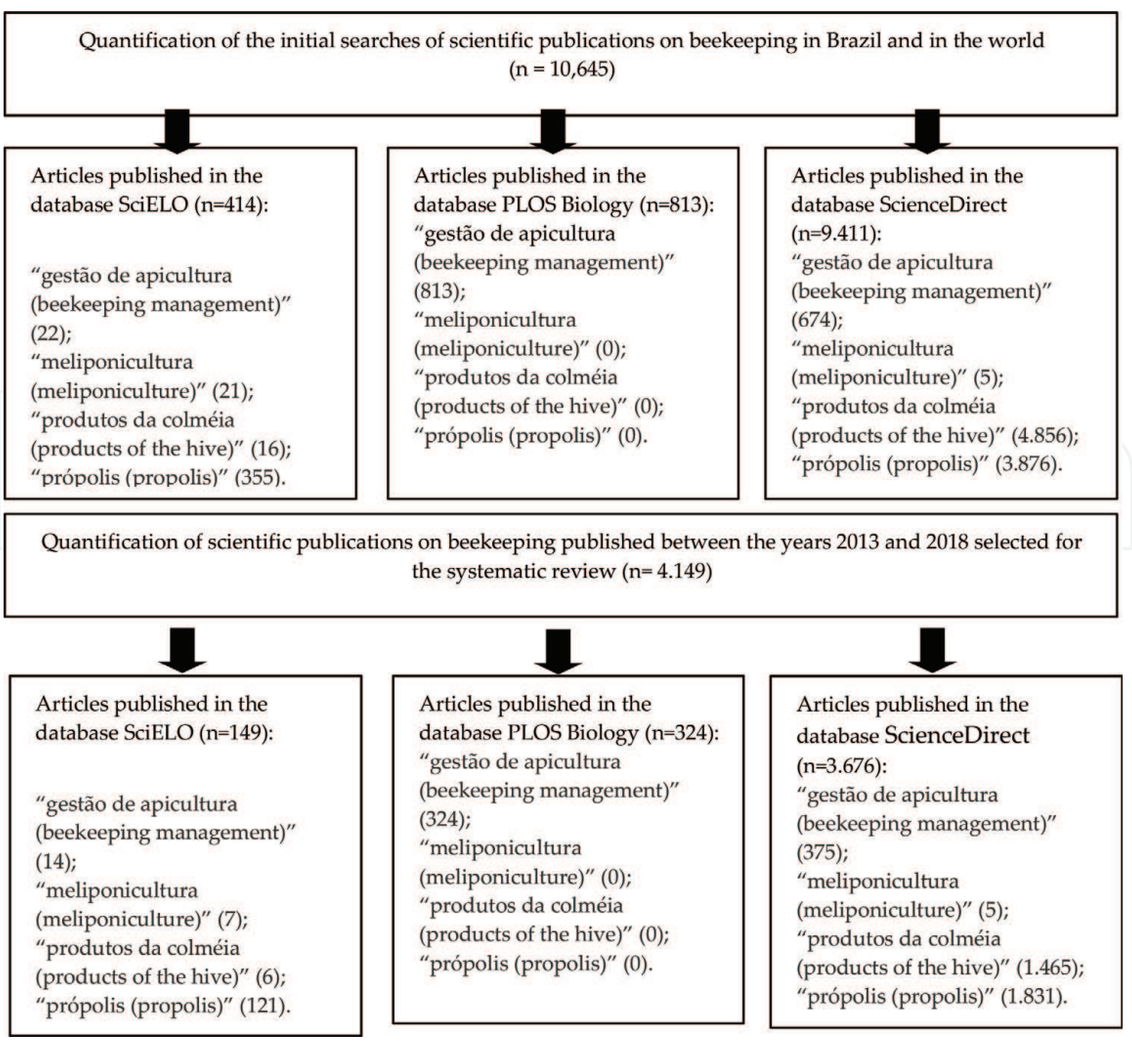

Figure 1.
Logical framework of the systematic review, studies on beekeeping in Brazil between the years 2013 and 2018.

of works on this subject in Brazil, mainly in the base PLOS Biology. The results obtained with the application of the described search strategy are presented in the logical framework of the study (**Figure 1**).

Table 1 summarizes the papers evaluated for this study.

N°	Bibliographic reference	Conclusions
01	Canhos et al. [11]	By 2014, more than 95% of SpeciesLink Network users were from Brazil. In the last decade, the open-access movement has boosted the development of many web platforms for data sharing. Adequate policies unfortunately have not followed the same pace, and now many initiatives may perish. Part of the problem facing electronic infrastructures is that agencies prioritize innovative projects and rarely fund ongoing and long-term initiatives
02	Faita et al. [12]	In terms of their defensive behavior, bees in the southern region of the state were not influenced by bees of the European origin
03	Ponciano et al. [13]	It was verified that the educational level positively influenced the development of beekeepers. The level of illiteracy was null for beekeepers in these municipalities, and most of them have finished at least high school. Other characteristics that contributed to raise this index in the mentioned municipalities were technical assistance, management of the queen exchange, and the practice of migratory beekeeping. Thus, the modernization of beekeepers in order to improve the technological level, expand productivity, and diversify their production necessarily passes through the level of knowledge of the beekeeper and socioeconomic situation
04	Alves et al. [14]	The increase in temperature and the decrease of humidity resulted in increased frequency of bees foraging activity, accounting for 46.9% of activity in *A. mellifera*
05	Camargo et al. [15]	In the multivariate analysis of the grouping, five groups were formed, due to the similarity of management, indicating the highest average production in hives in the most populous area of Santa Helena and lowest average production in the most populous of Marechal Cândido Rondon. The clustering of hives, differences in honey production, and floristic survey indicated that these differences could be associated with management and climatic differences recorded during the production period in the studied areas
06	Salis et al. [16]	The melliferous species evaluated in the region of the Urucum Massif, on the western border of the Pantanal, flourish throughout the year, with the highest number of species in summer (January to March) and lowest in winter (July to September). The interaction between the growth habit of melliferous plants and the climate influences the flowering season and causes herbs and lianas to flower mainly in summer and autumn (January to June) and trees and shrubs in the spring (late September to December). There is availability of nectar and pollen throughout the year, with supply decreasing in the winter months (July to September)
07	Souza et al. [17]	Both the quantitative and qualitative analyses of the pollen types found in the propolis of *Scaptotrigona* aff. were valuable for their characterization. The results obtained provide support to know the possible species suppliers of resin for Tubi, increasing the scientific knowledge about the propolis of stingless bees that are still incipient, and may also contribute to the protection of this species of bee in the elaboration of conservation programs and replanting of their areas of occupation
08	Araújo et al. [18]	Propolis samples collected in the two regions of Tocantins presented concentrations of moisture, ash, and wax that fall under Brazilian legislation for propolis quality. They also evidence a high concentration of phenol compounds and good antioxidant capacity. The variety of phenol compounds identified in propolis samples collected for this study, compared to the diverse biological functions described in literature for these compounds, indicates that there is a great pharmacological potential in this raw material

N°	Bibliographic reference	Conclusions
09	Siqueira et al. [19]	The red propolis, collected in the region of Brejo Grande-SE, presents characteristics of identity and quality compatible with the parameters established by the Ministry of Agriculture and has proven effective against *E. faecalis*, being able, with more studies, to become a valuable endodontic treatment
10	Pimenta et al. [20]	The present study demonstrated that, although medications based on brown propolis with or without calcium hydroxide have limitations inherent to an in vitro study, they are effective against *E. faecalis*
11	Siqueira et al. [21]	The results of this study show that, similar to chlorhexidine, red propolis alcoholic extract has good fungistatic and fungicidal activity against most samples of *Candida* species. This antifungal activity may hold a promise for future applications as an alternative treatment for infections caused by these fungi. Further investigation into the use of red propolis for the prevention and treatment of periodontal diseases is required, including microbiological, randomized controlled trials and longitudinal studies
12	Toledo et al. [22]	For the first time, films could be successfully obtained using the residue obtained from the preparation of propolis extracts, which is normally discarded. Density, water vapor permeability, moisture uptake capacity, and the mechanical properties of the films were adversely affected by the addition of polymeric adjuvants with different affinities for water. The thermal stability of films was observed, and using the technique of FT-IR, it was proven that while the adjuvant played a role, BP is the main component responsible for the characteristics of the films. Therefore, considering the results obtained and the principles of sustainability (reduce, reuse, and recycle), this work could contribute to the utilization of BP to obtain films for use in the food and pharmaceutical industries. However, further research is needed to gain a better understanding of the properties and applications of these films
13	Pagliarin et al. [23]	The results of this study suggest that propolis paste may be a feasible substitute for triple antibiotic paste in the disinfection of root canals of immature teeth with necrotic pulps, with the advantage of not causing changes in tooth color. The new tissues formed inside the root canal showed characteristics similar to the cementum, bone, and periodontal ligament
14	Valones et al. [24]	The present study demonstrated that a dentifrice containing exclusively rosemary extract has the capability of inhibiting the growth of the studied bacteria. However, for the inhibition of *L. rhamnosus*, a propolis-based commercial dentifrice was more effective than the dentifrice containing rosemary extract
15	De Luca et al. [25]	All rats gained weight and remained apparently healthy and active throughout the experiment. The PV (typ. 12 propolis from Southeastern Brazil—propolis ethanolic extract, 15%, w/v) reduced the development of smooth enamel caries as compared to the untreated group, without significant difference of GS (gold standard). GS significantly reduced the severity of sulcus lesions, affecting dentin. No macroscopic abnormality or abnormality of the tissue was observed in the oral cavity of the animals throughout the experiment
16	Monteiro et al. [26]	The level of schooling, the number of hives populated, and the participation and/or knowledge about some type of program or specific actions for the apicultural segment promoted by the federal government exerted positive effects on the index of innovation and learning of beekeepers in all evaluated quantile, while the variable time of operation of the beekeeping company only influenced the IIA (innovation and learning index) in the lower part of the distribution
17	Potrich et al. [27]	*B. bassiana* reduced the survival of *A. mellifera* workers in the four bioassays tested (spraying on *A. mellifera*, contact on a smooth surface, contact on soy leaves, and mixed with candy paste) in the laboratory. The entomopathogens *B. bassiana*, *B. thuringiensis*, and *M. anisopliae* did not cause morphometric changes in the midgut of *A. mellifera* fed with candy paste

N°	Bibliographic reference	Conclusions
18	Sattler et al. [28]	The results of the chemical analysis showed that the samples were in accordance with the relevant regulations. The composition of vitamins and pollen types varied among the samples. Some bee pollen could be classified as a source of a particular vitamin in a standard dose (25 g). Lipid and protein content from Rio Grande do Sul presented higher mean values (p b 0.05) compared with the other two states. Some correlations between chemical composition and botanical taxon were observed. Principal component analysis showed that the samples from the states of Rio Grande do Sul and Paraná presented similarities in terms of composition for each location. HCA (hierarchical cluster analysis) and PLSDA (partial least squares discriminant analysis) were not able to classify the samples based on the chemical markers used. The analysis of vitamins confirmed that BP from this region can be a good source of antioxidant vitamins and that it can provide important nutritional information to food researchers and bioactive compounds for consumers
19	Neves et al. [29]	The botanical origin of propolis samples is difficult to ascertain on the basis of palynological analysis only, and a more definitive confirmation depends on analysis comparing the chemical profile of the samples with the chemical profile of resins and extracts from the plants found in close vicinity of the bee's hives. It should be stressed that red propolis has been suggested to be the only propolis type derived from a plant from the Leguminosae family (*D. ecastaphyllum*), rich in isoflavones such as genistein and formononetin. Although flavonoids exhibit pleiotropic activity affecting several different targets, and synergistic effects cannot be ruled out, our results suggest that the isoflavone formononetin is responsible at least partially for the antimicrobial activity of red propolis
20	Bittencourt et al. [30]	Twenty-nine metabolites were identified along with 34 other metabolites that were classified into the following classes: triterpenoids (12), acetyltriterpenoids (3), sesquiterpenes (6), steroids (4), and hydrocarbons (9). The antioxidant capacity (IC50) ranged from 21.50 to 78.77 μg/mL, whereas the content of total phenolic compounds ranged from 31.88 to 204.30 mg GAE/g of dry weight. Total phenolic compounds and methyl retinoate showed a positive correlation with the antioxidant capacity, whereas tetradecanal, γ-palmitolactone, and ethyl hydrocinnamate showed a negative correlation. Different sets of metabolites are shown to correlate with the antibacterial activity of the extracts, which is largely dependent on the type of microorganism. This innovative approach allowed us to identify likely bioactive compounds in the extracts, although the mechanisms underlying antibacterial activity encompass a complex trait, which might involve synergistic effects
21	Almeida et al. [31]	HPLC/UV and LC/ESI/FTMS/Orbitrap identified different secondary metabolite classes such as isoflavones, chalcones, pterocarpans, flavonones, flavones, phenolic acids, terpenes, and guttiferones in the Brazilian red propolis tinctures. LC/ESI/FTMS/Orbitrap was a useful tool in the confirmation of different chemical markers of the red propolis and demonstrated the complexity of this apiceutical product. The tincture and microcapsules of the red propolis presented high flavonoid quantities especially for the spray-dried microcapsules. The tinctures and spray-dried microcapsules presented similar antioxidant activity and were better than the freeze-dried microcapsules. The tinctures and microcapsules proved to be bioactive against Gram-positive and Gram-negative bacteria; moreover, the Gram-positive bacteria were more sensible than the Gram-negative bacteria. The LC/ESI/FTMS/Orbitrap and microbiological methods were sensitive and could distinguish the quality of the tinctures and the microcapsule compositions. Thus, the tinctures and microcapsules of the red propolis have a potential application for nutraceutical products
22	Araújo et al. [32]	In conclusion, propolis was more efficient in inhibiting mycelia growth of *Pythium insidiosum*, while geopropolis showed a fungistatic effect. This effect

N°	Bibliographic reference	Conclusions
		may be due to the propolis chemical composition, which has more active compounds than geopropolis. Since propolis exhibited a better response, further experiments should be carried out both in vitro and in vivo, as treatment with conventional antifungal agents is still problematic
23	Silva et al. [33]	The acute study revealed no lethal effects at 300 mg/kg of HERP, but toxic signs were observed, as HERP had na LD50 of more than 300 mg/kg, indicating a warning. The most toxic signals in subacute studies were observed in males at a dose of 200 mg/kg HERP. These results suggest estrogen-like activity, possibly from the isoflavones in HERP
24	Rodrigues et al. [34]	The results of the analyses show the main components (inorganic and organic components) of the "caba-leão" wasp nests (*Sceliphron* sp., *Sphecidae*) used by "caboclos" as a topical medication to treat mumps and earaches. The ethnopharmacological data collection consisted of samples of wasp nests and soil, as a source of inorganic elements, from the Jaú and Unini Rivers, in the River Negro basin, Amazon, Brazil. The inorganic components are formed by minerals (quartz, kaolinite, illite, and gibbsite), identified by X-ray diffraction and infrared spectroscopy, which are common in the soil of the region. The analyses by X-ray fluorescence indicate that the most common oxides are SiO2, Al2O3, and Fe2O3 within minerals
25	Silva et al. [35]	Twenty-two pollen types were identified. The total phenolic content ranged from 17 to 66 mg GAE/g of extract; the highest contents were found in honeys produced from pollen types such as *Clidemia* and *Myrcia*. The antioxidant activity was higher in the samples that contained higher quantities of phenolic compounds. In relation to the antibacterial activity, samples CAD3, CAD4, and SAD3 presented the best results. Fourteen phenolic compounds were determined. Among them, we identified the flavonoid taxifolin, which has not previously been described in honeys from stingless bees, and we report the identification of catechol in Brazilian honey samples for the first time

Table 1.
Summary of the papers of beekeeping in Brazil between the years 2013 and 2018.

4. Discussion

It was possible to observe a large number of articles published on this topic, but it was necessary to compile the data obtained by all these studies. The products obtained by beekeeping are honey, beeswax, pollen, and royal jelly, which are used in both human nutrition and conventional and traditional medicine [1]. For the commercialization of these products, there are requirements in the Brazilian legislation for inspection, with the objective of evaluating the zoosanitary requirements and the certificates for the importation of queen bees and bee products [36]. The beekeeping activity in Brazil has a great challenge related to the absence of laboratories and official techniques to analyze the absence of pathogens, except for the microbiological analysis to identify spores of *Paenibacillus larvae* [37].Brazil is the ninth largest honey producer in the world and the second largest producer in Latin America behind only Argentina. In Brazil, the amount of honey produced was 37.82 thousand tons in 2015, representing a reduction of 1.7% in relation to the previous year. The last drop had occurred in 2012, when honey production was heavily affected by the scarcity of rainfall in the major producing regions [38].

It is interesting to discuss bee products and aspects of health in Brazil. Therapeutic activities of Brazilian propolis and honey were reported in the works highlighted in the present literature review (**Table 1**). The identified compounds

are described as important in defense of oxidative damage of biological molecules and capable of assisting in the treatment of various pathologies.

Propolis is a water-insoluble resinous mixture of bees' saliva and vegetable resin with a wide range of important biological and therapeutic properties (antioxidant, anti-inflammatory, antitumor, immunomodulatory, antibacterial, antiviral, autobiofilm, antifungal, analgesic, anesthetic), and several studies have shown that propolis has bactericidal and bacteriostatic activity against several Gram-positive bacteria, such as *S. aureus*, *S. mutans*, and *B. subtilis*, and Gram-negative bacteria, including *E. coli*, *K. pneumoniae*, and *P. aeruginosa*. In addition, a synergistic inhibitory effect of propolis and antibiotics has also been reported on growth of *S. aureus*. The relevance of such antimicrobial activity of propolis is increased if one considers the growing appearance of antibiotic-resistant microorganisms in hospitals and in the community. Notably, this situation is exacerbated by the inadequate use and prescription of antibiotics and the scarcity of new medicines [39–42].Torres et al. [43] performed the chemical characterization and antimicrobial activity of propolis obtained from the stingless bees *Melipona quadrifasciata quadrifasciata* and *Tetragonisca angustula*, and verified that their ethanolic extracts of propolis (EEPs) of *M. quadrifasciata quadrifasciata* and *T. angustula* presented antimicrobial activity against Gram-positive and Gram-negative bacteria and antioxidant activity. The chemical analysis of EEPs revealed the presence of terpenoids, flavonoids, and polyphenols, which were more abundant in EEP from *M. quadrifasciata quadrifasciata*.

The use of propolis has also been associated with the treatment of lung cancer, since its therapeutic potential for the treatment of several diseases is well studied and elucidated [44]. Szliszka et al. [45] performed some epidemiological and preclinical studies and suggested that polyphenols and flavonoids in propolis have direct antitumor and chemopreventive effects. Propolis was used as a dietary supplement, and it was observed that the anticarcinogenic activity of the flavonoids in it can suppress the growth of the lung tumor, inhibiting angiogenesis and inducing apoptosis of tumor cells [46]. It has also been reported that the protective effect of propolis against various types of cancer, including lung cancer, can occur by directly inhibiting the growth of tumor cells and inducing apoptosis [47] or indirectly by capturing ROS and increasing the activities of antioxidant enzymes [48].

Brihoum et al. [49] investigated the antitumor effect of Algerian propolis on a human lung adenocarcinoma cell line and its chemopreventive effect on experimentally induced lung cancer and found results suggesting that Algerian propolis may act against lung cancer and may lead to the potential use of these natural compounds for the treatment and prevention of lung cancer.

According to [35], which evaluated the propolis of the region of Amazonas state in Brazil, the antioxidant activity was higher in the samples that contained larger amounts of phenolic compounds. The papers highlighted in the present review identified the following substances of antioxidant capacity: gallic acid, ellagic acid, catechin, gallocatechin, hesperidin, kaempferol, luteolin, morin, naringin, naringenin, and rutin. Honey analysis also confirmed the presence of antioxidant substances, highlighting phenolic compounds.

The meliponiculture has a great importance in Brazil and in the world. Most of the published works were carried out in the South [50], Southeast [51], and Northeast regions [52]. These three regions also have the highest honey production in Brazil, which in 2013 was 35,365 tons: the South contributed 50.2%, the Southeast 21.5%, and the Northeast 21.3%. The Central-West region is one of the least-producing honey regions in the country, with only 4.4% participation in the national production, despite the rich native flora found mainly in the Cerrado and Pantanal biomes [16]. Conservation practices such as meliponiculture tend to support the conservationist effect of the sustainable use of Brazilian vegetation [9].

In order for beekeeping to offer greater economic benefits to the producer, it is necessary to associate this activity with other agricultural activities. This activity requires relatively low investment and continuous cash flow for agricultural depots [10].

According to [12], the productivity of apiculture products is directly linked to the appropriate management techniques applied in the apiary. In the study by [13], it was noticed that the technological level of beekeepers is relatively low, which can exert a strong influence on the management of beekeeping in Brazil. Apiculture, in order to be competitive, requires the adoption of good management practices, adequate equipment, specific knowledge of technologies, management, marketing, and organization to add value to products [13].

5. Conclusion: key results

In order to help the process of standardization of bee products and traceability of the production chain, it was possible to draw a profile of the main bioactive substances of the beehive products of Brazil. It was also possible to relate the benefits of an adequate management of beekeeping and meliponiculture in Brazil. Standardization is not yet observed in scientific research and legislation in Brazil. The available information on the honey flora in Brazil is still empirical and restricted to some regions of the country. The low amount of research on the subject in Brazil reflects on the technological level of apiaries and consequently on the management of beekeeping in Brazil. In this context, it is necessary to carry out more research and public policies that help in the improvement of beekeeping and meliponiculture in Brazil.

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