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REVIEW ARTICLES

Analysis of innovations in kombucha production and the protection of intellectual property

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Highlights

- Innovations in kombucha production
- Perspectives of the coffee kombucha production scenario
- Intellectual property of innovations in kombucha production
- Prospecting and innovations in kombucha production

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KEYWORDS
Fermented beverage;
Functional beverage;
Patents;
Food science;
Coffee.

Abstract: The aim of this review was to carry out a detailed and descriptive survey of patents on kombucha, using the European Patent Office platform – Espacenet – and the Brazilian data bank of the National Institute of Industrial Property – INPI. This study investigated the increasing popularity and innovations in the fermented beverage sector, starting with kombucha and ending with coffee-flavored kombucha, as well as the importance of patents for protecting inventions. The research was divided into three principal debates; first an analysis of patents related to the term "kombucha", identified 393 documents, of which 238 remained after removing duplicates. This point examined the countries with the greatest production of patents, inventors and requesting institutions, such as individuals, legal entities, companies, and universities. Secondly, the patents related to the beverage market were discussed (164 documents), which by detailed description could be grouped into the areas of food science, biotechnology, engineering and biochemistry. Finally, the research focused on patents combining kombucha with coffee, identifying only two recent patents related to the area of food science. The study revealed that despite the increasing interest and demand for kombucha, the number of patents deposited was still relatively low, indicating a significant opportunity for development and innovation. Also, the analysis of the patents provided a deeper understanding of the application areas and emerging technologies, suggesting considerable potential for new research projects, even though the number of patents

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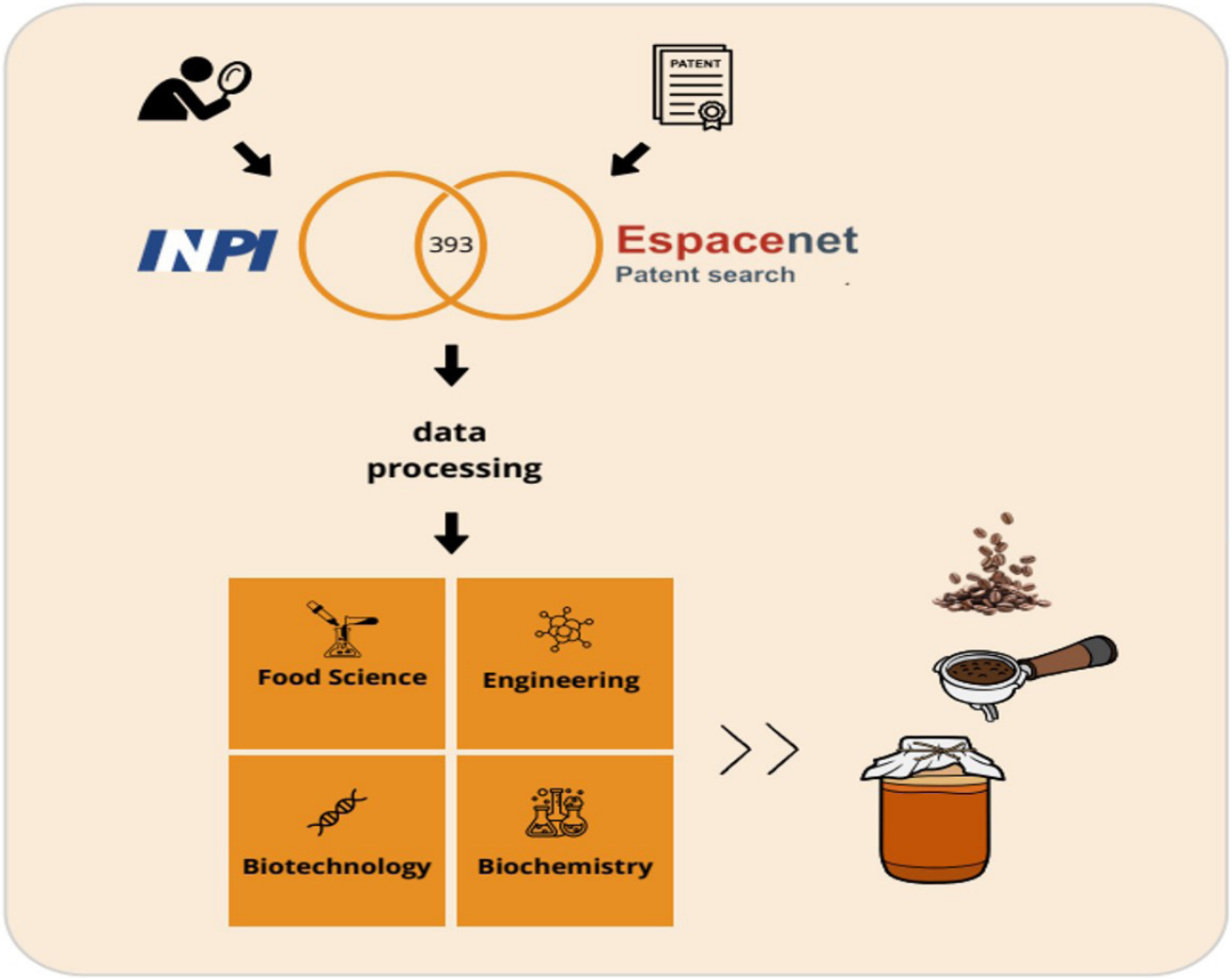
involving the production of kombucha with the addition of coffee in the world, was very small. Thus, these results showed that the innovation of kombucha with the addition of coffee could be promising, considering biotechnology, engineering, and biochemistry as allies in offering an increasingly high-quality and scientific investment in the sector.

Graphical Abstract



Introduction

Technological advances have become easier and easier due to globalization, creating an environment where innovation propagates rapidly, and commercial frontiers become less restrictive. In this context, the companies must remain competitive, which demands not only efficient processes that facilitate production, but also a clear view of future tendencies so that they can remain in front of market competitors. To guarantee a sustainable commercial advantage, many of these innovative productions, inventions and methods need to be adequately protected. Patents play a crucial role in this aspect, since they are legal documents that ensure that the use of an invention be the exclusive property of the individual or entity that invented it. This impedes the use, manufacture, sale or importation of the invention by non-authorized third parties, offering the inventor solid legal protection (Paranhos & Ribeiro, 2018).

The prospection of patents allows us to identify existing scientific developments and technologies in a determined sector, and thus perceive gaps that could direct research as a strategy of innovation for the market. This process helps companies take strategic decisions, such as fusion, the directing of investment and research, the projection of innovations and strategic acquisitions, providing a

competitive advantage on the market (Amparo et al., 2012; Coelho et al., 2005).

The kombucha market has grown significantly, with the expectation of almost quintupling between 2019 and 2027. This imminent growth is bubbling up the kombucha production market and providing an impulse for the development of new production technologies and the innovation of flavors, aiming to conquer consumers who are more and more demanding (Fortune Business Insights, 2024, Kim & Adhikari, 2020). According to Kim et al. (2022) consumers associate kombucha with a healthy lifestyle and the label provides information that it is low-calorie and artisanal, with the most sought-after information on labels being about calories and the amount of sugar.

For a kombucha to be labeled as functional or to have health claims, it must follow Brazilian standards as established by Resolution No. 19, dated April 30, 1999 (BRASIL, 1999), presenting the text of the claim exactly as approved in the evaluation process, including warnings and other information required for joint publication (BRASIL, 2019). Therefore, for kombucha to be a functional beverage, it must contain substances with standardized claims and the respective specific requirements. Although the use of ingredients with fiber, vitamins and minerals in Brazilian kombucha is permitted, there are currently no reports of their commercialization. In Brazil, there is Normative Instruction No. 41 of September 17, 2019, from the Ministry of Agriculture, Livestock and Supply (BRASIL), which governs the Identity and Quality Standard (PIQ), which stipulates some parameters for the drink to be considered a kombucha such as pH, acidity, alcoholic strength and pressure in kombucha when added with carbon dioxide. It is she who stipulates the parameters of pH, volatile acidity, alcohol content and pressure of the drink when added with carbon dioxide. This document states that the use of expressions such as: artisanal, homemade, family-style, live drink, probiotic drink, ancient drink, elixir, elixir of life, energizing, invigorating, special, premium, among others that attribute characteristics of superlative qualities and functional properties not approved in specific legislation, is prohibited on the kombucha label.

Most kombucha producers do not perform the necessary analyses to obtain the functional food label, which makes it difficult to obtain data on the quantity of kombuchas with functional property claims on the market. The lack of information on the safety and quality of the drink may be related to the decision to purchase and consume the product. The lack of information about the safety and quality of the drink may be related to the decision to purchase and consume the product (Batista et al., 2022).

At a global level, kombucha is a fermented beverage of Asiatic origin with refreshing sensory characteristics, slightly sweet and acid, obtained by fermenting a sweetened *Camellia sinensis* tea (Jayabalan et al., 2014). It is considered a functional beverage, since it contains nutrients essential for health maintenance such as chlorogenic acid, phenolic compounds, organic acids, water soluble vitamins and a variety of micronutrients produced during fermentation (Miranda et al., 2023), as shown in figure 1.

As a result of symbiosis between the yeasts and lactic acid bacteria, a cellulose film known as SCOBY (Symbiotic Culture of Bacteria and Yeasts) is formed, suspended in the teas, containing the microorganisms. These bacteria and yeasts have complementary metabolic activities and use the available sucrose in the kombucha to produce acids and other compounds (Jayabalan et al., 2014). The presence and amounts of these metabolites depend on the types of microorganisms present in the symbiotic culture used to ferment the kombucha, and factors such as the time, temperature, amount of substrate and type of tea used in the fermentation should also be considered (Jayabalan et al., 2014; Watawana et al., 2015).

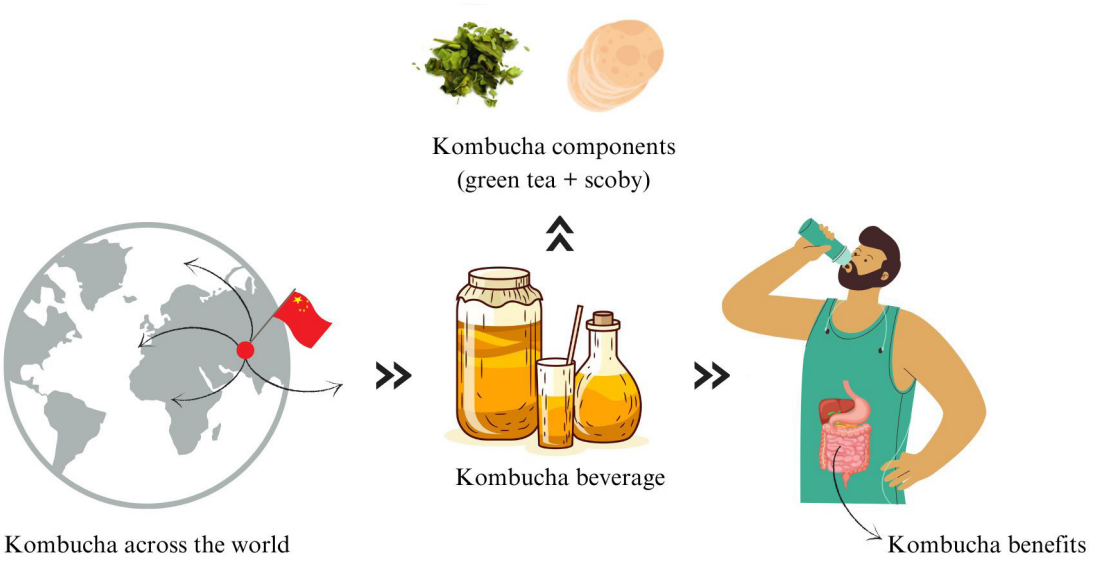


Figure 1. Presentation of the kombucha beverage

The benefits of kombucha cited in the literature include anti-inflammatory activity, protection against cancer, prevention against microbial diseases and infections (Jung et al., 2019), free radical elimination activity (Cardoso et al., 2021), antioxidant activity (Osiripun & Apisittiwong, 2021; Fu et al., 2014) hypoglycemic and antilipemic properties (Aloulou et al., 2012; Hardoko et al., 2020), anti-hypertensive activity, and gastrointestinal functions, amongst others (Miranda et al., 2023; Silva et al., 2021).

According to the Food and Agriculture Organization (FAO), both coffee and *camellia sinensis* tea are the beverages most consumed throughout the world. Both coffee and teas share the presence of bioactive compounds to which health benefits are attributed, the main ones being caffeine and phenolic compounds – catechins in tea and chlorogenic acids in coffee (Silva et al., 2021; FAO, 2023; FAO, 2024).

Considering the beneficial effects of green tea and coffee, kombucha with added coffee appears to have great commercial potential as an alternative for those searching for a healthy, stimulating, and sparkling beverage. Innovation with respect to the flavors of kombucha could be a strategy for the factories to maintain themselves on the competitive market, together with the innovation of processes that potentize the beverage and adequate it to the norms demanded in each country (Kim & Adhikari, 2020). Research carried out showed that flavors popular kombucha flavors are fruits (green, yellow or red), herbs, spice, vegetables, tea and algae (Kim & Adhikari, 2020, but they do not comment on whether they used natural or artificial flavorings in the drinks. Some scientific research demonstrates the viability of some ingredients as apple (Zubaidah et al., 2018), cocoa (Yuliana et al., 2023), and, other ingredients, not permitted by Brazilian law, such as the milk used in the initial culture (Sarkaya et al., 2021). Recently, studies on the use of coffee leaf husks and Arabica coffee in kombucha production were published with good results, suggesting that both by-products and roasted and ground coffee can be viable substrate options for fermentation (Sales et al., 2024; Saito et al., 2024).

Considering the above, the objective of this study was to collect and analyze data concerning the production of kombucha with coffee, starting with a general vision of the kombucha patents, to understand how much has been produced, where it is being produced and who is producing it. The patents were then analyzed according to the areas of contribution, including food science, biotechnology, engineering and biochemistry. Finally, the study concentrated on the kombucha with coffee market, identifying technological innovations, market tendencies and potential development areas. The study also aimed to identify existing gaps, providing a general vision concerning the state of the art and recent advances in the production of this fermented beverage.

Methodology

The methodology used was suggested by Ribeiro (2018), which indicates that the mapping of technological production should follow the following steps: a) Definition of the data bases to be surveyed; b) Definition of the objectives and delimitation of a theme to search for patents; c) Search and selection of the documents; d) Removal of repeated files; e) Elaboration of spreadsheets for the statistical studies and qualitative analysis.

The prospection of patents was carried out in April and May of 2024. Two data banks of patents were used – the European Patent Office (Espacenet), which has the data od documents from more than 90 countries, and the Brazilian data bank of the National Institute of Industrial Property (INPI). A search strategy was elaborated considering, initially, the keywords “kombucha” and “kombucha coffee” to learn about the production of the beverage and its position as a functional food. The search was then refined using the keyword “kombucha” together with other terms of interest, such as “production” and “beverage” together with the international classification codes for patents “A23L2/38”, related to non-alcoholic beverages, and “A23F” for coffee, tea, and substitutes – manufacture, preparation, or infusion.

The “advanced search” feature was used with the search fields “IPC”, “title” and “summary”. The files of the patent documents were compacted and exported to the Microsoft Office Excel 2010 software using the CSVed version 2.4 program, where the treatment and analysis of the information obtained from the documents could be carried out. The indicators used for the treatment of the data analyzed were the international classification codes, the year deposited, the inventors, the companies and teaching institutions that made the most deposits, the country of origin and the application area. The results found were placed on figures.

In general, many inventions in the patents related to the beverage industry concerned the addition of new ingredients and additives and the use of different technologies. To classify these patents in the beverage industry, four main groups were identified: food science, biotechnology, engineering, and chemistry. In Food Science, the emphasis was on patents that added ingredients to improve the flavor and aroma, and on production methods using different concentrations or origins of the raw materials. In the Biotechnology area, patents were grouped together that employed processes and microorganisms to improve the beverage properties. In Engineering, patents concerning machines, tanks and electronic mechanisms that aided the production of kombucha beverages, making storage, transport and the controls of temperature, oxygen, and pressure easier, were considered. Finally, Biochemistry included patents that introduced components with the objective of aggregating specific functional properties, such as stress reduction, or the improvement of nutrient absorption.

Results and discussion

Search for materials

As shown in table 1, a total of 393 words were found on the Espacenet and INPI platforms when considering the keyword “kombucha”. After removing repeated files, a total of 238 patent documents remained. This result shows the limited number of patents on the subject, despite the search for and interest in the tea. In the search the descriptives

Table 1. Results of searches in the patent data bases Espacenet and INPI in May 2024.

	Results for the bases Espacenet and INPI		Total
	Espacenet	INPI	
Kombucha	382	11	393
Kombucha Coffee	2	0	2
Kombucha A23	256	0	256
Kombucha A23F	150	0	150
Kombucha Production	80	0	80
Kombucha and Beverage	101	0	101
Kombucha and Beverage A23	94	0	94
Kombucha and Beverage A23F	51	0	51
Kombucha A23L2/38	68	0	68
TOTAL	1.184	11	1.195

"kombucha production" and "kombucha" with the addition of related codes, such as "beverage", "A23L2/38", "A23F" and their combinations, were also added. Table 1 also shows the specific results of the terms found. Two patents were found concerning kombucha with the addition of coffee.

Figure 2 shows the main international classification codes of the patents deposited concerning Kombucha. These codes are used to classify and separate the patents according to the theme of interest. In the present study, most of the patents were related to section A, Human Needs, classified in class A23, which are foods or food products. Of the subgroups of class A23 the following subjects studied can be found: A23L2/38 for non-alcoholic beverages; A23F3/16 for tea preparations using additives (flavorings); A23L33/00 for modifications of the nutritive value of foods, dietetic products, preparation or treatment, amongst others, as also patents related to section C, which corresponds to microorganisms, such as C12N1/20 related to bacteria and their culture media, and C12M1/00 for microbiological apparatuses.

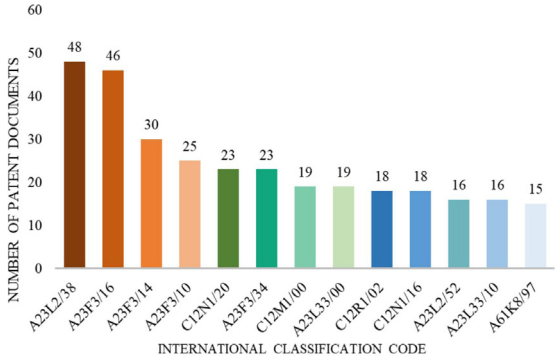


Figure 2. Number of patent documents per International Classification Code of the subgroups of class A23.
Source: elaborated by the author (2024). A23l2/38: Non-alcoholic beverages; A23F3/16: Tea extraction, tea extracts, treatment of tea extract making it instantaneous; A23F3/14: Tea preparations using additives (flavorings); A23F3/10: Fermentation with addition of enzymes or microorganisms; C12N1/20: Bacteria and their culture media; A23F3/34: Tea substitutes, extracts or infusions; C12M1/00: Microbiological apparatuses; A23L33/00: Modification of the nutritive value of foods, dietetic products, their preparation or treatment; C12R1/02: Microorganisms (processes using microorganisms); C12N1/16: Microorganisms (yeasts and their culture media);; A23L2/52: Addition of ingredients (preservatives); A23L33/10: Use of additives (addition of substantially non-digestible substances) A61K8/97: Obtained from algae, plants and their derivatives.

Geographical and temporal contextualization of the deposits

Figure 3 shows the main countries that deposited Kombucha patents. China appears in first place with 149 documents, followed by the Korean Republic with 45, the USA with 11 documents and Germany with 7. China has the greatest number of patents, probably because it is the origin of the beverage, being highly common amongst the local population, leading to incentives to produce the beverage and new requests for patents.

As shown in Figure 4, from the distribution of kombucha companies North America is the leader in terms of the number of brands registered, followed by Asia, Europe and South America (Kim & Adhikari, 2020). North America not only has more companies, but also leads in terms of marketing with an annual turnover of 0.97 billion dollars in 2019, more than the European and Asian markets (Fortune Business Insights, 2024).

Although Asia, which is the birthplace of kombucha, is the greatest producer of patents, with 200 documents found, it is not the continent with the greatest number of registered brands due to market difficulties with rigid regulations and competition with other traditional fermented beverages, which reduce the demand for kombucha (Kim & Adhikari,

2020). In contrast, North America is showing a significant increase in this sector, with the impulse of the adoption of favorable regulations and by the industrialization of the production, which started around 1990. Western USA, especially California, stands out for the number of registered kombucha brands, due to a culture focused on health and diversified agricultural resources. The North American market is characterized by a wide variety of functional products offering profiles with distinct flavors, reflecting an increasing consumer interest for healthy beverages aimed at well-being, such as kombucha (Fortune Business Insights, 2024; Kim & Adhikari, 2020).

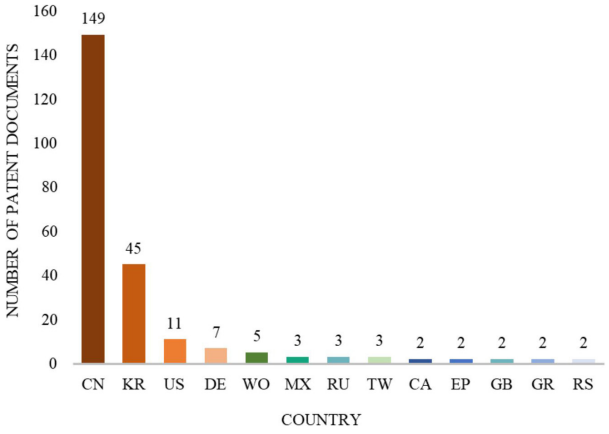


Figure 3. Number of patent documents in the main depositing countries. CN:China, RK: Korea (South), US: United States of America, DE: Germany, WO: World Intellectual Property Organization (WIPO), MX:Mexico, RU: Russian Federation, TW: Taiwan, CA: Canada, EP: European Patent Office, GB: United Kingdom, GR: Greece, RS: Serbia.

Eleven patents concerning kombucha were found in Brazil, the principal being: i) preparation process for a beverage with a microbial consortium to ferment China tea as the raw material – BR1020180140779 A2 (Matias & Galina, 2019); ii) solar massage shoe, modular, 3d printed, app controlled, powered by organic photovoltaic panels, with kombucha coated sole and handles - BR102017016414-4 A2 (Santos, 2019); iii) process for manufacturing a probiotic alcoholic beverage and the probiotic alcoholic beverage BR 101 2018 074125 0 (Carvalho et al., 2020); iv) natural cosmetics with probiotics – BR 10 2019 003550 1 (Pettres, 2020); and v) edible ice cream and sherbets based on kombucha – BR10 2020 014087 6 (Silva et al., 2022), amongst others.

An analysis of the annual evolution of the number of patents concerning kombucha deposited between 2001 and 2024 allows for the inference that, in the decades surveyed, the growth of this technology started in 2016, with various oscillations between the other years, as shown in Figure 5. The first patent was deposited in 1997 in China, referring to the elaboration of kombucha, products and the elaboration process – IL120554 (A) (Hava. 2000). More patents were deposited in 2016 as compared to the previous years. Studies have shown that, as from this year the use of kombucha started becoming more popular throughout the

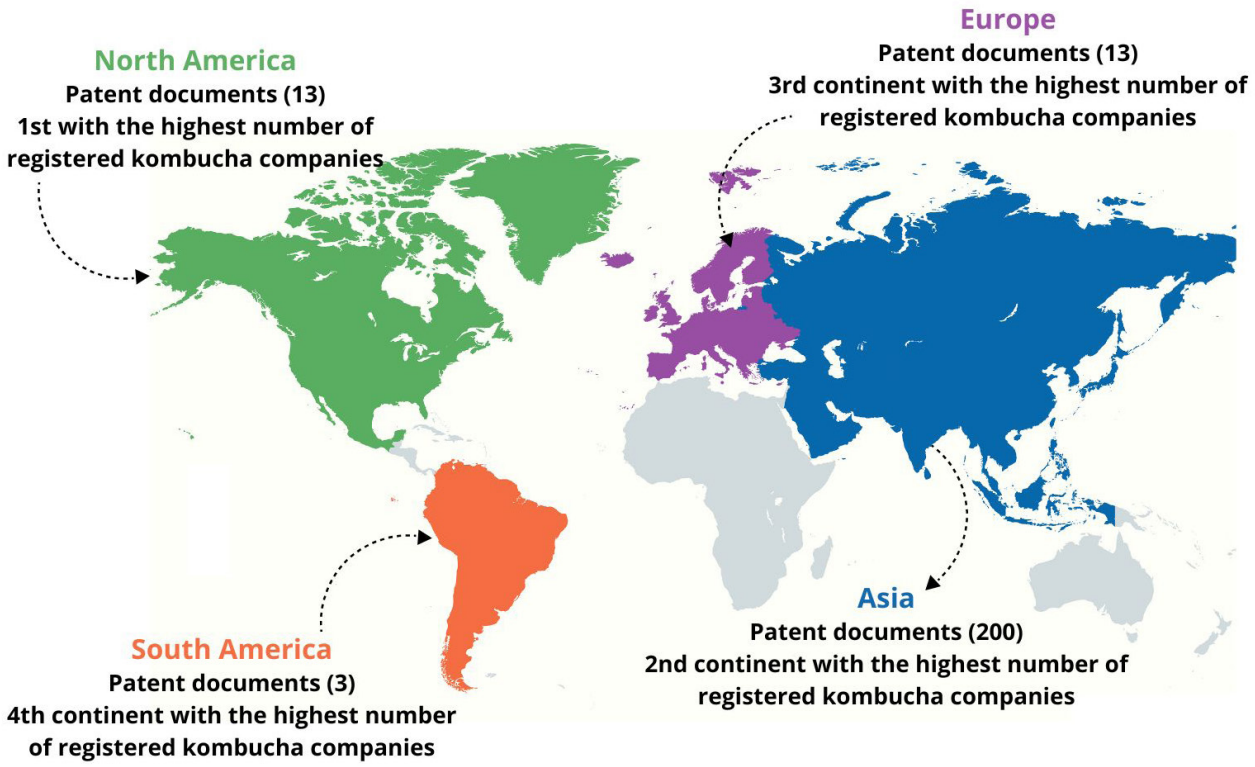


Figure 4. Distribution of patents and registered kombucha companies in the world.

world, being mostly known as a functional beverage (Bruschi et al., 2018). The number of patent applications oscillated between 2017 and 2020 but started to increase again in 2021 after the advent of the COVID-19 pandemic, with a record of 39 patents deposited.

Thus, the apex of patent deposits occurred between 2016 and 2021, with a total of 156 patents, including: kombucha reproduction and preparation method (RU2580046 (C1)) (Amparo et al., 2012), protein kombucha beverage and its preparation method (CN105211363 (A)); CN105211363 (B)) (Zhengjun et al., 2016), beverages containing passion fruit and kombucha and anti-alcoholism preparations (CN106071612 (A)) (Jun, 2016), an iced tea method to produce kombucha (WO2022144613 (A1)) (Eliot & Romaine, 2022), amongst others.

By way of the tendency line, an increasing number of patent documents were also seen to have been deposited between 2016 and 2021. The decrease in the numbers of deposits between 2012 and 2014 and between 2022 and 2024 can also be justified by the confidentiality period, which corresponds to 18 months after a deposit.

A total of 91 inventors were found and figure 6 shows those that presented the greatest number of patents deposited. The inventor Han stood out the most, being the only one with 8 patent documents, all deposited in 2015. His patents include banana kombucha (CN104304562 (A)) (Han, 2015a); sweet tea kombucha (CN104304560 (A)) (Han, 2015b); cucumber kombucha (CN104287017 (A)) (Han, 2015c), amongst others. The Chinese inventors Laiquan & Liang presented 7 documents of deposited patents, which emphasized non-food products, giving emphasis to new kombucha fermentation devices. The majority of the inventors were Chinese, in agreement with the fact that China has 149 patent documents deposited.

With respect to the main depositors, Figure 7 shows individuals, companies, and universities. He Han, Chinese, individual, deposited the greatest number of patents about kombucha, with a total of 8 documents, all deposited in 2015. He Han's patents include a biological beverage with Camellia chrysantha as the vehicle and preparation method (CN104304577A) (Han, 2015d); carrot bacteria tea beverage and its preparation method (CN104305451A) (Han, 2015e); pitaya tea fungus (CN104304578A) (Han, 2015f), amongst others, all including kombucha. The company Hainan Huinuo Tech Co Ltd for technological production appears in second place, with a total of 7 patents, the patents having been developed by the inventors Laiquan & Liang. Their patents include a device to detect the fermentation of kombucha (CN214991578U) (Laiquan & Liang, 2021a), a device for the cleaning and sterilization of the raw material for kombucha fermentation (CN214962505U) (Laiquan & Liang, 2021c), amongst other documents. The Chinese company Anhui

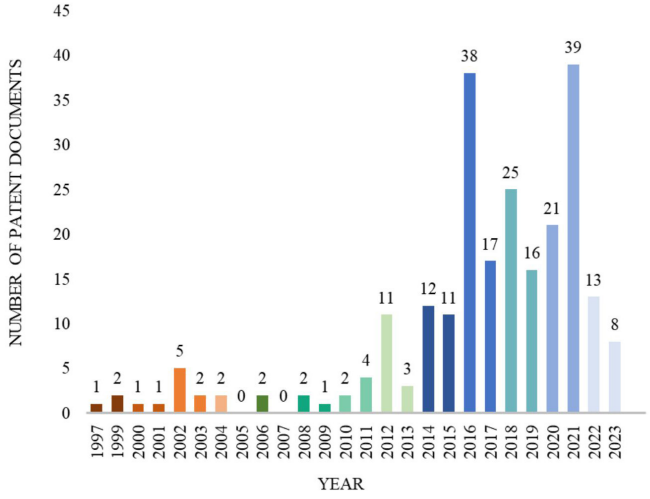


Figure 5. Annual evolution of the number of kombucha patent from 1997 to 2024.

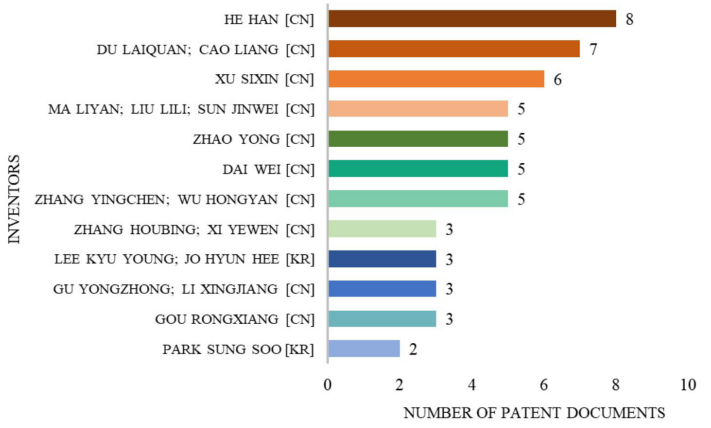


Figure 6. Inventors with the greatest number of patent documents deposited.

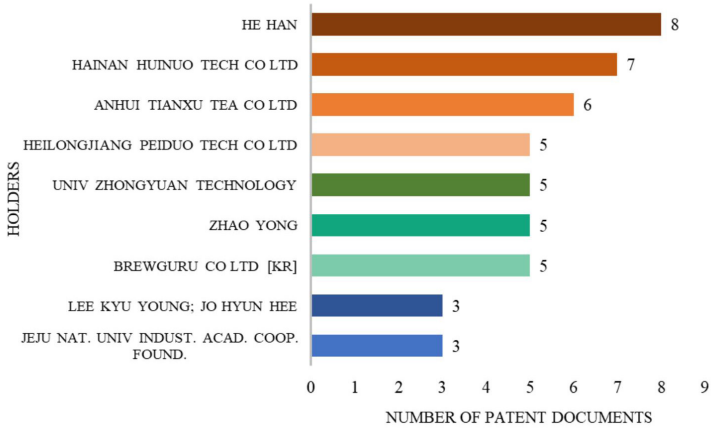


Figure 7. Main kombucha patent document holders.

Xintuxang Tea Ind Co Ltd, which produces green and black teas, appears in third place, with a total of 6 patents, green and black teas being the basis of kombucha and agricultural products, including the patents for tea perfumed with essential oil for slimming and the reduction of body fat (CN106551036A) (Wei, 2017a), nutritive yogurt and medicinal granules of rose tea (CN106551049A) (Wei, 2017b), amongst others, all equally involving kombucha. It should be mentioned that 6 of these patents refer to cosmetics, showing that kombucha has other specificities, not only as a beverage for consumption.

Of the different sectors of society, private companies showed the greatest number of patent documents deposited, with about 40% of the total (99 documents), followed by individuals with 37% (91 documents) and the universities with the remaining 23% (54 documents), as shown in Figure 8. The present study found that the percentages of the number of patents deposited by individuals and companies were very similar to the total number of documents deposited about kombucha. Amongst the universities, the Zhongyuan Technology University stood out, with 5 patents involving a method for the production of kombucha beverages using a liquid pulverization tower and a method for the production of bacterial cellulose using fermentation in a liquid pulverization tower (CN103421860 (A); CN103421860 (B) (Yingchen; Hongyan; Xianan, 2013)/ CN103421859 (A); CN103421859 (B) (Yingchen & Hongyan, 2013a)/ CN103416545 (A); CN103416545 (B) (Yingchen & Hongyan, 2013b)/ CN103416544 (A); CN103416544 (B) (Yingchen & Hongyan 2012)/ CN103416543 (A); CN103416543 (B)) (Yingchen & Hongyan, 2013c).

Figure 9 shows the classification of patents per industrial application area. Most of the documents dealt with some product added to the manufacturing process, amounting to 39.1% (93 documents), followed by new processes to produce tea, with 23.1% of the deposited patents (55 documents). Non-food products came in third place with 21% (50 documents) as kombucha based products for cosmetics and animal feeds, and in last place, food products, with 16.8% (40 documents), principally kombuchas with the addition of new ingredients, which will be analyzed in more detail in the following topic. These results show the high potential of kombucha, not only as a beverage, but also as material for new techniques and processes both for beverages and for the apparatuses related to their production and research with the kombucha microorganisms.

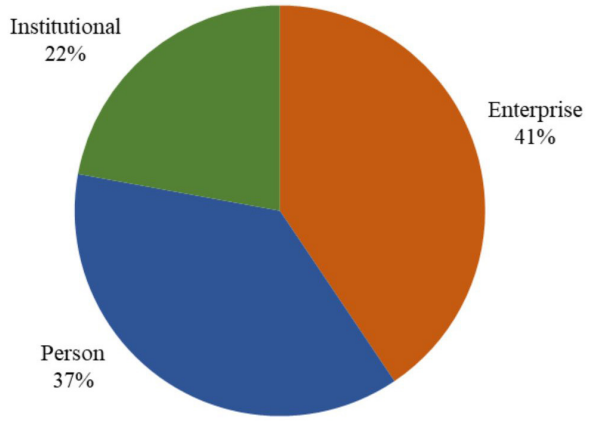


Figure 8. Distribution of the types of kombucha patent document holders.

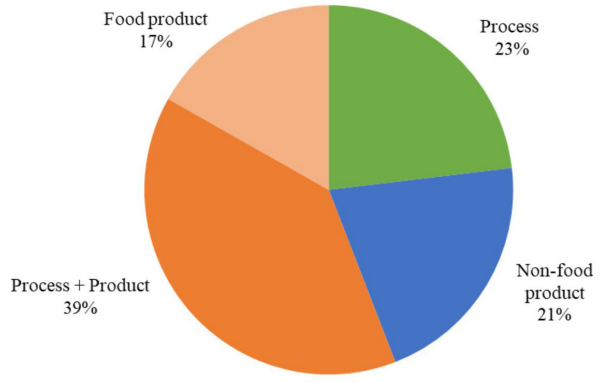


Figure 9. Distribution of patent documents per industrial application area.

Technological analysis of innovations in the kombucha-related beverage sector

For this topic, all the kombucha patents related to the beverage industry (164 documents) were analyzed and grouped into four large categories: food science (101 documents), biotechnology (21 documents), engineering (28 documents), and biochemistry (14 documents). This classification allowed for a detailed analysis of the advances being carried out in the sector, allowing for the identification of the areas with the greatest innovation and technological development, as illustrated in Figure 10.

Food science

The food science aspects applied to the kombucha industry were discussed in this topic, classified into two distinct moments: the addition of new ingredients and the process methods. The first part considered how the inclusion and the concentrations of new ingredients (77 documents) impacted the sensory profile and functional properties of the beverage, whereas the second part explored the production techniques (24 documents) and their innovations, highlighting how the extraction methods and sucrose sources could optimize the quality and effectiveness of the product.

In the production of kombucha, the patents related to food science considered the addition of diverse new ingredients, which could be infusions, teas, juices, pulps, or extracts from varied origins. Of the fruit ingredients, the following stand out: jaboticaba (CN104232430A) (Zhihui, 2014), persimmon leaves and fruits (KR20140079167A, KR20220073321A) (Young, 2014a, Mi, 2020), coffee fruits (CN115886108A) (Wang, 2022) and coffee extracts (KR20230067090A) (Seo, 2021). The group of vegetables include carrot (Han, 2015e), black soybean, mung bean, red bean (CN106509143A) (Seo, 2021) and sweet potato (CN107467460A) (Seo, 2021). The list for mushrooms and others included mushrooms, jasmine flowers, red ginseng (CN106561897A) (Shangzhan, 2017) and marine algae (KR102598253B1) (Yeol, 2023). Herbs and others included mint (KR20140079169A) (Young, 2014b), Cudrania tricuspidata (KR20220023092A) (Chil, 2022), olives, areca flowers, black tea leaves, yarrow root (CN110089588A) (Zhichao, 2019), ginger (KR102598663A) (Joong, 2023) and beetroot extract (KR102450013A) (Yun, 2022). In addition, other relevant ingredients included cannabis (WO2019100168A) (Bouchard & Jaremowich, 2019), Petasites japonicus (KR20200094392A) (Ron & Min, 2020), whole rice (KR102529533B1) (Young, 2023), milk, nuts, milk whey, powdered corn germ (DE20210471U1) (Bernhard & Rupert, 2003), lotus leaves (CN107996755A) (Rongxiang, 2018a), lotus seeds (CN108013304A) (Rongxiang, 2018b) and roses (CN108634041A) (Jie, 2018).

The application of new production methods is a crucial aspect in the innovation of the beverage. It includes variations in concentration of the raw material, cold extraction methods of the tea (Eliot & Romaine, 2022) and the use of different sucrose sources (white sugar was generally used), such as honey and brown sugar. The patents can approach these innovations in different ways, detailing processes that optimized the flavor, aroma, and functional properties of the kombucha, and also specific production techniques which influence the quality and effectiveness of the final product. Of the patents, a method to manufacture kombucha extract with greater conservation and active ingredient contents, using a process including washing, drying, roasting, supercritical extraction, fermentation, sterilization, filtration and conservation treatment with natural materials, as described in the patent (KR102541360B1) (Min & Sun, 2023).

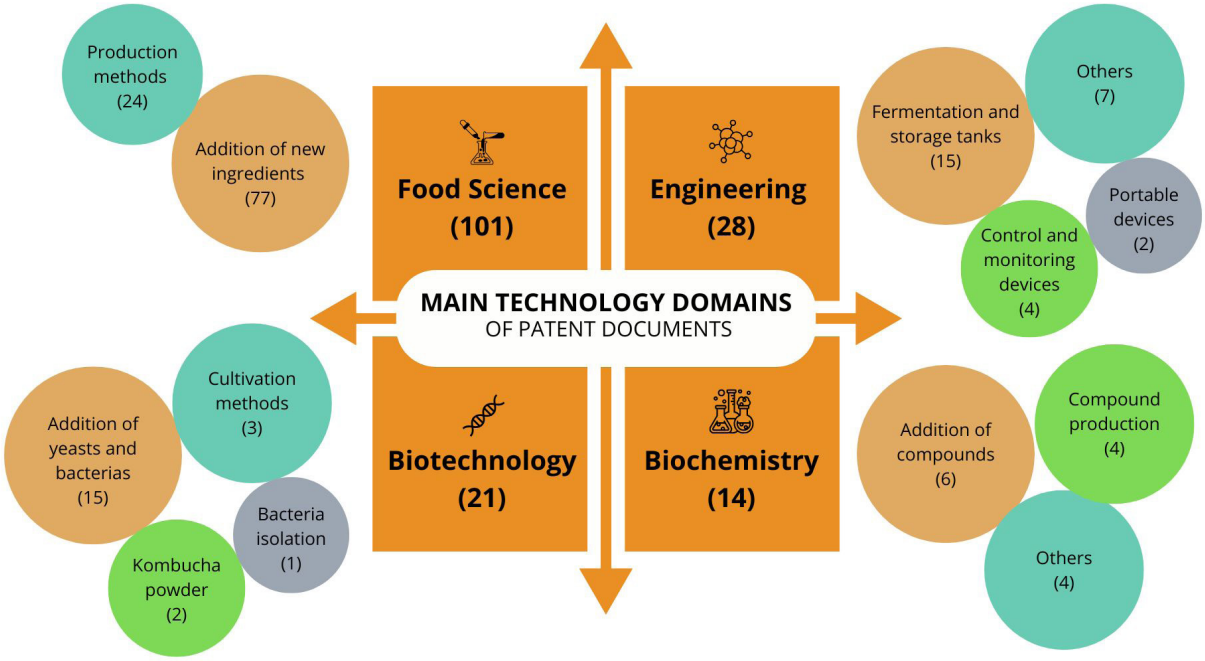


Figure 10. Classification of the kombucha patents into four large areas: Food science, biotechnology, engineering, and biochemistry.

Manufacture methods in closed tanks were also described with circulating liquid fermentation (US2024138444A1) (Michel & Scott, 2024).

The addition of new ingredients and variations in temperature, sugar concentration and duration of the fermentation played a crucial role in the final properties of the kombucha. Barakat et al. (2024) investigated the addition of grape bagasse and showed that the addition of ingredients enriched the nutritional profile of the beverage, increasing the amounts of bioactive compounds such as polyphenols and anthocyanins, which possess antioxidant and anti-inflammatory properties. Also, factors such as temperature, amount of sugar and fermentation time influenced the microbial activity, flavor, acidity and intensity of the beneficial compounds in the beverage (Barakat et al., 2024).

In a complementary way, the study of Kartelias et al. (2024) concerning the kombucha made from Mount Olympus tea (Sideritis scardica) showed that the addition of herbs, spices and fruits improved the physicochemical, nutritional and microbiological properties of the beverage. Increases in the phenol content, antioxidant content and the concentration of minerals such as potassium and iron were observed, as well as in the ascorbic acid and carotenoid contents.

Thus, the use of different ingredients or a combination of them allowed for a personalization of the kombuchas, resulting in a beverage that could be adapted to attend different flavor preferences and health requirements. For this reason, a study of new ingredients and production methods, such as variations in time, temperature, sugar content and type of tea are so important in the Food Science area. This field stands out since it impulses innovations and product improvement, making it one of the areas with more patents, reflecting its relevance and a continuous technological advance in the production of functional beverages like kombucha.

Biotechnology

Biotechnology plays an essential role in the innovation and development of kombuchas, applying advanced techniques to improve the fermentation process and functional properties of the beverage. In the patent documents related to the beverage industry, biotechnology is mainly used to optimize the use of microorganisms, including the addition of yeast and bacterial strains (15 documents), culture methods (3 documents) to improve the fermentation performance, the production of a powdered kombucha mixture for inoculation or beverage preparation, and the isolation of specific bacteria originating from the kombucha (1 document).

The addition of microbial strains stands out in the biotechnology applied to kombucha production. The patent CN113943663(A) (Xiaomin & Qi, 2024) uses Candida stellata Y3-13 to intensify the fragrance and improve the flavor of the kombucha, providing a controlled, stable fermentation process, ideal for large scale production. The patent KR20200066842(A) (Kwon & Min, 2020) combines yeast with acetobacter in a scoby to produce a kombucha with excellent flavor and functionalities in a short time, using lactobacilli to promote fermentation. The patent CN110791516(A) (Cunduo & Lunguang, 2020) presents a gene of Lactobacillus senmaizukei to increase the production of GABA, resulting in a kombucha with improved functional properties. Finally, the patent KR20220103484(A) (Ran & Hyon, 2024) introduces the strain Gluconacetobacter europaeus JB202002, which reduces the odor of fermentation and improves the refreshing sensation of the beverage.

The cultivation methods used to improve the fermentation performance of kombuchas include diverse innovative approaches. The patent RU2580046(C1) (Vasilevich et al., 2016) described a method to reduce the kombucha maturation time, cultivating the fungus with controlled aeration and adjusting the tea plus sugar solution during the process. On the other hand, the patent KR20220106325(A) (Park & Choo, 2022) concentrated on improving the antioxidant activity of the kombucha, using a specific seed cultivation method (SCOBY). This process involves the preparation of an initial culture medium with a tea and sugar extract, followed by controlled fermentation, resulting in a beverage with accentuated anti-ageing properties. Finally, the patent CN114600986(A) (Yanping & Jing, 2022) presented a fermentation agent based on 3D impression technology, which facilitated continuous fermentation, improving efficiency, and allowing for prolonged storage, ideal for kombucha commercialization.

The production of kombucha powder, described in two patents, focused on an efficient industrialization of beverages. The patent CN109294857(A) (Shuguang & Yanshuai, 2021) described a kombucha powder fermentation agent involving the culture, freeze-drying and composition of strains such as Lactobacillus plantarum, Hansenula polymorpha and Acetobacter xylinum, producing a stable fermentation agent ideal for use in tanks directly in the industry. On the other hand, the patent KR102448738(B1) (Young & Hyun, 2022) detailed a method to produce a powdered kombucha mix, including the fermentation of green tea extracts, addition of additives, spray drying and a mixture of functional powders, resulting in a product quick to produce, and with a high absorption of the functional ingredients by the body.

The invention KR102243418B1 (Han; Suh, 2021) refers to the strain Acetobacter aceti KOM, an acetic acid bacterium derived from kombucha, used to prepare a kombucha beverage. This strain, deposited under the number KCCM12535P, allows for the production of a kombucha with consistent quality, ideal for industrial production.

Engineering

The advances in engineering for kombucha production are mainly the development of equipment destined to optimize both the industrial production and the domestic consumption of kombucha. The patents analyzed protect significant innovations such as fermentation and/or storage tanks (15 documents), control and monitoring devices (4 documents), portable devices (2 documents) and others (7 documents).

With respect to the fermentation and storage tanks, the patents frequently included additional devices such as heat dissipators (CN214781842U) (Laiquan & Liang, 2021b), filters, lids, and air entrances and exits (CN211445702U) (Guoqiang & Jianping, 2020) as well as configurations for tanks in series for the first and second fermentations (US11678763B2) (Churchill & Amijo, 2023). One notable example is the Fermentation Tank (Yingchen & Hongyan, 2012; Yingchen & Hongyan, 2013a; Yingchen & Hongyan, 2013b; Yingchen & Hongyan, 2013c; Yingchen; Hongyan; Xianan, 2013), which introduced a fermentation tower for spraying the liquid filled with tissue, with tissue non-tissue and dyed tissue, optimizing the

kombucha production by improving the liquid distribution, controlling contaminants, managing the formation of bacterial cellulose and offering process flexibility, resulting in more efficient, high quality, fermentation.

The patents related to control and monitoring dealt with equipment with temperature control, such as a device to control fermentation and instruments that measure the pH, temperature, and the oxygen and sugar concentrations (KR20220106329A, KR20220069399A) (Park & Park, 2022, Hon & Jae, 2022). These devices are essential to guarantee precise and high-quality production.

The portable devices were represented by two main patents: the Kombucha Dispensing Device (Wei, 2011) which facilitates distribution of the beverage, maintaining it at an ideal temperature and preserving its quality, and the Portable Kombucha Tea Kit (CN202086162U) (Ma et al., 2021), a practical, easy system for transportation, equipped with a chamber to store water and cups, ideal for mobile consumption.

Finally, other patents were classified as "others", including devices such as mixers (CN215209378U, CN214991504U) (Tull & Aycok, 2020, Xiaoxuan & Fang, 2021), equipment for cleaning and sterilizing the raw material (Laiquan & Liang, 2021c) and kombucha fermentation trays that limit the production of alcohol during fermentation, increasing productivity and with a more efficient use of the plant space (US10787634B2) (Xiaoxuan & Fang, 2021), amongst others. These technological advances reflect the growing sophistication and diversification of the processes involved in kombucha production.

Biochemistry

The kombucha patent documents related to the area of biochemistry will be discussed in this topic. Documents in the categories of compound production (4 documents), addition of compounds (6 documents) and others (4 documents), with the intention of improving the nutritional and pharmacological properties of the beverage, stood out.

The documents dealing with compound production presented methods to obtain beverages richer in antioxidants, such as patents to increase the concentrations of antioxidants, for example the patents CN107410796A (Xiaoxuan & Fang, 2021) and KR202200707704A, and also the production of acids CN113577116(A) (Zhichao, 2021).

Productions with a focus on the addition of chemical compounds, such as alkaloids, can result in beverages with a stress-reducing potential (Xiaoxuan & Fang, 2021). Also, the addition of specific compounds such as collagen, zinc acetate and vitamin B6 aims to improve determined functional properties of the beverage, as mentioned in patents KR20210153184A and CN113826733A (La & Eun, 2021, hang & Denglong, 2021). The patent composed of a formula using tea, cane sugar or glucose, water, compound polysaccharide enzyme, Saccharomyces, lactic bacteria, xylitol, galacto-oligosaccharide GOS and acetic bacteria to improve fermentation, stands out CN112931650(A) (Shuguang & Xin, 2021).

Documents and patents related to kombucha developed to be nutraceutical beverages were placed in the category of "others", as described in the patent MX2018006058(A) (Pliego & Vazquez, 2019), and methods to produce beverages with less calories, as in the patent KR20200038199A (Man, 2020). Also, processes that altered the composition of compounds, such as reducing the original bitterness of Fructus chebulae and a minimization of the active ingredient molecules, such as chebulinic acid and gallic acid (Zhichao, 2021). Another example is the fermentative extraction process of meconopsis kombucha, according to the patent CN114098067(A) (Zhichao, 2022). These advances reinforce the importance of chemistry in the formulation of functional beverages with additional health benefits.

Kartelias et al. (2024) elaborated kombucha with different ingredients and the beverage enriched with hibiscus calyxes, rose petals and lavender flowers caused a significant reduction in the actions of in vitro α-amylase, α-glucosidase, acetylcholinesterase and butyrylcholinesterase. On the other hand, the beverage enriched with ginger, saffron and grated lemon skin showed the inhibition of α-glucosidase and increase in α-amylase, acetylcholinesterase and butyrylcholinesterase. The observation of these effects suggests an anti-diabetic potential of the beverage, which is particularly relevant considering the increase in concern with diabetes and metabolic health.

Functional beverages are highly relevant in the biochemical field since they improve the health-providing properties of the kombucha and stimulate the development of new beverages with health benefits. These innovations stimulate the market, offering products which attend the increasing demand for options that help in the prevention and handling of metabolic conditions. Thus, a kombucha with bioactive ingredients stands out as a promising alternative for innovation, and strengthens the functional beverage market, with a constantly increasing appeal for consumer health.

Technological analysis of innovations in the kombucha with coffee sector

After analyzing the patents relating kombucha with coffee in the data banks European Patent Office – Espacenet – and in the Brazilian National Intellectual Property Institute – INPI – only two patents were found.

The first patent of Wang (Fengwen, 2017), deposited in 2022 and published in 2023, of Chinese origin, does not have the complete dossier available for access. Denominated as "Preparation method of kombucha multi-substance fermented coffee", the patent summary informs that the production takes place in the following steps: addition of fresh coffee fruits and a flavoring substrate to the kombucha liquid, together with white sugar, and ferment the mixture at a temperature between 24-36 ºC for 36-48 hours. The beverage obtained has unique fragrance and flavor, combining the sour and sweet flavor of the kombucha with the bitterness of the coffee.

The second patent of the inventor Seo was deposited in 2021 and published in 2023, of Korean origin, with the title "Coffee-kombucha and manufacturing method thereof". This patent describes a kombucha made with green, black or Urung tea, together with what he calls "per", a preparation containing monosaccharides (glucose, fructose or galactose), disaccharides (sucrose, maltose or lactose) and polysaccharides, and includes yeasts and acetobacter. This preparation passes through an initial fermentation process. The invention concentrates on

a manufacturing method that uses coffee extract as one of the main ingredients of the kombucha manufacturing process, highlighting the flavor profile with coffee characteristics, The coffee extract is made with Guatemalan coffee beans using specific methods such as cold extraction, dripping or expresso, in specific amounts for each method. To prepare the diluted coffee solution, specific proportions, varying from 1:2 to 1 ;5 were used, and sugar added. This diluted and sweetened coffee extract was then mixed with the fermented tea in a proportion of 10:1, added more sugar and allowed to ferment again. The resulting coffee kombucha has specific pH and Brix values, indicating the acidity and sweetness levels, important for the general flavor and beverage quality. According to the coffee extraction method, the resulting beverage presents distinct sensory properties. The method aims to improve the kombucha flavor and aroma, seasoning it with coffee, at the same time reducing the acidity and sweetness, resulting in a milder flavor.

Although neither China nor Korea stands out as coffee producers, according to the International Coffee Organization – ICO, Asia is the second largest coffee consumer. It appears that the patents involving coffee come from this region since it is a great kombucha patent producer and consumes coffee on a large scale (ICO, 2023).

Brazil stands out as the largest world coffee producer, producing 60.4 million coffee bags between 2021 and 2022 (International Coffee Organization, 2023). For this reason, Saito et al. (2024) had the idea of using a special Brazilian coffee infusion (100% Arabica) and adding a green tea infusion before the first fermentation process, allowing for the coffee compounds to pass through the fermentation process. The study compared 4 coffee concentrations and showed that the greater the coffee concentration the lower the volatile acidity and the higher the pH value. It was also shown that the kombucha with the highest concentration of coffee infusion showed the highest scores for color, flavor and aroma (Saito et al., 2024).

Another alternative for the usage of coffee in the production of kombucha is to prepare an infusion of coffee leaves for the first fermentation. Sales et al. (2024) compared kombuchas made with black tea (Camellia sinensis), coffee leaves, China tea (Ilex paraguariensis) and a mixture of mate herb with coffee leaf. The addition of coffee increases the quantity of volatile organic compounds (Sales et al., 2024).

The kombucha market in Brazil is expanding, helped by an increasing consciousness concerning health and well-being. One study revealed that 67.3% of the participants knew about the beverage and 48.6% had already tried it. Although the Brazilian market is just starting as compared to more mature markets, such as that in the USA, acceptance of kombucha is increasing, especially among young people. Challenges such as a lack of information concerning the benefits of kombucha represent an opportunity to educate consumers and give an impulse to the market (Góis et al., 2023).

Perspectives

Innovation of the kombucha formula by adding new ingredients presents great potential to expand the market, attracting different publics. This approach not only offers a variety of unique, interesting flavors, but also enriches the beverage with specific functional properties, such as antioxidant and anti-inflammatory effects and the control of glycemia. Wu et al. (2023) showed that the incorporation of alternative ingredients improved consumer perception, providing differentiated sensory experiences and health benefits. In line with the growing tendencies to consume natural and functional products, this innovation allows for the brands to stand out in a competitive market.

Concerning the patents, the majority are directed to kombucha as a functional beverage, frequently enriched with fruits, herbs and spices. However, the number of patents associated with kombucha plus coffee is still limited, with only two recent patents. This is evidence of a vast field for research and innovation, especially considering the potential of combining kombucha with coffee, two markets with strong global appeals.

In Brazil, the rich biological diversity and its position as the largest coffee producer in the world, offer unique opportunities for the development of new kombuchas, including those fermented with different types of coffee and their co-products. These innovations can explore distinct sensory characteristics, promote sustainable production practices and aggregate value to these national products. The adaptation to local flavors such as the inclusion of different ingredients, for example coffee (Kartelias et al., 2024; Saito et al., 2024; Sales et al., 2024; Wu et al., 2023) could increase the range of beverage flavor options, indicating a promising future for the category.

In addition, market analyses and the identification of emerging tendencies are essential to direct the development of new production processes which optimize the fermentation and quality of the final product. Advanced technologies, such as biotechnology and automation, can improve production efficiency and guarantee the consistency of the functional attributes of the beverage. Investigating the functional properties of kombuchas enriched with ingredients such as coffee, is crucial to validate and promote the health benefits of these beverages. Combining innovation, technology and sustainability, this scenario suggests a promising environment for the creation of new kombucha formulations, with functional potential, potentializing the union of the coffee and kombuchas markets and giving impulse to the development of new technologies and patentable products in the sector.

Conclusions

This prospective study concerning patents related to kombucha revealed that China detains most of the patent documents in this area, highlighting the importance that the country attributes to the protection and exclusivity of the associated technologies. Most of the existing patents focus on kombucha as a functional beverage, frequently enriched with additional ingredients, but also include innovations in the preparation methods and significant advances in the biotechnological and biochemical areas. These advances could involve new fermentation processes, improvements in the yeast cultures and beneficial bacteria,

and optimization of the bioactive compounds present in the kombucha.

The combination kombucha with coffee arose as a promising innovation area, with only two recent patents, indicating that its potential is still open. This scenario offers a significant opportunity for the research and development of new technologies and products that integrate the benefits of both the beverages.

In the Brazilian context, the vast diversity of natural resources presents a unique opportunity to create new varieties of kombucha the use of different types or varieties of coffee and its coproducts could lead to the development of products with distinct sensory characteristics and promote sustainability. Uniting the coffee market, one of the most consumed beverages throughout the world with the promising kombucha market, a new coffee-based beverage segment appears with a strong potential for global acceptance, offering a promising field for innovations that attend the increasing demand for functional, healthy beverages.

The conclusion of the article highlights the importance of prospecting patents in the identification of innovations and tendencies on the kombucha market, especially the variation of ingredients with changes in the flavor and aroma of the beverage. The study revealed that, despite the increasing interest and demand for kombucha, the number of patents deposited is still relatively low, especially coffee-flavored kombucha, indicating a significant opportunity for development and innovation. I addition, an analysis of the patents provides a deeper understanding of the application areas and of the emerging technologies, suggesting there is a considerable potential for new research and products in the sector. Finally, the review concludes that the combination of kombucha with coffee not only diversifies the beverage options, but also opens the way for new approaches in the production and formulation of fermented beverages. Innovations in the beverage production chain can be an impactful goal, considering one of the main Brazilian commodities, which is coffee.

Conflict of interests

All authors declare that there were no conflicts of interest for the research described, the publication of the results, or financial questions.

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