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Kombucha's functional features and fermentation dynamics: a bibliometric assessment in sustainable food production

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Kombucha is a mildly acidic and carbonated functional beverage produced by fermenting tea leaves (*Camellia sinensis*) with sugar and symbiotic bacteria (SCOBY). It draws attention to traditional fermented beverages due to its antimicrobial and antioxidant properties and positive effects on health. Kombucha's positive effects on health are based on polyphenols, organic acids, probiotics, and biologically active ingredients. This study evaluates the global spread, academic effect, and publication tendencies of scientific research on Kombucha with a bibliometric approach. Web of Science Core Collection (WoS) catalogue (www.webofknowledge.com) was used to obtain the data. The keyword "Kombucha" was analysed without filtering. In the last 30 years, 1,099 scientific articles have been published in this area and the annual growth rate has been calculated as 9.06%. While China, Brazil, the United States and India were the countries with the highest publication, the countries with the highest citations were India, China and Brazil. When looking at the average number of citations per publication, countries such as Slovenia, Denmark, and the Netherlands were recognized as having the highest academic impact in terms of the quality of studies on Kombucha. Kombucha research is increasingly adopting an interdisciplinary approach, including food science, biochemistry, microbiology, and health sciences. SCOBY optimization, standardization of production processes, and long-term health effects are the areas where more research is needed in the existing literature. Despite the growing literature, there is no comprehensive bibliometric study mapping the development of Kombucha research and future perspectives. The bibliometric analysis we have conducted is the first of its kind. This study contributes to the potential of sustainable food production by revealing the current situation of Kombucha research and future research orientations.

KEYWORDS

Kombucha, fermented beverage, biological activity, bibliometric analysis, health benefits

1 Introduction

Fermentation is one of the oldest methods known to humans for preserving food. The origins of fermented teas can be traced back several 10,000 years (Bishop et al., 2022). Fermented tea Kombucha is a fermentation of tea leaves (*Camellia sinensis*) infused with sugar and a symbiotic culture of bacteria and yeasts (SCOBY), resulting in an acidic and slightly carbonated beverage (Júnior et al., 2022). Regarding Kombucha production, sucrose is the most commonly used carbon source, infusion preparation temperature of 90–100°C, and fermentation time of 14 days at 25–28°C are the most commonly used preparation conditions (Barros et al., 2024).

Over the past decade, consumer demand for functional foods has increased, leading to a rise in the popularity and consumption of Kombucha (de Oliveira et al., 2022; Bressani et al., 2024). With the increasing demand for Kombucha, Kombucha-like beverages have been produced using different substrates such as various herbs, fruits, milk, and coffee, in addition to traditional tea leaves (Vitas et al., 2020; Kruk et al., 2021; Sanwal et al., 2023; Candra et al., 2024). Numerous studies have been conducted on Kombucha derivatives produced from various substrates. The studies have focused on the chemical composition of Kombucha and the effects of its biological activities on health (González-Herrera et al., 2025).

Kombucha contains many bioactive compounds such as vitamins, polyphenols, antioxidants, probiotics, organic acids, and amino acids (Selvaraj and Gurumurthy, 2023). As reported in the existing literature, Kombucha has been shown to contain high levels of bioactive compounds and to demonstrate potent antioxidant and antimicrobial properties. The type of tea used, brewing parameters, SCOBY composition, and fermentation conditions all influence these properties (Antolak et al., 2021). Additionally, the type and concentration of sugar used during fermentation significantly impact the resulting bioactive compounds (Bortolomedi et al., 2022). As demonstrated by Mfopa et al. (2024), the composition of Kombucha is influenced by the duration of the fermentation process, exhibiting a high abundance of phenolic compounds, catechins, terpenoids, saponins, quinones, and coumarins (Mfopa et al., 2024). Kaewkod et al. (2019), detected a variety of organic acids, including glucuronic acid, gluconic acid, D-saccharic acid 1,4-lactone, ascorbic acid, acetic acid, succinic acid (Kaewkod et al., 2019).

The microorganism diversity of Kombucha may vary depending on the raw material, starter culture, and fermentation temperature. It contains acetic acid bacteria (*Acetobacter, Gluconobacter, Gluconacetobacter, Komagataeibacter*), lactic acid bacteria (*Lactobacillus, Lactiplantibacillus, Lacticaseibacillus*) and yeasts (*Brettanomyces, Candida, Saccharomyces, Zygosaccharomyces*) (Içen et al., 2023). These microorganisms in a symbiotic relationship in Kombucha tea help to produce extracellular cellulose fibrils by forming a biofilm between the air and liquid surfaces (Laavanya et al., 2021). Bacterial cellulose, a by-product of Kombucha, has found application in various domains, including food industry packaging, biomaterial production in the textile industry, and the treatment of skin wounds (Rivas-Arreola, 2025).

Kombucha has some health benefits, which are attributed to synergistically acting bioactive compounds in its structure (Leal et al., 2018). Kombucha has been shown to possess significant antioxidant activity and is a source of bioactive compounds with antimicrobial properties against many pathogens (Antolak et al., 2021; Içen et al., 2023). Kombucha has been reported to have anticancer properties by targeting specific proteins involved in the carcinogenesis process (Taupiqurrohman et al., 2024). In addition to these properties, studies have shown that it can prevent high cholesterol and blood pressure and improve glucose tolerance and insulin sensitivity (Leal et al., 2018; Alaei et al., 2020; Moreira et al., 2022). The observed decline in oxidative stress markers and serum hepatic enzyme levels indicates the hepatoprotective properties of Kombucha (Ezzat et al., 2025). There is still no clarity about the probiotic status of Kombucha. However, it is thought that the *"postbiotic"* definition may be more appropriate (Içen et al., 2023). In addition, Kombucha consumption can regulate gut microbiota, alleviating disorders caused by a Western-style diet by increasing propionate production and promoting the growth of beneficial bacteria (Costa et al., 2022).

Although the scientific literature references numerous potential health benefits of Kombucha, there is a paucity of studies addressing its safety and toxicological implications (Lima Ribeiro et al., 2025). There is no conclusive evidence of the potential toxicity of Kombucha. However, due to the occurrence of possible side effects, its consumption is contraindicated for infants, children under 4 years of age, pregnant women, individuals with renal failure and patients with HIV (de Miranda et al., 2022).

Bibliometric research has become an important tool. Bibliometrics is often used to measure the impact of research articles. It gives an indication of how much influence the article will have on future research (Diane Cooper, 2015). Bibliometric analysis is a widely used and systematic method for analyzing large-scale scientific data. As a quantitative approach, it examines scientific literature by assessing its external characteristics. This method integrates statistical and mathematical analyses to identify the research status, emerging trends, and defining characteristics of specific fields. While elucidating the evolutionary trajectory of a given subject, it also provides a short-term forecast for future developments (Wang and Su, 2020; Donthu et al., 2021).

The present study employed bibliometric analyses to elucidate Kombucha's research trends and future prospects over the past three decades.

2 Methodology

The Web of Science Core Collection (WoS) catalogue[1] was used to retrieve the data. The Web of Science Core Collection was chosen for its comprehensive indexing, organized metadata and compatibility with advanced bibliometric tools. Future work could benefit from a multi-database approach to further improve coverage and minimize bias, particularly in capturing regional research outputs. The search was launched and terminated on February 25, 2025, to avoid misinterpretation caused by daily fluctuations in a number of publications. The bibliometric data were retrieved from the Web of Science Core Collection using the keyword "*Kombucha*" in the Topic field, which includes title, abstract, author keywords, and Keywords Plus. This research applied no filtering (no time, language or geographic filters) to include all possible productions in the area in

1 www.webofknowledge.com

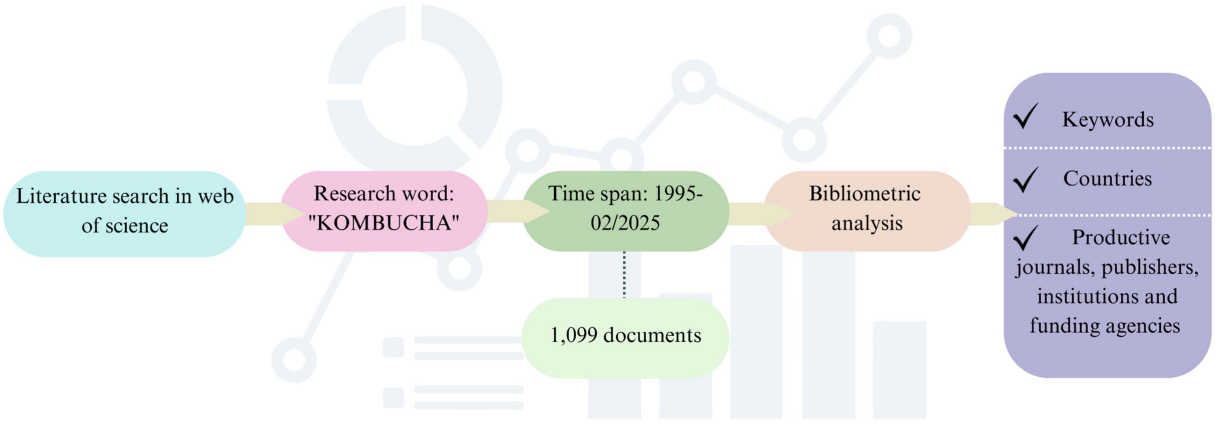

FIGURE 1
Methodological flowchart.

question. All document types indexed under the keyword (research articles, review articles, conference proceedings, and editorial materials) were included. No exclusion criteria were applied at this stage to avoid any potential bias and to ensure a comprehensive overview of the global Kombucha research landscape. The txt documents were downloaded and analyzed from the WoS website.

Gross Domestic Product (GDP) is described as the total value of goods produced and services provided in a country during 1 year. GDP per capita is gross domestic product divided by midyear population (Bureau of Labor Statistics, 2012). Based on the idea in Konar et al's work, countries' production activities were standardized to both simplify the interpretation and to clarify the population size and Gross Domestic Product-Purchasing Power Parity (GDP-PPP) values in this present research (Konar et al., 2022). Indexes calculated for standardization were provided below:

$$\text{Publication / Population Index} = \left(\frac{Publication}{Population}\right) * 1{,}000{,}000.$$

$$\text{Publication / (GDP – PPP) Index} = \left(\frac{Publication}{GDP - PPP}\right) * 1{,}000.$$

$$\text{TC / Population Index} = \left(\frac{TC}{Population}\right) * 100{,}000.$$

$$\text{TC / (GDP – PPP) Index} = \left(\frac{TC}{GDP - PPP}\right) * 100.$$

2.1 Statistical analysis

Frequency (n) and percentage (%) were provided for categorical ones. Income classifications, population size, and GDP-PPP values of countries were retrieved from the https://databank.worldbank.org/ website. Spearman Correlation Coefficients were calculated to determine the associations between bibliometric indicators and GDP-PP values. The Linear Extrapolation Method was employed to predict the Number of publications (NP) for the next 5 years. Biblioshiny web application of bibliometrix package[2] were utilized for bibliometric analyses. R Statistical Programming Language was used for the remaining analyses. Two-sided p-value ≤ 0.05 was taken as significant in all analyses.

3 Bibliometric research results

3.1 Main data statistics

The analysis indicates that 1,099 documents about Kombucha were published between 1995 and 2025. The annual growth rate was 9.06%, indicating an upward trend in Kombucha-related papers. 4,040 authors contributed to the field, while 40 single-author publications were produced. The average age of the documents was 4.87 years, while the average number of citations per document was 21.25.

The year 2024 was identified as the year in which the highest number of Kombucha-related publications were produced. Conversely, 2007 proved to be the year with the most citations, with an average of 9.84 citations per year. The analysis revealed that articles constituted the predominant document type, while Science Citation Index Expanded (SCI-EXPANDED) indexed journals dominated the landscape of Kombucha publications. The methodological flow of this paper is summarised in Figure 1.

3.2 Keywords and conceptual structure co-occurrence network

While visualizing the most frequently used keywords and their associated links in scientific research on Kombucha, dominant research trends and priority topics in the field were revealed

2 www.bibliometrix.org

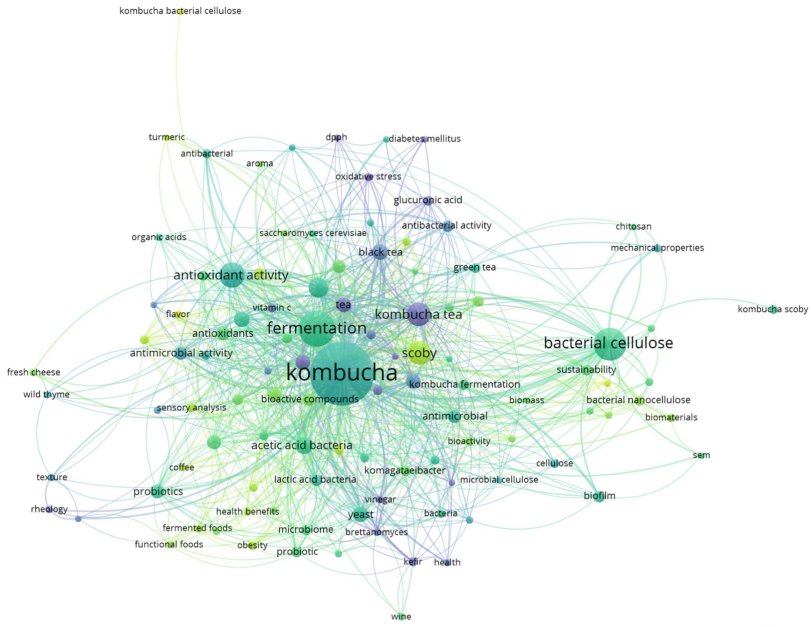

FIGURE 2
Temporal co-occurrence map of the most frequently cited keywords in Kombucha research. Cluster 1: Fermentation and microbial dynamics. Cluster 2: Health-related bioactivities. Cluster 3: Bacterial cellulose-based applications.

(Figure 2). The keywords prominently displayed on the map have been shown to have a strong relationship with key research axes such as Kombucha's biological activity, fermentation process, antioxidant capacity, microbial composition, and potential effects on health. This can be regarded as an indication of the mounting scientific interest in evaluating Kombucha as a functional beverage (Permatasari et al., 2022).

The presence of dense links between specific keywords indicates that an interdisciplinary framework shapes the research. Kombucha studies extend beyond food science to encompass disciplines such as microbiology, biochemistry, and health sciences.

Moreover, the word networks identified on the map provide significant indications concerning identifying knowledge gaps in Kombucha research and potential research areas for future studies. In particular, the standardization of the Kombucha fermentation process, the isolation and characterization of the bioactive compounds in its structure, and the pharmacological effects of these bioactive compounds have been identified in the scientific literature as the primary areas requiring further research (Sanwal et al., 2023). In recent years, there has been a notable surge in research endeavors concerning Kombucha bacterial cellulose, accompanied by a rise in global interest. While the development of bacterial cellulose-based composites is among the topics being investigated, antimicrobial properties are also being studied (Infante-Neta et al., 2024).

Figure 2 showed the temporal co-occurrence map of the most cited keywords in Kombucha research. Colors denoted the keywords' average publication year: ranging from 2018 (blue) to 2024 (yellow). Three dominant themes observed in the figure: fermentation dynamics and microbial composition (e.g., SCOBY, acetic acid bacteria, fermentation), antioxidant and antimicrobial activity (e.g., antioxidants, bioactive compounds, antibacterial), and applications of bacterial cellulose (e.g., biomaterials, nanocellulose, sustainability). These findings show the course of Kombucha research in a process. In conclusion, the standard word map in Figure 2 is a critical tool for analysing the scope of scientific publications on Kombucha and the most current research trends in the field.

3.3 The place of Kombucha research worldwide

Kombucha is a fermented tea beverage historically native to Asia but has recently become a hot topic in Western countries (Coton et al., 2017). Kombucha research is a rapidly growing field worldwide, with countries such as the USA, China, India, and Brazil producing the highest number of academic publications (de Melo et al., 2024). Furthermore, there has been a considerable increase in the number of patent applications. This surge in applications is particularly notable among private enterprises, including reGenics, Shi Weiyao, and EPC Natural Products Co. Ltd., which are developing innovative patents related to Kombucha (Alves et al., 2024).

An exhaustive analysis of global scientific research on Kombucha was conducted by the data presented in Table 1. In terms of the total number of publications, China (126), Brazil (97), the USA (84), and India (76) are among the most productive countries, and it is seen that these countries are the leaders in Kombucha research. However, countries such as Iran (52), Indonesia (51), and Serbia (51) also draw attention with their increasing academic productivity.

In addition to the analysis of publication productivity, in terms of the scientific impact factor of the countries, India (2,866

TABLE 1 The most active and most cited countries in Kombucha research.

Country	NP	SCP (%)	MCP (%)	Country	TC	Country	AAC
China	126	105 (83.3)	21 (16.7)	India	2,866	Slovenia	111.5
Brazil	97	74 (76.2)	23 (23.7)	China	2,365	Denmark	82.5
USA	84	76 (90.5)	8 (9.5)	Brazil	1822	Netherlands	78.8
India	76	59 (77.6)	17 (22.3)	USA	1,550	Macedonia	73.0
Iran	52	45 (86.5)	7 (13.5)	France	1,444	Slovakia	66.5
Indonesia	51	37 (72.5)	14 (27.4)	Serbia	1,206	Ireland	63.7
Serbia	51	51 (100)	0 (0)	Poland	917	Switzerland	58.3
Poland	42	38 (90.5)	4 (9.5)	Iran	801	Tunisia	57.6
France	35	20 (57.1)	15 (42.9)	Ireland	637	Latvia	48.3
Spain	28	21 (75.0)	7 (25)	Korea	595	Australia	41.8
Thailand	27	20 (74.1)	7 (25.9)	Tunisia	518	France	41.3
Korea	26	19 (73.1)	7 (26.9)	Australia	502	Belgium	39.7
Romania	26	23 (88.5)	3 (11.5)	Mexico	491	Nigeria	38.0
Turkey	23	22 (95.7)	1 (4.3)	UK	474	India	37.7
Malaysia	21	20 (95.2)	1 (4.8)	Netherlands	473	Sri Lanka	35.7
United Kingdom	21	18 (85.7)	3 (14.3)	Turkey	438	Finland	35.5
Mexico	19	12 (63.2)	7 (36.8)	Indonesia	416	Canada	28.6
Italy	16	12 (75.0)	4 (25.0)	Italy	415	Argentina	28.5
Vietnam	14	9 (64.3)	5 (35.7)	Romania	358	Italy	25.9
Australia	12	8 (66.7)	4 (33.3)	Canada	343	Mexico	25.8

SCP: Single Country Publications; MCP: Multi-Country Publications; AAC: Article Average Citations.

citations), China (2,365 citations) and Brazil (1,822 citations) were identified as the countries with the highest total citations. However, when the average number of citations per publication is considered, countries such as Slovenia (111.5 citations), Denmark (82.5 citations), and the Netherlands (78.8 citations) are recognized as having the highest academic impact in terms of the quality of studies on Kombucha.

When scientific collaborations between countries are evaluated, France (42.9%), Slovenia (33.3%), and Denmark (33.3%) are among the countries that produce the most multicenter publications. The high number of multicenter studies shows that Kombucha research in these countries is more open to international collaborations, and interdisciplinary approaches are more adopted. In contrast, countries such as Serbia (100%) and Turkey (95.7%) produced publications based almost entirely on local research. Since international collaborations are critical in increasing scientific impact in Kombucha research, encouraging multicenter studies in these countries may increase the scientific impact factor.

Figure 3 presents a detailed analysis of country-specific contributions to Kombucha research from 1995 to 2025, along with the temporal evolution of these contributions. There was no significant increase in publications until 2007, when India emerged as a leading contributor between 2007 and 2018. Since 2019, a marked increase in publication activity has been evident across all five countries. Following 2023, China and Brazil are the most prolific countries regarding research productivity, while the United States, Iran, and India have exhibited comparatively lower publications. This observation underscores the growing significance of Kombucha in the context of scientific research.

3.4 Country-based collaboration and impact in Kombucha research

Figure 4 visualizes the global distribution of scientific publications on Kombucha between 1995 and 2025 and the scientific collaboration between the most productive countries. The countries on the map facilitate the identification of the primary actors contributing to Kombucha research and enable a comparative analysis of scientific productivity and citation impact.

3.5 Publication, population, gross domestic product, and total citations for the best countries in Kombucha research

As demonstrated in Table 2, the scientific productivity of countries engaged in Kombucha research has been evaluated in terms of population size and gross domestic product (GDP). Serbia has been found to demonstrate consistently high values across all indicators, with notable scores, including 77.0 for the publication/population ratio, 268.5 for the publication/GDP ratio, 1820.9 for the total citations/population ratio, and 63.5 for the total citations/GDP ratio. Despite its relatively small population and economic size, this finding indicates that Serbia exhibits intensive academic activity in Kombucha research and attains a high scientific impact.

Following Serbia, New Zealand is a country of particular interest, given its notably elevated values about publication/population (23.0) and total citation/population ratio (281.4). This observation indicates that scientific endeavors in the nation are significant concerning

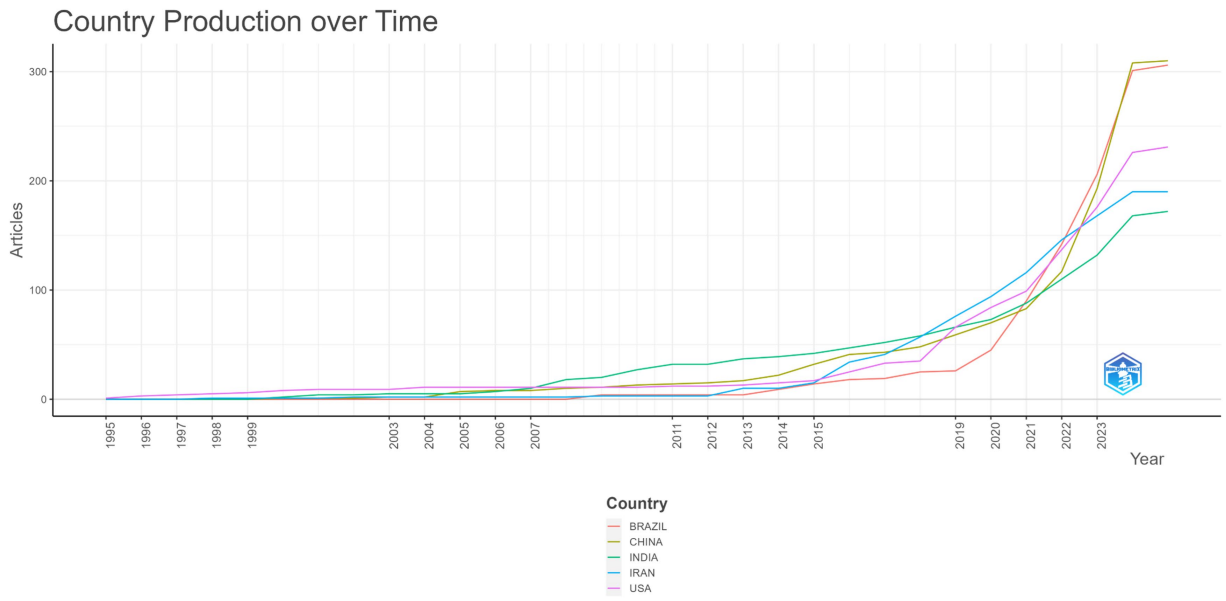

FIGURE 3
Article productivity of countries over time.

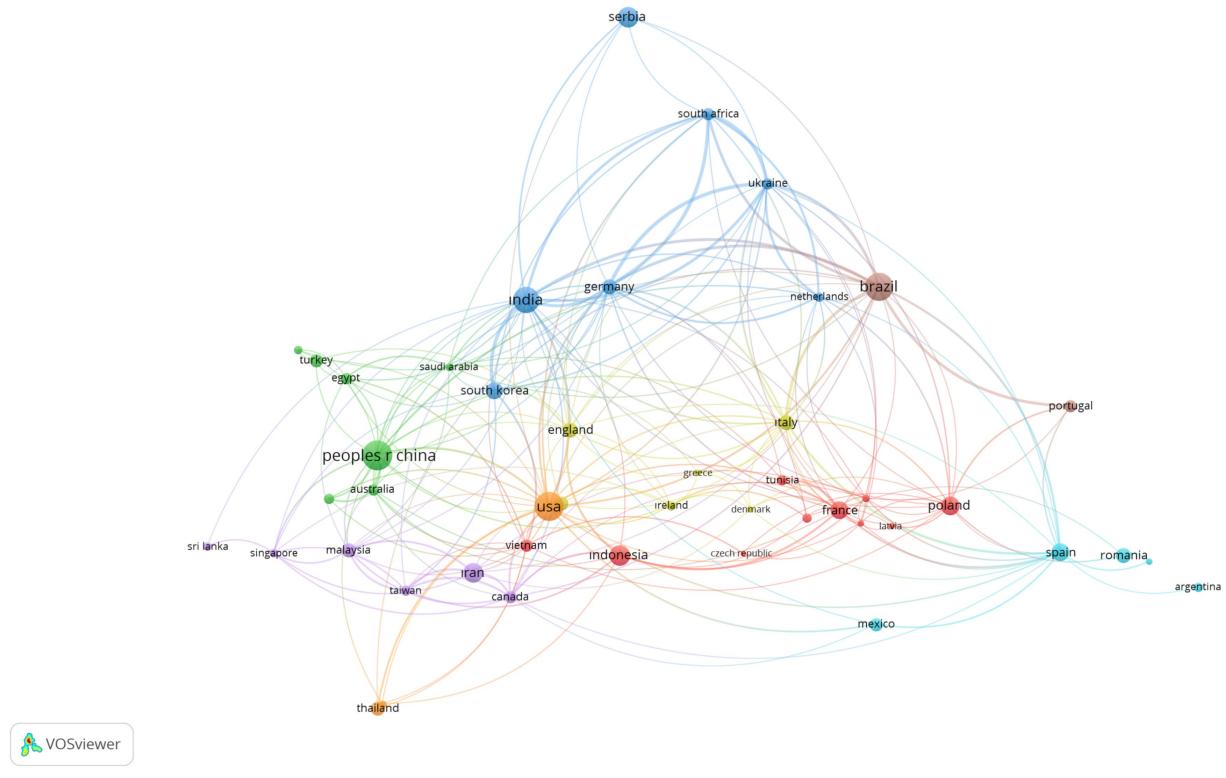

FIGURE 4
Co-authorship map of the countries with the most publications on Kombucha between 1995 and 2025. Cluster 1 (red): Belgium, Czech Republic, France, Indonesia, Latvia, Lithuania, Poland, Sweden, Tunisia, Vietnam. Cluster 2 (green): Australia, Egypt, New Zealand, China, Russia, Saudi Arabia, Turkey. Cluster 3 (dark blue): Germany, India, the Netherlands, Serbia, South Africa, South Korea, Ukraine. Cluster 4 (yellow): Denmark, England, Greece, Ireland, Italy, Turkiye. Cluster 5 (purple): Canada, Iran, Malaysia, Singapore, Sri Lanka, Taiwan. Cluster 6 (light blue): Argentina, Ecuador, Mexico, Romania, Spain. Cluster 7 (orange): Japan, Thailand, the USA. Cluster 8 (brown): Brazil, Portugal.

TABLE 2 Publication/population index, publication/GDP index, TC/population index, and TC/GDP index for top countries*.

Country	Publication/ population index	Country	Publication/ GDP index	Country	TC/ population index	Country	TC/GDP index
Serbia	77.0	Serbia	268.5	Serbia	1820.9	Serbia	63.5
New Zealand	23.0	New Zealand	43.0	New Zealand	281.4	Poland	5.4
Romania	13.6	Iran	32.5	Poland	249.9	New Zealand	5.3
Poland	11.4	Romania	29.9	France	211.5	Iran	5.0
Malaysia	6.0	Poland	24.6	Romania	187.8	Romania	4.1
Spain	5.8	Brazil	21.8	Korea	115.1	Brazil	4.1
Iran	5.7	Malayiia	16.4	Iran	88.4	France	3.6
France	5.1	Thailand	16.0	Brazil	86.3	Argentina	2.3
Korea	5.0	Indonesia	11.8	Italy	70.3	Korea	2.2
Brazil	4.6	Spain	10.9	Malaysia	70.3	India	2.0
Thailand	3.8	Korea	9.7	UK	69.3	Malaysia	1.9
UK	3.1	France	8.8	Argentina	69.0	Thailand	1.8
Italy	2.7	Argentina	8.0	Spain	58.3	Mexico	1.5
Turkey	2.7	Turkey	6.4	Turkey	51.3	Italy	1.2
USA	2.5	Mexico	5.9	USA	46.3	Turkey	1.2
Argentina	2.4	UK	5.3	Thailand	41.7	UK	1.2
Indonesia	1.8	India	5.2	Mexico	37.8	Spain	1.1
Mexico	1.5	Italy	4.7	India	19.9	Indonesia	1.0
China	0.9	China	3.6	China	16.8	China	0.7
India	0.5	USA	3.0	Indonesia	14.8	USA	0.6

TC: Total Citations; GDP: Gross Domestic Product; *: Cut-off value of NP was 10. Countries with number of publications 10 and above were taken into consideration.

productivity and academic influence. Romania, Iran, and Poland also achieved high scores in total citations, with Poland, in particular, standing out with its publication/GDP (11.4) and total citations/GDP (249.9). France is distinguished as a nation with a notable scientific impact in Europe, exhibiting a total citation/GDP ratio of 211.5.

It is evident that countries with larger economies, such as the USA, China, and India, exhibit low rankings regarding total citation and publication productivity. For instance, China's publication/population ratio of 0.9 and total citation/population ratio of 3.6 are very low, indicating that its scientific contribution in this field remains limited in proportion to its population.

3.6 Journals, publishers, institutions and funding organizations

When the academic distribution of Kombucha research is analysed, the journals with the highest number of publications are Foods (47 publications), Fermentation (30 publications), Food Chemistry (30 publications), Food Bioscience (27 publications), and LWT-Food Science and Technology (23 publications). The fact that these journals are mostly in the Q1 and Q2 categories shows that research on Kombucha has been published in academic platforms with high impact factors.

The most productive academic institutions are the University of Novi Sad (62 publications), Brawijaya University (39 publications), Chiang Mai University (37 publications), and Islamic Azad University (34 publications). It has been demonstrated in previous studies that Bharathiar University and the University of Novi Sad have been identified as the most productive universities (Alves et al., 2024). Most of these universities come from countries with high academic productivity in Kombucha research (China, India, Brazil, and Iran). In particular, the University of Novi Sad stands out as the institution with the most publications on Kombucha in Europe. At the same time, Brawijaya University and Chiang Mai University in Asia make significant contributions to Kombucha research.

When examined in terms of publishers, it is seen that most publications on Kombucha research have been published by leading international academic publishers such as Elsevier (285 publications), MDPI (184 publications), Springer Nature (105 publications), Wiley (100 publications), and Taylor & Francis (33 publications). This shows that Kombucha research is not limited to regional academic platforms but has spread globally to a broad academic impact area (see Table 3).

3.7 Most relevant sources

Bradford's law defines an exponentially decreasing return when expanding a search for references in journals and can be used to identify "core" journals in a field (Desai et al., 2018). The following graph illustrates the most significant scientific sources of Kombucha research by Bradford's Law. The graph identifies the core sources with the highest number of publications, and the leading sources are Foods (47 articles), Fermentation-Basel (30 articles), Food Chemistry (30 articles), Food Bioscience (27 articles), and LWT-Food Science and Technology (23

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TABLE 3 The most productive journals, publishers, institutions, and funding agencies regarding Kombucha research.

Sources	Best Quartile	NP	Affiliation	NP	Publisher	NP	Funding Agency	NP
Foods	Q1	47	University Of Novi Sad	62	Elsevier	285	Coordenacao De Aperfeicoamento De Pessoal De Nivel Superior Capes	43
Fermentation-Basel	Q2	30	Brawijaya University	39	Mdpi	184	Conselho Nacional De Desenvolvimento Cientifico E Tecnologico Cnpq	41
Food Chemistry	Q1	30	Chiang Mai University	37	Springer Nature	105	National Natural Science Foundation Of China Nsfc	35
Food Bioscience	Q1	27	Islamic Azad University	34	Wiley	100	European Union Eu	25
Lwt-Food Science and Technology	Q1	23	Egyptian Knowledge Bank (Ekb)	30	Taylor & Francis	33	Ministry of Education Science Technological Development Serbia	19
International Journal of Gastronomy And Food Science	Q2	17	Shiraz University Of Medical Science	29	Amer Chemical Soc	27	Fundacao Para A Ciencia E A Tecnologia Fct	15
Food Research Internatıonal	Q1	15	National Academy Of Sciences Ukraine	23	Frontiers Media Sa	22	Consejo Nacional De Ciencia Y Tecnologia Conacyt	11
Journal of Food Science And Technology-Mysore	Q2	14	Helmholtz Association	22	Oxford Univ Press	13	Fundacao De Amparo A Pesquisa Do Estado De Minas Gerais Fapemig	10
Frontiers İn Microbiology	Q2	13	Universidade Federal De Vicosa	21	Royal Soc Chemistry	12	Department of Science Technology İndia	9
International Journal of Biological Macromolecules	Q1	13	Centre National De La Recherche Scientifique (Cnrs)	20	Nature Portfolio	11	Fundacao Carlos Chagas Filho De Amparo A Pesquisa Do Estado Do Rio De Janeiro Faperj	8
Journal Of Food Processing And Preservation	Q3	12	Khon Kaen University	20	Amer İnst Physics	10	National Academy of Sciences of Ukraine	8
Polymers	Q1	12	Universidade Federal De Minas Gerais	18	Hindawi Publishing Group	9	National Research Foundation of Korea	8
Beverages	Q2	11	Universiti Putra Malaysia	18	Iop Publishing Ltd	9	National Science Foundation Nsf	8
Biocatalysis And Agricultural Biotechnology	Q2	11	German Aerospace Centre (Dlr)	17	Faculty Food Technology Biotechnology	8	UK Research Innovation Ukri	8
Journal of Food Science	Q2	11	Universite De Toulouse	17	Karger	8	Engineering Physical Sciences Research Council Epsrc	7
Antioxidants	Q1	10	Inrae	16	Korean Society Food Science & Technology-Kosfost	7	Fundacao De Amparo A Ciencia E Tecnologia Do Estado Do Rio Grande Do Sul Fapergs	7
International Journal of Food Science And Technology	Q2	10	University Of West England	16	Mary Ann Liebert, İnc	7	Fundacao De Amparo A Pesquisa Do Estado De São Paulo Fapesp	7
International Journal Of Molecular Sciences	Q1	10	National Research And Innovation Agency Of Indonesia (Brin)	15	Assoc Chemical Eng	6	Ministry Of Education, Science And Technological Development, Republic Of Serbia	7

(Continued)

TABLE 3 (Continued)

Sources	Best Quartile	NP	Affiliation	NP	Publisher	NP	Funding Agency	NP
Cellulose	Q1	9	Uludag University	15	Lippincott Williams & Wilkins	6	Region Bourgogne Franche Comte	7
Molecules	Q2	9	Universidade De São Paulo	15	Soc Brasileira Ciencia Tecnologia Alimentos	6	Spanish Government	7

NP: Number of Publication.

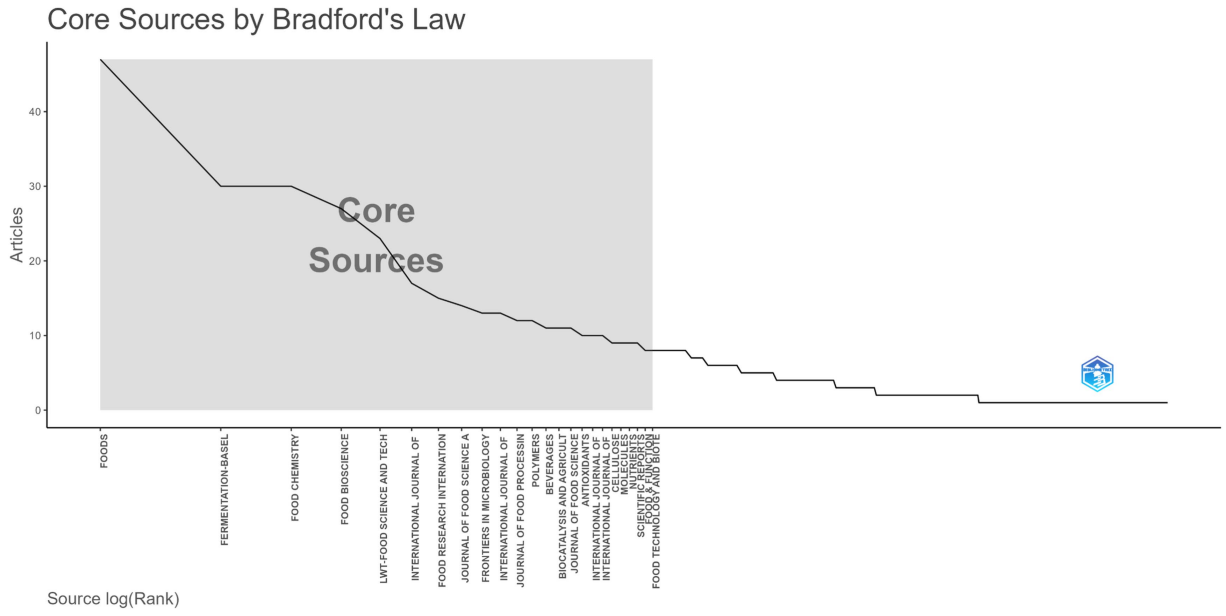

FIGURE 5
Core sources by Bradford's Law.

articles). While the initial journals represent a substantial proportion of the total publications, subsequent journals exhibit fewer articles. This observation suggests that most Kombucha research has been published in a select group of high-impact journals that are recognized as the leading academic platforms in the field (see Figure 5).

The standard word map presented in Figure 6 visualizes the journals with the most scientific publications about Kombucha and the relationships between them. By identifying the primary academic platforms through which Kombucha research is disseminated, this map facilitates an understanding of the interdisciplinary distribution of the field and the journals that serve as conduits for scientific studies in this domain.

The map shows that prestigious journals in food sciences such as Foods, Fermentation, Food Chemistry, Food Bioscience, and LWT-Food Science and Technology are among the sources that publish the most in Kombucha research. This finding underscores the comprehensive and multidisciplinary nature of Kombucha research, which extends beyond the purview of food science to encompass diverse fields such as microbial ecology, biotechnology, and biomedical sciences. As illustrated in Figure 6, analyzing academic platforms about Kombucha research can offer valuable insights. This map serves as a crucial reference point for researchers, guiding them in selecting the most suitable publication channels, identifying leading academic platforms for future studies, and assessing the disciplines exerting the most influence on scientific publications concerning Kombucha. Moreover, it underscores the necessity for interdisciplinary collaboration in research within this domain, proposing that Kombucha should be assessed from a more comprehensive scientific standpoint.

3.8 The place of Kombucha research in functional foods and future perspectives

In recent years, a significant number of diverse Kombucha products blended with various substrates have been developed (Kitwetcharoen et al., 2025). The expansion of the Kombucha market has given rise to a diversification of ingredients utilized in producing Kombucha-like beverages, extending beyond traditional tea. This diversification encompasses a range of raw materials, including various plants, fruits, milk, and agro-industrial ingredients (Sanwal et al., 2023).

The production of Kombucha is not subject to standardization in the present day. The beverage composition largely depends on the substrates utilized and the specific conditions of production. This variability in composition leads to significant differences in the properties of

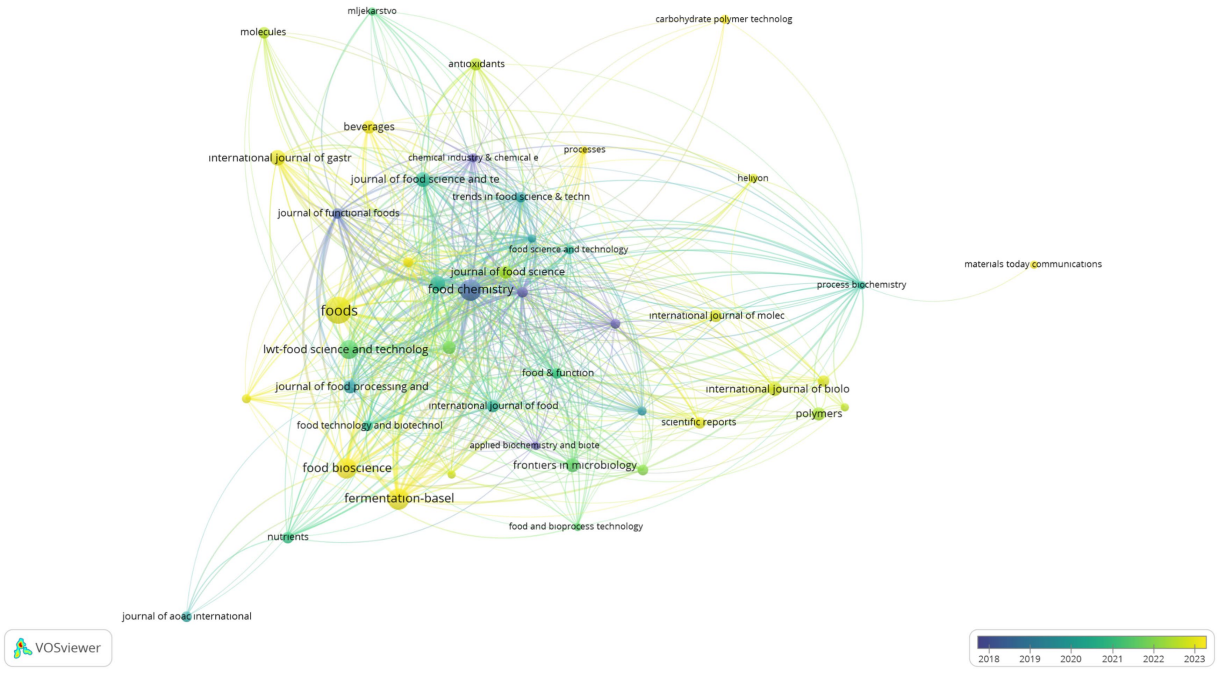

FIGURE 6
Co-occurrence map of the journals with the most publications on Kombucha.

Kombuchas, both between producers and across different batches within a producer's portfolio. Consequently, the validity of assumptions about quality standards is called into question (Vargas et al., 2021). For future studies, it is recommended to focus on exploring additional human health effects of Kombucha beverages, sensory evaluation, correlation analysis between volatile organic compounds in its structure and organoleptic properties, and *in vivo* analyses (Kitwetcharoen et al., 2025).

In recent times, SCOBY has been employed in various fields, including food technology, cosmetics, and biomedical industries. The subject has demonstrated considerable potential yet to be fully actualised. This has spurred global scientific and commercial interest (de Melo et al., 2024). In particular, the focus is on producing bacterial cellulose to reduce costs and enhance environmental sustainability. The incorporation of antimicrobial agents into bacterial cellulose matrices and the development of active packaging solutions that extend food shelf life and improve safety are also highlighted (Infante-Neta et al., 2024). Research has demonstrated that compounds exhibiting antioxidant properties become entrapped within bacterial cellulose, rendering it suitable for specific applications, including food packaging (Sabatini et al., 2025).

Prospective forecasts in Kombucha studies are demonstrated in Figure 7. The Linear Extrapolation Method revealed that China will be the lead country in the next 5 years as its number of Kombucha products will reach 41 by 2030. However, analysis findings suggested that India and Brazil, particularly India, will experience a sharp rise in the upcoming 5 years, and by 2030, publications will be 33 and 12, respectively, as the statistical method suggested. Even though a rapid increase for specific countries is foreseen, the extrapolation method depicted the current rank as China, Brazil, the USA, and India will repeat in the following 5 years in Kombucha research.

Correlation analysis findings demonstrated that there is a strong positive correlation between Citation Count (CC) and NP ($r = 0.899$; $p < 0.001$). Moreover, a strong positive association was also detected between CC and SCP ($r = 0.877$; $p < 0.001$) and CC and MCP ($r = 0.814$; $p < 0.001$). Similarly, regarding income classification, results revealed that as the number of papers increases, CC also increases in lower-middle income ($r = 0.986$; $p < 0.001$), upper-middle income ($r = 0.968$; $p < 0.001$), and high-income ($r = 0.873$; $p < 0.001$) countries.

3.9 Health effects of Kombucha and tea-based fermented beverages

Kombucha is believed to offer several health benefits that can be attributed to its distinctive chemical components formed during the fermentation process. It is thought to have a positive effect on the gastrointestinal tract and immune function and is an effective detoxification tool (Taupiqurrohman et al., 2024). Various health benefits such as antioxidant, anticarcinogenic, antidiabetic, anti-inflammatory, and anti-bacterial properties were highlighted in studies (de Oliveira et al., 2023). Cardoso et al. (2020) showed that green tea Kombucha has antibacterial activity and increased antiproliferative activity against cancer cell lines (Cardoso et al., 2020). Wang et al. (2024) stated that some of the acetic acid bacteria strains found in Kombucha have probiotic properties, while Içen et al. (2023) suggested that Kombucha meets the definition of a postbiotic (Içen et al., 2023; Wang et al., 2024). When used as a hepatoprotective agent, Kombucha has been reported to improve markers of oxidative stress and serum levels of liver enzymes (Ezzat et al., 2025).

Although the literature reports the benefits of Kombucha, studies are needed to assess the composition of bioactive compounds relevant to human health, and more *in vivo* studies are needed to assess its bioavailability. Clinical trials are essential to better understand the benefits and risks of Kombucha (de Oliveira et al., 2023).

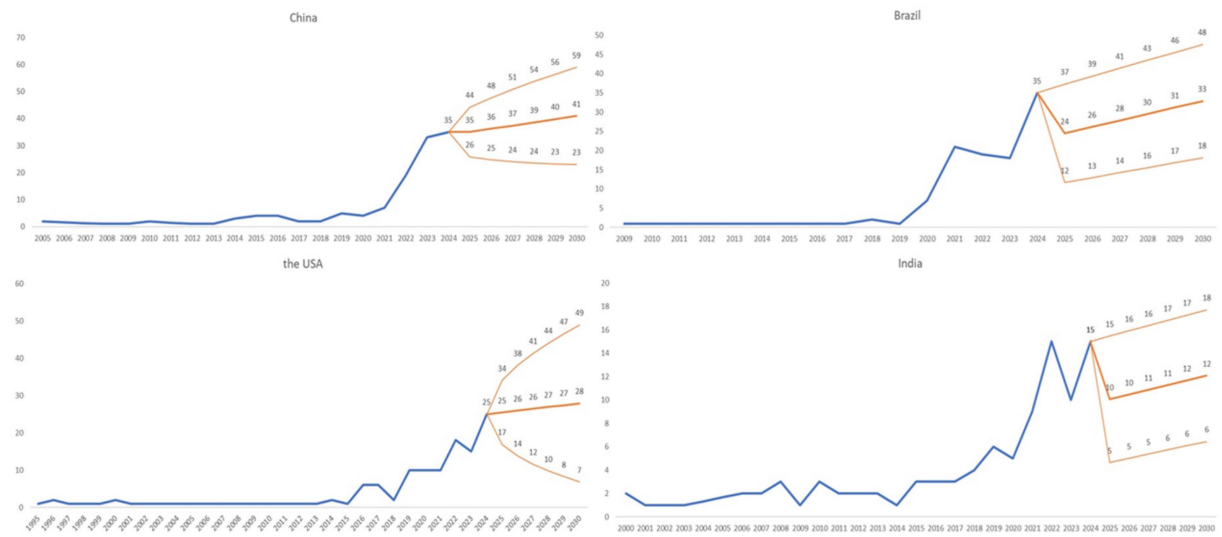

FIGURE 7
Predictions for China, Brazil, the USA and India fort he next 5 years.

4 Conclusion

In recent years, the interest in functional foods has increased, and in parallel, the popularity of Kombucha has increased. Bioactive components such as Kombucha's vitamins, polyphenols, antioxidants, probiotics, and organic acids have positive effects on health. In the bibliometric analysis, 1,099 articles on Kombucha in the last 30 years have been published, and the highest publication China, Brazil, the USA, and India. In the next 5 years, Kombucha research in China is expected to peak. Basic research subjects include Kombucha's biological activity, fermentation process, antioxidant capacity, and health effects. Increasing interest in understanding Kombucha's therapeutic potential creates opportunities for new studies in this field. In the future, there is a need for a more detailed investigation of the standardization of initial culture and production methods. In addition bacterial cellulose, a by-product of Kombucha, is currently used in different fields. It is expected that innovative applications will be used in the future, especially in the food and textile industry. This study reveals the current situation and future research orientations of Kombucha's potential effects on sustainable food production and health.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

GA: Project administration, Software, Visualization, Methodology, Formal analysis, Writing – review & editing, Investigation, Supervision, Writing – original draft, Data curation, Conceptualization, Validation. NK: Software, Writing – original draft, Funding acquisition, Validation, Resources, Writing – review & editing, Investigation, Formal analysis, Project administration, Conceptualization, Visualization, Methodology, Data curation, Supervision. SY: Software, Writing – review & editing, Writing – original draft, Investigation, Project administration, Data curation, Methodology, Supervision, Visualization, Conceptualization, Validation. HE: Software, Methodology, Writing – original draft, Supervision, Conceptualization, Investigation, Visualization, Validation, Project administration, Writing – review & editing, Data curation. SÖ: Visualization, Resources, Conceptualization, Project administration, Writing – original draft, Validation, Writing – review & editing, Methodology. AY: Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

Publisher's note

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