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Global research trends on herbal tea: a bibliometric and visualized analysis

Weihua Kong[1#], Lijie Jiang[1#], Qi Cui[1], Jiacheng Xu[2], Qiang Yuan[1*] and Juzhao Liu[1*]

[1] *School of Pharmaceutical Sciences, Zhejiang Chinese Medical University, Hangzhou 311402, PR China*
[2] *Shanghai Qixia Technology Co., Ltd., Shanghai 202150, PR China*
[#] These authors contributed equally: Weihua Kong, Lijie Jiang
[*] Corresponding authors, E-mail: yuanqiang0825@sina.com; JZLiu@zcmu.edu.cn

Abstract

Herbal tea, being a beverage with medicinal and edible properties, has served a significant role in promoting health and preventing diseases, leading to ongoing research advancements. This study utilizes bibliometric analysis to examine the comprehensive research status. CiteSpace was employed to conduct an analysis of the literature in the herbal tea field from 2000 to 2023, examining authorship, country and region distribution, institutional affiliations, and keyword relationships using data from the Web of Science database. The findings revealed a fluctuating yet overall upward trend in the volume of publications. China, the USA, Italy, Poland, and Malaysia emerged as the primary drivers of development in this domain. The collaboration network among authors and institutions is still in the developmental stage. Extensive cooperation can facilitate swift and sustained progress, which is urgently needed for the development of this field. Notably, there is substantial interest in the antioxidant properties of herbal tea and its phenolic compounds, particularly flavonoids, while fruit tea is emerging as a new research frontier. Furthermore, the safety aspects of herbal tea have garnered considerable research attention. There are numerous types and complex functions of herbal teas worldwide, and the regulations for their adaptation need to be improved.

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Introduction

Herbal tea, a time-honored traditional herbal beverage, is crafted from various parts of indigenous plants, including leaves, stems, flowers, fruits, roots, and more, as well as from single or small compound herbs. It refers to *non-Camellia* tea prepared by steeping diverse plant species in hot water[1]. Following suitable preparation, it is either infused with or without tea leaves, steeped in boiling water, or lightly decocted in water, and is consumed to promote health and disease prevention[2,3]. Besides the conventional Chinese herbal teas, the world boasts a collection of distinctive treasures categorized as herbal teas, including *Cyclopia spp.*, *Aspalathus linearis* and *Chamomilla recutita*[4,5]. According to traditional Chinese medicine, herbal tea serves 30 distinct health functions, with heat-clearing, detoxification, and cough relief being prominent among them[6]. Contemporary medical research demonstrates that herbal tea primarily exhibits pharmacological activities, including antiviral, antioxidant, antibacterial, and anti-inflammatory effects, among others[7]. Herbal tea exhibits preventive and alleviating effects on a range of conditions, including cancer, hyperlipidemia, hypertension, hyperglycemia, and various chronic diseases[8,9]. Herbal tea, combining medicinal and dietary attributes, has garnered growing attention in healthcare due to its simplicity, convenience, and versatile integration into daily consumption. Analyzing the state of research in this field can elucidate its progress, pinpoint key advancements, and identify emerging research frontiers, effectively catalyzing the advancement of the discipline[10].

Bibliometrics serves as a viable approach for both quantitative and qualitative analysis of scientific accomplishments and research progress. Advances in information technology have enabled the visualization of bibliometric data, and several outstanding bibliometric software tools, including CiteSpace, HistCite, and VoSviewer, among others, are being extensively employed[11]. As an illustration, Yan et al. applied bibliometric techniques to visualize the worldwide scientific output related to necroptosis in the field of neuroscience, as published in the Web of Science (WOS) between 2007 and 2019. Their findings suggested that shifts in mitochondrial function, stroke, ischemia-reperfusion, and neuroinflammation may represent focal points for future investigations in the realm of neural necrosis and ptosis[12]. Chen et al. employed bibliometrics to examine research focal points pertaining to inflammatory bodies and apoptosis within the brain. They put forward recommendations for investigating the associated mechanisms, which can be instrumental in the development of effective treatment strategies and the initiation of large-scale clinical trials related to inflammatory bodies and apoptosis[13]. According to Shen et al.[14], artificial intelligence shows promising potential in the domain of prostate cancer. Their bibliometric study revealed a growing dedication of scholars to research on artificial intelligence in the context of prostate cancer. However, there is a need for increased collaboration between countries and institutions in this area[14]. Bibliometrics offers a convenient method for examining global trends in a specific field of interest. It aids in the assessment of contributions from scholars across various institutions and countries, while also

guiding efforts to strengthen existing strengths and address weaknesses within the field[15].

Over the past few decades, there has been a substantial increase in the volume of research publications concerning herbal tea. Nonetheless, there is currently a dearth of systematic assessments of the extant literature. In this study, CiteSpace was employed to conduct a comprehensive evaluation of the literature pertaining to herbal tea from 2000 to 2023, with the aim of delineating the current state of this field and pointing towards emerging directions[16]. The primary objectives of this study are to discern the collective advancements in herbal tea research, identify the determinants of research efficiency, pinpoint the research frontiers, and offer insights to guide exploration and innovation. By doing so, this research endeavors to enrich the field of herbal tea, furthering its development and application.

Materials and methods

Search strategy and data collection

WOS stands as one of the most reputable and dependable literature databases, renowned for its exceptional indexing capabilities. WOS offers comprehensive information, encompassing paper titles, authorship details, affiliations, geographical data, and keywords, along with references[11,17]. The search for scientific articles was executed by employing advanced query techniques within WOS. The specific search formulas employed are presented below:

(1) (TS = (Chinese herbal tea) AND LA = (English))

(2) (TS = (Chinese medicinal tea) AND LA = (English))

(3) (AK = (herbal tea) AND LA = (English))

The time frame for the search spanned from January 1, 2000, to August 31, 2023, encompassing document types limited to articles and reviews. Following the elimination of irrelevant literature, the search yielded a total of 588 pertinent documents.

Data analysis

The research employed CiteSpace 6.2.4, a visualization analysis software, to analyze and graph the compiled literature. The analysis encompassed the examination of publication trends, author collaboration networks, national collaboration networks, institutional collaboration networks, keyword co-occurrence clustering, keyword timeline, keyword burst mapping, emerging research directions, and co-cited literature[18].

Results and discussion

Distribution of articles by publication years

A total of 588 publications were obtained, comprising 524 articles (89.12%) and 64 reviews (10.88%). Figure 1 illustrates the annual publication trends. There were no relevant publications retrieved between 2000 and 2002. The number of publications exhibited an upward trend, increasing from 1 in 2007 to 75 in 2022, albeit with some fluctuations. It's worth noting that the count for 2023 might indicate a misleading decrease due to the statistical cutoff on August 31. Clearly, interest in herbal tea is steadily on the rise. As shown in Fig. 1, the increasing publication trend can be categorized into three distinct stages: an initial stage (2003–2007) characterized by a modest publication rate; an intermediate stage of unstable growth

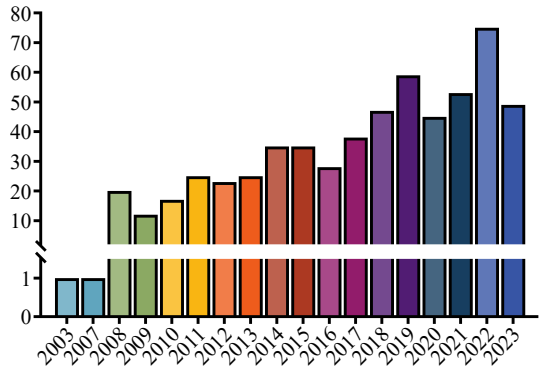


Fig. 1 Annual trends in the number of published documents from 2003 to 2023.

(2008–2017) marked by a slight upward trend with fluctuations; and a subsequent phase of rapid growth (2018–2022) where output volatility accelerates and culminates in 2022. Research on herbal tea continues to thrive, likely driven by its recognized health benefits and widespread global acceptance. Moreover, the abundant varieties of herbal tea offer a promising avenue for exploration, each with its distinct advantages[6]. The observed volatility can be attributed to the transient nature of individual hotspots, as they often lack the enduring appeal needed for long-term investigation. Furthermore, the identification of topics with enduring research value remains limited at present. Additionally, there is a noticeable deficiency in scholarly collaboration, marked by dispersed research interests and a progressive but incohesive relationship between studies conducted by different researchers.

Co-authors analysis

Figure 2a illustrates the contributions and collaborative relationships among researchers in the herbal tea research field. The network comprised 240 nodes and 238 connections. All primary authors from the dataset's literature were integrated, where each node signified an individual author and the connections between authors denoted direct collaborations through co-authorship. Author nodes are variably sized to reflect their respective publication counts. The colors-brown, yellow, and green-indicate the years spanning from 2003 to 2023. Notably, Joubert E (29) stands out as the most prolific author in this field, with De Beer D (17) and Muller M (5) following closely behind. All three authors hail from South Africa and share affiliations with Stellenbosch University. Additionally, Joubert E and De Beer D are associated with the Agricultural Research Council of South Africa. Within this field, a collaborative group has coalesced around Joubert E as the central figure, boasting a lengthy research history and substantial output, thus forming a robust team. Conversely, the majority of other authors have not engaged in cooperative endeavors, with some involved in only a limited number of small-scale collaborations, resulting in lower research output (≤ 2). It is evident that in this research domain, the presence of collaborative teams among authors significantly influences research output, with enduring collaboration proving more favorable for sustained and in-depth research development. The team led by Joubert E serves as a case in point. While the field comprises a substantial number of researchers, the scarcity of collaborative teams results in relatively limited individual research output. Encouragingly, Fig. 2a reveals the emergence of several new

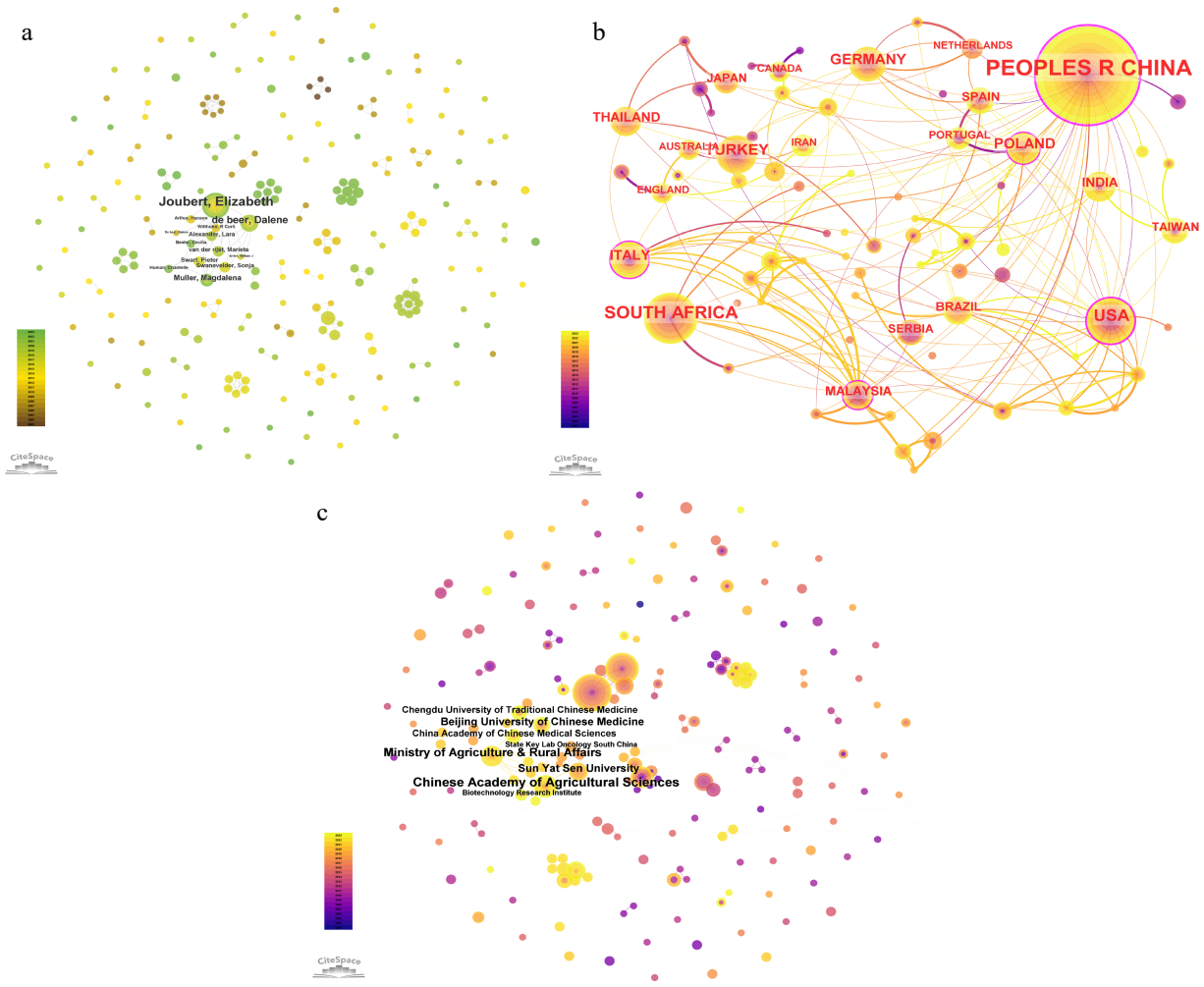


Fig. 2 (a) Authors' publications and cooperation network from 2003 to 2023, (b) national publications and cooperation networks from 2003 to 2023, (c) agency publication and cooperation network from 2003 to 2023.

collaborative teams symbolized by the interconnected green nodes. These teams often comprised authors with notable research output, signifying the potential for further advancement in the field of herbal tea. Enhanced communication and collaboration hold promise for fostering research progress. With optimism, this trend is expected to drive further developments in the field.

Analysis of cooperation networks across countries

The visualization map of the collaborative country network illustrates the influence of each node, as depicted in Fig. 2b. The network's organization is based on betweenness centrality, with high betweenness centrality nodes indicated by a thicker purple outline. The red tree rings signify the burstiness of citations, and the degree of burstiness for a given node corresponds to the thickness of its red tree rings. The dataset encompassed a total of 76 countries and regions. The centrality score represents the mediating role of nodes in information transmission between other nodes. The higher the intermediation centrality of a research subject, the closer the connection between that and other research subjects, and the more opportunities for cooperation[19]. The country cooperation network map comprised 76 nodes and 171 links. Notably, China led with the highest number of publications (150) and boasts the highest centrality score (1.31). The USA (0.21), Italy (0.12), Poland (0.11), and Malaysia (0.11) follow. These countries, with centrality values greater than 0.1, hold pivotal positions in the critical pathway of herbal tea research, and their contributions to national and regional collaborative research are of significant importance.

China, a prominent hub for the consumption of herbal tea, has fostered collaborative ties with numerous countries and regions, resulting in sustained research output over an extended timeframe. China continually seeks fresh partnerships and extends cooperation, further stimulating research productivity in this domain. Remarkably, countries with comparatively low centrality scores, including South Africa (0.06) and Turkey (0.01), exhibit notable publication rates. South Africa boasts a well-established national research consortium that has made significant and exceptional contributions to the field of herbal tea research. Turkey has not yet established a formal research team in this field but has demonstrated enthusiasm and potential for research. Currently, there is limited cross-border collaboration and research result exchange among different countries, posing a hindrance to the advancement of research in this field. This limitation is believed to stem from regional research autonomy and the variances in characteristic species. Moreover, academic barriers between countries impede collaborative research endeavors. It is imperative to underscore the

pivotal role of proactive domestic and international cooperation and knowledge exchange in driving the advancement of relevant research.

Institution analysis

The institutional cooperation network, resulting in 187 nodes and 135 connections, reveals that a significant portion of the 187 institutions lack stable collaborative arrangements. Figure 2c illustrates the presence of a stable collaborative consortium in China. This consortium is anchored by key nodes such as the Ministry of Agriculture & Rural Affairs, Beijing University of Chinese Medicine, Sun Yat-Sen University, and China Academy of Chinese Medical Sciences, encompassing a total of 18 institutions. The yellow color of the nodes signifies that cooperative activities have transpired in recent years, accompanied by notable research output, signifying robust and promising collaborative relationships. It's noteworthy that all 18 institutions involved in this consortium are based in China. In particular, Stellenbosch University and the Agricultural Research Council of South Africa, the leading contributors, maintain a cooperative connection. However, this connection may not meet the criteria for a typical collaborative team. The collaboration between authors Joubert E and De Beer D, who are affiliated with both institutions, has played a crucial role in creating this unique situation. Their collaboration between authors and institutions has yielded significant advantages in terms of related research output.

The regional cooperation of institutions is strong, and there is more cooperation among Chinese institutions, which reflects the interest of Chinese scholars in herbal tea. Still, more cooperation is needed. Some other institutions have engaged in prior cooperative endeavors, but these interactions have not evolved into mature and sustained collaborative relationships. Domestic and international collaborations tend to operate independently, with limited transnational cooperative efforts. Various cooperation barriers exist between institutions, hampering the establishment of effective collaborative relationships and offering limited support for the holistic advancement of research in this field. The obvious lack of international cooperation may be attributed to the inconveniences of communication, and the scarcity of cooperative opportunities stemming from differing institutional focuses, research methodologies, and capabilities, which serve as barriers between agencies. Furthermore, herbal tea research is not exceptionally complex and has not received sufficient attention from institutions. Nevertheless, the preceding analysis underscores that inter-agency collaboration can significantly enhance research depth and innovation within the herbal tea field. It is advisable to prioritize such collaborations to advance comprehensive and sustainable development in this research domain.

Co-occurring author keyword networks

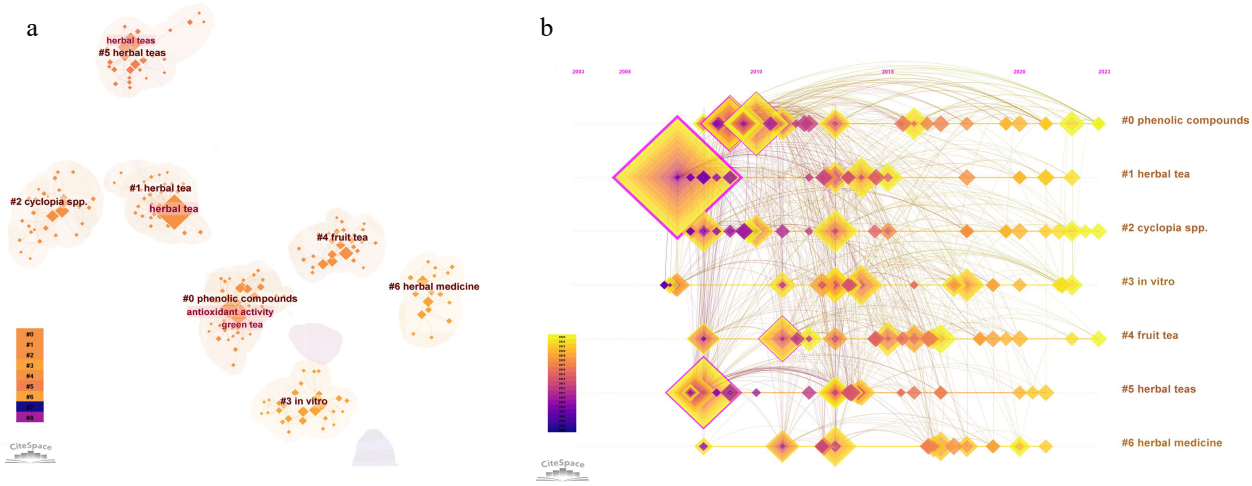
The keyword cluster graph, depicted in Fig. 3a, encompassed 228 nodes and 1146 connections. Table 1 presents the top 10 keywords exhibiting the highest count and centrality, excluding 'herbal tea' and 'herbal teas'. Figure 3a revealed the generation of a total of seven clusters through logarithmic likelihood ratio, encompassing keywords such as phenolic compounds, herbal tea, *Cyclopia spp*., *in vitro*, fruit tea, herbal teas, and herbal medicine. Excluding 'herbal tea' and 'herbal teas', the most prominently featured keyword is 'antioxidant activity'. Antioxidant activity stands as a crucial pharmacological attribute of herbal tea, as evidenced by examples such as *Eucommia*[20] and Vine tea[21]. In fact, the antioxidant activity of certain herbal teas surpasses that of green tea, renowned for its abundance of tea polyphenols[22]. Green tea, a traditional and well-known variety, is frequently used in conjunction with herbal tea to achieve specific or enhanced effects, or for comparative studies on aspects such as chemical composition and pharmacological effects[23,24]. As revealed by the clustering results, the majority of research pertaining to this subject is centered on antioxidant effects. It is evident that the component analysis of herbal tea enjoys considerable popularity. Among the constituents of herbal tea, phenolic compounds, particularly flavonoids, are recognized for their diverse pharmacological effects, with a primary emphasis on antioxidant, anti-inflammatory, and anti-tumor properties[25–28].

According to Fig. 3b, the most extensive cluster is 'phenolic compounds' (#0), followed by 'herbal tea' (#1) and '*Cyclopia spp.*" (#2). At the top, the years from 2003 to 2023 are horizontally arranged, accentuating the differences in the emergence timelines of the six clusters. The larger the size of the diamond, the greater the extent of research conducted on the respective topic. Each cluster's label is positioned at the conclusion of the timeline. As previously discussed, phenolic compounds, encompassing elements like flavonoids, hold a significant role in herbal tea and have garnered prolonged attention. Furthermore, a timeline aids in grouping references based on temporal aspects, facilitating the comprehension of the period in which a specific topic is prominent and contributing to the analysis of the field's evolution[29]. Analyzing the temporal distribution of these clusters reveals that current research hotspots encompass 'phenolic compounds' (#0), '*Cyclopia spp.*' (#2), and 'fruit tea' (#4). The significant share of research concerning '*Cyclopia spp.*' is notably associated with authors Joubert E and De Beer D, who exhibit a pronounced focus in this area. In relative terms, 'fruit tea' represents an emerging and widely embraced hotspot that has garnered the attention of researchers from diverse countries, such as China, Turkey, and Germany. This subject has enjoyed sustained research efforts, implying the likelihood of future advancements.

'Burst keywords' are words that experience frequent citations over a specific period. By examining the distribution of the most prominently cited keywords, we can anticipate the emerging research frontiers[30]. The top 14 keywords with the most significant citation surges are presented in Fig. 3c. If a keyword is frequently used, it will be indicated by a red bar, while infrequently used keywords will have a green bar. 'Chemical composition' stands out as the most frequently cited keyword in recent years, reflecting the current focus on investigating the components present in herbal tea. Its prominence is second only to 'flavonoids', surpassing other keywords by a significant margin. Thus, delving into the chemical composition holds substantial importance for advancing herbal tea research. The research hotspots and frontiers outlined above offer scholars valuable references and inspiration for further exploration of herbal tea.

Citation and co-citation analysis

Based on the citation frequency reported by WOS, Table 2 presented the top 10 highly cited publications. The number of citations in this range varies from 128 to 312. At the top of the list is 'Flavonoids from *Artemisia annua* as Antioxidants and Their Potential Synergism with Artemisinin against Malaria and



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Keywords	Year	Strength	Begin	End	2003–2023
alternative medicine	2009	2.85	2009	2012	
extracts	2009	2.59	2009	2011	
rhodobryum ontariense	2012	2.48	2012	2013	
mass spectrometry	2013	3.14	2013	2015	
capacity	2013	2.44	2013	2015	
flavonoids	2008	5.69	2014	2016	
liquid chromatography	2014	2.5	2014	2015	
infusions	2016	3.78	2016	2020	
herbal medicine	2017	3.35	2017	2021	
expression	2018	3.56	2018	2021	
apoptosis	2013	2.76	2018	2019	
leaves	2010	2.6	2018	2020	
plants	2013	2.46	2020	2021	
chemical composition	2016	4.68	2021	2023	

Fig. 3 (a) Keyword cluster of herbal tea publications from 2003 to 2023, (b) timeline of keywords published in the herbal tea field from 2003 to 2023, (c) top 14 keywords with the strongest citation bursts.

Table 1. Top 10 keywords with the highest count and centrality.

Rank	Count	Keyword	Centrality	Keyword
1	56	Antioxidant activity	0.17	Antioxidant activity
2	43	Green tea	0.16	Green tea
3	41	extracts	0.15	Extracts
4	31	Identification	0.11	Identification
5	29	oxidative stress	0.10	dietary supplements
6	27	Flavonoids	0.09	Medicinal plants
7	24	polyphenols	0.09	Products
8	23	In vitro	0.08	oxidative stress
9	23	leaves	0.05	Polyphenols
10	23	Food	0.05	extract

Cancer' published in Molecules by Ferreira JFS in 2010. This review delved into the synergistic interaction between artemisinin and flavonoids, the primary bioactive components in traditional Chinese herbal medicine preparations (tea). Artemisinin has consistently garnered significant attention, and flavonoids are crucial active constituents in traditional Chinese medicine. Hence, the exploration of their synergistic effects is a reasonable area of focus. In summary, the highly cited articles cover a range of topics, including the introduction of pharmacological actions (No. 1, No. 6), safety (No. 2, No. 7), unique tea varieties (No. 3, No. 4, No. 9, No. 10), and nutrient content (No. 5, No. 8). While the investigation of pharmacological activities is a natural focus, the safety of herbal tea is also a significant concern. This aspect merits the attention of more scholars, offering ample opportunities for collaborative research and the potential for significant advancements in the field of herbal tea research.

Co-citation analysis, alongside high citation analysis, is an essential method for evaluating references. As depicted in Fig. 4, the most frequently cited authors are Bodi D (nine citations), followed by Erasmus LM (eight citations), Zhao J (eight citations), Schulze AE (seven citations), and Joubert E (seven citations). Additionally, authors such as Joubert E, Lambert JD, Bodi D, de Beer D, and Bunchorntavakul C exhibit high centrality in the co-citation network. According to the centrality ranking, Joubert E (2011) holds the top position, signifying significant influence in the field of herbal tea. This ranking is attributed to a comprehensive review that summarizes the latest developments in the traditional herbal tea *Cyclopia spp.* industry in South Africa. The review provides an analysis of the challenges facing the industry and offers insights into necessary research directions to maintain competitiveness. It's worth noting that a substantial portion of the related literature is co-authored by Joubert E, which contributes significantly to his high centrality[41].

Table 2. Top 10 highly cited papers of herbal tea in WOS.

Rank	Title	First author	Journal	Publication year	Total citations
1	Flavonoids from *Artemisia annua* L. as antioxidants and their potential synergism with artemisinin against malaria and cancer[31]	Ferreira JFS	Molecules	2010	312
2	Hepatotoxicity from green tea: A review of the literature and two unpublished cases[32]	Mazzanti G	European Journal of Clinical Pharmacology	2009	265
3	From 2000 years of *Ganoderma lucidum* to recent developments in nutraceuticals[33]	Bishop KS	Phytochemistry	2015	225
4	Rooibos (*Aspalathus linearis*) beyond the farm gate: From herbal tea to potential phytopharmaceutical[34]	Joubert E	South African Journal of Botany	2011	165
5	Evaluation of trace metal concentrations in some herbs and herbal teas by principal component analysis[35]	Kara D	Food Chemistry	2009	155
6	Antioxidant and antimicrobial activities of various leafy herbal teas[36]	Oh J	Food Control	2013	136
7	Determination of pyrrolizidine alkaloids in tea, herbal drugs and honey[37]	Bodi D	Food Additives & Contaminants Part A	2014	134
8	Mineral content of some herbs and herbal teas by infusion and decoction[38]	Ozcan MM	Food Chemistry	2008	132
9	Mangiferin – a Bioactive Xanthonoid, not only from mango and not just antioxidant[39]	Matkowski A	Mini Reviews in Medicinal Chemistry	2013	129
10	*Citri Reticulatae Pericarpium* (Chenpi): Botany, ethnopharmacology, phytochemistry, and pharmacology of a frequently used traditional Chinese medicine[40]	Yu X	Journal of Ethnopharmacology	2018	128

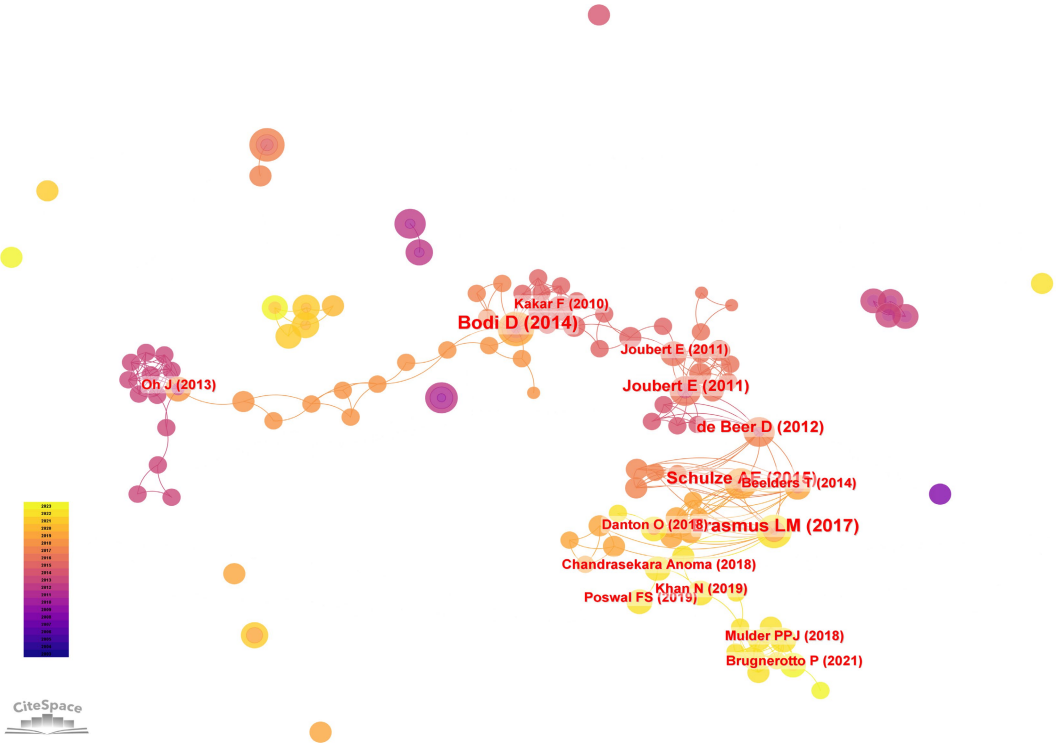

Fig. 4 Author co-citation network map from 2003 to 2023.

Sources of Chinese herbal tea

A total of 107 common Chinese medicinal herbs suitable for preparing herbal teas were identified through a comprehensive literature review (Table 3). These herbs are distributed among 54 different families[6]. The most predominant family is Asteraceae, featuring 12 species, followed by Rutaceae with seven species[42–44]. These plants exhibit four primary growth forms, including herbs, trees, shrubs, and vines. Additionally, fungi are utilized as ingredients in herbal teas[33]. Various parts of Chinese medicinal materials are employed in the production of herbal teas, encompassing leaves, flowers, fruit, seeds, whole plants, subterranean components, aerial parts, and more[45–47]. The most commonly utilized plant component in herbal teas is the subterranean parts, constituting 25.30% (42 species) of Chinese herbal teas. Following this, fruit and/or seeds and leaves are used in 20.48% (34 species) and 19.88% (33 species) of the herbal teas, respectively[48–50]. Interestingly, the flowers of many plants in the Asteraceae family are used as raw materials for herbal tea, as observed in species like *Dendranthema morifolium* and *Arctium lappa*. It's evident that nearly all Chinese herbal teas exhibit two or more pharmacological effects, and there is no distinct pattern. Possibly due to containing multiple active components derived from plants, herbal tea often exerts more than one effect. The primary pharmacological effects encompass attributes such as heart-clearing, detoxification, tonification, heat clearance, and pain alleviation[51–53].

Table 3. 107 common Chinese medicinal herbs for tea making.

No.	Family name	Latin name	Chinese pinyin name for tea	Growth form	Part used for tea	Pharmacology	Ref.
1	Acanthaceae	*Andrographis paniculata*	Chuanxinlian	Herb	Stem, leaf	Clearing away heat, relieveing toxicity, alleviateing edema, alleviateing pain, stopping dysentery	[6]
2	Acanthaceae	*Strobilanthes cusia*	Banlan	herb	Subterranean part, leaf	Clearing away heat, relieveing toxicity, cooling blood, resolving sore throat, hemostasis, clearing liver	[6]
3	Acoraceae	*Acorus calamus var. angustatus Besser*	Shichangpu	Herb	Subterranean part	Promoting digestion, relieveing dampness, dispelling phlegm, refreshing	[6]
4	Amaranthaceae	*Achyranthes bidentata*	Niuxi	Herb	Subterranean part	Activateing blood, tonic, alleviating edema, promoting urination, anti-hypertension	[6]
5	Apiaceae	*Foeniculum vulgare*	Huixiang/ Xiaohuixiang	herb	Fruit and/or seed	Anti-bacterial	[6]
6	Apiaceae	*Saposhnikovia divaricata*	Fangfeng	Herb	Whole plant	Expelling wind-dampness	[6]
7	Apiaceae	*Angelica sinensis*	Danggui	herb	Subterranean part	Tonic, activating blood, regulating menstruation, alleviating pain, promoting digestion	[6]
8	Apiaceae	*Angelica dahurica*	Baizhi	Herb	Subterranean part	Expelling wind-dampness, alleviateing pain	[6]
9	Apocynaceae	*Cynanchum paniculatum*	Xvchangqing	herb	Whole plant	Expelling wind-dampness, activating collaterals	[6]
10	Araceae	*Pinellia ternata*	Banxia	Herb	Subterranean part	Relieveing dampness, dispelling phlegm, relieving vomiting, activaeing collaterals, alleviating edema, alleviateing pain	[6]
11	Araliaceae	*Tetrapanax papyrifer*	Tongcao/ Tongtuomu	shrub	Pith	Refreshing, tonic, clearing away heat, promoting urination	[6]
12	Arecaceae	*Areca catechu*	Binglang	Tree	Fruit and/or seed	Tonic, promoting digestion	[6]
13	Asparagaceae	*Anemarrhena asphodeloides*	Zhimu	Herb	Subterranean part	Tonic	[6]
14	Asparagaceae	*Polygonatum odoratum*	Yvzhu	Herb	Subterranean part	Tonic, relieving thirst	[6]
15	Asparagaceae	*Polygonatum sibiricum*	Huangjing	Herb	Stem, subterranean part	Tonic	[6]
16	Asteraceae	*Chrysanthemum indicum*	Yejv	Herb	Flower, whole plant	Clearing away heat, relieving toxicity, expelling wind-dampness, activating blood, suppressing liver, improving vision, anti-hypertension, anti-inflammation, alleviating pain	[6]
17	Asteraceae	*Stevia rebaudiana*	Tianyejv	herb	Leaf	Substitute for tea	[6]
18	Asteraceae	*Senecio scandens*	Qianliguang	Herb	Whole plant, stem, leaf	Clearing away heat, relieving toxicity, improving vision, stopping diarrhea, stoping dysentery, alleviating pain	[6]
19	Asteraceae	*Arctium lappa*	Niubang	Herb	Subterranean part	Stopping cough, dispelling phlegm	[6]
20	Asteraceae	*Tussilago farfara*	Kuandonghua	Herb	Flower	Astringing lung, dispelling phlegm, stopping cough	[6]
21	Asteraceae	*Dendranthema morifolium*	Jvhua/Jinsi Huangju	Herb	Flower, leaf	Clearing away heat, suppressing liver, improving vision, relieving toxicity, expelling wind-dampness, activating blood, stopping cough, dispelling phlegm, anti-inflammation	[6]
22	Asteraceae	*Artemisia annua*	Huanghuahao/ Kucao	Herb	Whole plant	Clearing away heat, cooling blood	[6]
23	Asteraceae	*Carthamus tinctorius*	Honghua	Herb	Flower	Regulating menstruation, alleviating pain	[6]
24	Asteraceae	*Atractylodes lancea*	Cangzhu	Herb	Subterranean part	Relieveing dampness, expelling wind-dampness, dispersing cold	[6]
25	Asteraceae	*Xanthium strumarium subsp. sibiricum*	Canger	Herb	Fruit and/or seed	Refreshing	[6]
26	Asteraceae	*Atractylodes macrocephala*	Baizhu	Herb	Subterranean part	Tonic, relieving dampness	[6]
27	Asteraceae	*Artemisia argyi*	Aicao	herb	Leaf, aerial part, Subterranean part	Clearing away heat, relieving dampness, stopping cough, regulating menstruation, alleviating pain, hemostasis, activating collaterals, dispersing cold	[6]
28	Burseraceae	*Canarium album*	Ganlan	Tree	Fruit and/or seed	Relieveing dampness, harmonizing stomach, dispelling phlegm, stopping dysentery, clearing away heat, relieving toxicity, relieving thirst, resolving sore throat	[6]

(to be continued)

Table 3. (continued)

No.	Family name	Latin name	Chinese pinyin name for tea	Growth form	Part used for tea	Pharmacology	Ref.
29	Campanulaceae	*Platycodon grandiflorus*	Jiegeng	Herb	Subterranean part	Astringing lung, dispelling phlegm, resolving sore throat, alleviating pain	[6]
30	Campanulaceae	*Adenophora stricta*	Shashen	Herb	Subterranean part	Tonic, astringing lung, clearing away heat, cooling blood, relieving thirst	[6]
31	Campanulaceae	*Codonopsis pilosula*	Dangshen	Herb	Subterranean part	Tonic	[6]
32	Cannabaceae	*Cannabis sativa*	Ma/Dama/ Huoma	Herb	Fruit and/or seed	Tonic, astringing lung, alleviating pain	[6]
33	Caryophyllaceae	*Pseudostellaria heterophylla*	Haiershen/ Taizishen	Herb	Subterranean part	Tonic, promoting digestion, relieving thirst, astringing lung	[6]
34	Convolvulaceae	*Cuscuta chinensis*	Tusizi/Tusi	Herb	Whole plant	Tonic	[6]
35	Cucurbitaceae	*Gynostemma pentaphyllum*	Jiaogulan	Hine	Stem, leaf, whole plant, aerial part	Stopping cough, dispelling phlegm, reducing weight, clearing away heat, relieving toxicity, refreshing, anti-tumor, tonic, promoting sedative, alleviating pain, anti-hyperlipidemic, anti-hypertension	[6]
36	Cucurbitaceae	*Benincasa hispida*	Donggua	Herb	Fruit and/or seed	Promoting digestion, clearing away heat, relieving toxicity, dispelling phlegm	[6]
37	Cupressaceae	*Platycladus orientalis*	Cebai/Baiye	Tree	Leaf	Treat baldness, Hemostasis	[6]
38	Cyperaceae	*Cyperus rotundus*	Xiangfuzi	Herb	Subterranean part	Promoting sedative, regulating menstruation, alleviating pain	[6]
39	Ephedraceae	*Ephedra sinica*	CaomMahuang	Shrub	Fruit and/or seed	Substitute for tea	[6]
40	Eucommiaceae	*Eucommia ulmoides*	Duzhong/ Duzhongye	Tree	Leaf, bark	Tonic, anti-hypertension	[6]
41	Fabaceae	*Sophora flavescens*	Kushen	herb	Subterranean part, stem	Clearing away heat, relieving dampness, expelling parasite	[6]
42	Fabaceae	*Astragalus propinquus*	Huangqi	Herb	Flower, leaf, Subterranean part, stem	Tonic, anti-hypertension	[6]
43	Fabaceae	*Styphnolobium japonicum*	Huaimi/Huaihua	Tree	Flower	Cooling blood, hemostasis, clearing liver	[6]
44	Fabaceae	*Albizia julibrissin*	Hehuan/ Hehuanhua	Tree	Flower	Refreshing promoting sedative	[6]
45	Fabaceae	*Glycyrrhiza uralensis*	Gancao	Herb	Subterranean part, leaf	Clearing away heat, astringing lung, relieving thirst, stopping cough, tonic, dispelling phlegm, alleviating pain, relieving toxicity	[6]
46	Gentianaceae	*Gentiana scabra*	Longdan/ Longdancao	Herb	Subterranean part	Clearing away heat, relieving dampness	[6]
47	Ginkgoaceae	*Ginkgo biloba*	Yinxing/ Yinxingye	Tree	Leaf	Activating blood, anti-hypertension, astringing lung	[6]
48	Juncaceae	*Juncus effusus*	Dengxincao	Herb	Pith, leaf, whole plant	Clearing away heat, relieving toxicity, clearing heart	[6]
49	Lamiaceae	*Perilla frutescens*	Zisu/Zisuye	Herb	Leaf, stem	Clearing away heat, dispersing cold, dispelling phlegm, promoting digestion, stopping cough, relieving vomiting	[6]
50	Lamiaceae	*Nepeta tenuifolia*	LieyejJingjie	Herb	Whole plant	Expelling wind-dampness	[6]
51	Lamiaceae	*Scutellaria baicalensis*	Huangqin	Herb	Stem, leaf, flower, aerial part, whole plant	Clearing away heat, relieving toxicity, hemostasis, anti-inflammation, promoting digestion	[6]
52	Lamiaceae	*Salvia miltiorrhiza*	Danshen	Herb	Subterranean part	Activating blood, promoting sedative	[6]
53	Lamiaceae	*Leonurus japonicus*	DahuayYimucao	Herb	Whole plant, aerial part, leaf	Activating blood, alleviating edema, regulating menstruation, cooling blood, promoting urination	[6]
54	Liliaceae	*Lilium brownii var. viridulum Baker*	Baihe/Baihehua	Herb	Subterranean part	Tonic, astringing lung, refreshing, promoting sedative, stopping cough	[6]
55	Lygodiaceae	*Lygodium japonicum*	Haijinsha/Haijin Shacao	Vine	Subterranean part, flower, whole plant	Stopping cough, curing calculus, clear away heat, relieving dampness, relieving pain	[6]
56	Lythraceae	*Punica granatum*	Shiliu	Shrub	Leaf, fruit and/or seed	Stopping dysentery, promoting digestion, hemostasis	[6]
57	Magnoliaceae	*Magnolia officinalis*	Houpuo	Tree	Flower	Clearing away heat, relieving toxicity	[6]
58	Malvaceae	*Scaphium affine*	Pangdahai	Tree	Fruit and/or seed	Astringing lung, dispelling phlegm, resolving sore throat, promoting digestion	[6]
59	Oleaceae	*Ligustrum lucidum*	Kuding/Nvzhen/ Nvzhenzi	Shrub	Leaf, fruit and/or seed, leaf	Clearing away heat, tonic, improving vision	[6]
60	Oleaceae	*Forsythia suspensa*	Lianqiao	Shrub	Leaf, fruit and/or seed	Clearing away heat, relieving toxicity, anti-inflammation, promoting digestion, alleviating edema	[6]

(to be continued)

Table 3. (continued)

No.	Family name	Latin name	Chinese pinyin name for tea	Growth form	Part used for tea	Pharmacology	Ref.
61	Orchidaceae	*Dendrobium nobile*	Shihu	Herb	Stem, whole plant	Tonic, relieving thirst, promoting sedative, clearing away heat	[6]
62	Oxalidaceae	*Oxalis corniculata*	Cujiangcao	Herb	Whole plant	Alleviating pain, resolving sore throat, stopping diarrhea, clearing away heat, relieving toxicity, relieving dampness, alleviating center	[6]
63	Paeoniaceae	*Paeonia lactiflora*	Shaoyaohua	Herb	Fruit and/or seed, Subterranean part	Clearing away heat, cooling blood, alleviating pain	[6]
64	Paeoniaceae	*Paeonia × suffruticosa Andrews*	Mudanhua	Shrub	Subterranean part	Clearing away heat, cooling blood, activating blood	[6]
65	Paeoniaceae	*Paeonia anomala subsp. veitchii*	Chuanchishao	Herb	Subterranean part	Clearing away heat, cooling blood, hemostasis	[6]
66	Pedaliaceae	*Sesamum indicum*	Zhima	Herb	Fruit and/or seed	Tonic	[6]
67	Plantaginaceae	*Rehmannia glutinosa*	Dihuang	Herb	Subterranean part	Clearing away heat, relieving toxicity, tonic, relieving thirst	[6]
68	Plantaginaceae	*Plantago asiatica*	Cheqian/ Cheqiancao/ Chenqianzi	Herb	Whole plant, leaf, fruit and/or seed	Promoting urination, clearing away heat, improving vision, stopping diarrhea, dispelling phlegm, alleviating edema, resolving sore throat, relieving toxicity, cooling blood, stopping cough, astringing lung	[6]
69	Poaceae	*Coix lacryma-jobi*	Yiyi/Yiren/Yimi	Herb	Whole plant, fruit and/or seed	Cureing calculus, promoting urination, stopping diarrhea, clearing away heat	[6]
70	Poaceae	*Triticum aestivum*	Xiaomai	Herb	Fruit and/or seed	Promoting digestion, alleviating edema	[6]
71	Poaceae	*Phragmites australis*	Luwei/Luweigen	Herb	Subterranean part	Clearing away heat, relieving thirst, relieving vomiting, anti-inflammation, promoting urination, promoting sedative	[6]
72	Poaceae	*Oryza sativa*	Dao	Herb	Fruit and/or seed, Subterranean part, leaf	Promoting digestion	[6]
73	Polygonaceae	*Reynoutria japonica*	Huzhang	Herb	Subterranean part, leaf, stem	Expelling wind-dampness, activating blood, alleviating pain, relieving dampness, dispelling phlegm, stopping cough, clearing away heat, relieving toxicity	[6]
74	Portulacaceae	*Portulaca oleracea*	Machixian	Herb	Leaf, whole plant	Clearing away heat, relieving toxicity, cooling blood, stopping dysentery, alleviating edema, relieving dampness	[6]
75	Ranunculaceae	*Coptis chinensis*	Huanglian	Herb	Subterranean part	Clearing away heat, relieving dampness, relieving toxicity	[6]
76	Ranunculaceae	*Anemone chinensis*	Baitouweng	Herb	Subterranean part	Clearing away heat, relieving toxicity, cooling blood, stopping diarrhea	[6]
77	Rhamnaceae	*Ziziphus jujuba*	Zao/Suanzaoren	Tree	Fruit and/or seed	Tonic, promoting sedative	[6]
78	Rosaceae	*Rosa laevigata*	Jinyingzi	Vine	Fruit and/or seed, Subterranean part	Stopping diarrhea, clearing away heat	[6]
79	Rosaceae	*Sanguisorba officinalis*	Diyv/Diyvye	Herb	Stem, Subterranean part, leaf	Cooling blood, clearing away heat, relieving toxicity, hemostasis, expelling wind-dampness	[6]
80	Rubiaceae	*Gardenia jasminoides*	Zhizi/Zhizihua	Shrub	Fruit and/or seed, flower	Clearing away heat, promoting sedative, promoting urination, cooling blood, relieving toxicity	[6]
81	Rubiaceae	*Oldenlandia diffusa*	Baihuas Sheshecao	Herb	Whole plant	Clearing away heat, relieving toxicity, promoting urination, stopping cough, alleviating edema, activating blood, alleviating pain, resolving sore throat	[6]
82	Rubiaceae	*Morinda officinalis*	Bajitian	Vine	Subterranean part		[6]
83	Rutaceae	*Citrus medica*	Xiangyuan	Shrub	leaf, fruit and/or seed	Refreshing, dispelling phlegm, clearing away heat, stoping cough, anti-asthma	[6]
84	Rutaceae	*Citrus sinensis*	Tiancheng/ Chengzi	Tree	Fruit and/or seed	Dispelling phlegm, promoting digestion, harmonizing stomach, stopping cough, relieving vomiting	[6]
85	Rutaceae	*Citrus × aurantium*	Suancheng/ Zhishi	Tree	Fruit and/or seed, flower	Dispelling phlegm, promoting digestion	[6]
86	Rutaceae	*Phellodendron amurense*	Huangbo	Tree	Bark	Anti-bacteria, anti-virus	[6]
87	Schisandraceae	*Schisandra chinensis*	Wuweizi	Vine	Fruit and/or seed	Tonic, promoting sedative	[6]
88	Scrophulariaceae	*Scrophularia ningpoensis*	Xuanshen	Herb	Subterranean part	Cooling blood, tonic, clearing away heat, relieving toxicity	[6]

(to be continued)

Table 3. (continued)

No.	Family name	Latin name	Chinese pinyin name for tea	Growth form	Part used for tea	Pharmacology	Ref.
89	Selaginellaceae	*Selaginella tamariscina*	Juanbai	Herb	Whole plant	Activating blood, clearing away heat, stopping cough, hemostasis, relieving dampness	[6]
90	Smilacaceae	*Smilax glabra*	Tufuling	Shrub	Subterranean part	Clearing away heat, relieving toxicity, relieving dampness, stopping dysentery	[6]
91	Smilacaceae	*Smilax china*	Baqia	Shrub	Subterranean part, leaf	Relieving thirst, relieving toxicity, expelling wind dampness	[6]
92	Solanaceae	*Lycium barbarum*	NingxiagGouqi	Shrub	Leaf, fruit and/or seed	Tonic, improving vision, clearing away heat, expelling wind-dampness, relieving thirst	[6]
93	Zingiberaceae	*Amomum villosum*	Sharen	Herb	Fruit and/or seed	Relieving dampness, harmonizing stomach, stopping diarrhea	[6]
94	Rutaceae	*Citrus reticulata*	Chenpi/Qingpi/XiaoqingganJv	Tree	Fruit	Reducing diet-induced obesity, hepatic steatosis, dyslipidemia, and insulin resistance	[42,43]
95	Rutaceae	*Citrus maxima*	Youzi	Tree	Fruit	Immune regulation, antioxidant, anti liver cancer	[44]
96	Polyporaceae	*Ganoderma lucidum*	Lingzhi	Fungi	Subterranean part	Anti-bacterial, anti-inflammatory, anti-viral, anti-atherosclerotic, anti-diabetic, anti-cancer activity	[33]
97	Lamiaceae	*Elsholtzia ciliata*	Xiangru	Herb	Branch and leaf	Dispersing cold, promoting urination	[33]
98	Moraceae	*Ficus carica*	Wuhuaguo	Shrub	Fruit	Promoting digestion, anti-virus	[33]
99	Araliaceae	*Panax ginseng*	Renshen	Herb	Subterranean part, flower, leaf	Anti-fatigue, anti-tumor, hypoglycemic, and anti-inflammatory	[45]
100	Caprifoliaceae	*Lonicera japonica*	RendongJinyinhua	Vine	Flower, stem, leaf, whole plant	Clearing away heat, relieving toxicity, anti-inflammation, anti-hypertension, cooling blood, alleviating pain	[6,46]
101	Elaeagnaceae	*Hippophae rhamnoides*	Shaji	Tree	Leaf	Anti-inflammatory, antioxidative, antibacterial, adaptogenic, and tissue regenerative	[47]
102	Poaceae	*Hordeum vulgare*	Damai	Herb	Fruit and/or seed	Promoting digestion, antioxidant, and hypolipidemic	[48]
103	Rosaceae	*Crataegus pinnatifida*	Shanzha	Tree	Leaf, fruit and/or seed	Promoting digestion, anti-hyperlipidemic, activate blood	[49]
104	Oleaceae	*Osmanthus fragrans*	Guihua	Tree	Flower	Protecting stomach and liver, dispersing phlegm, and antioxidant activity	[50]
105	Rosaceae	*Rosa rugosa*	Meigui/Meiguihua	Shrub	Flower, fruit and/or seed	Suppressing liver, promoting sedative, activating blood, alleviating pain	[6,51]
106	Solanaceae	*Lycium chinense*	Gouqi	Shrub	Leaf, fruit and/or seed, Subterranean part, bark	Clearing away heat, cooling blood, improving vision, tonic, relieving toxicity, relieving thirst, expelling wind-dampness	[6,52]

For example, *Lycium chinense*, known as gouqi which is highly popular, has functions such as clearing heat, cooling blood, brightening the eyes, nourishing, detoxifying, quenching thirst, dispelling wind and dehumidifying[53]. *Lonicera japonica* is used to clear heat and detoxify, reduce inflammation, reduce blood pressure, cool blood, and relieve pain[9].

More attention-grabbing herbal teas

Upon reviewing all retrieved articles, it is discovered that in addition to herbal teas like *Cyclopia spp.*, which have garnered significant attention owing to extensive research conducted by a specific group of authors, there are other herbal teas that possess their unique appeal and are found to be the subjects of many studies. One such herbal tea is *Gynostemma pentaphyllum*, a commonly consumed beverage in China. It is renowned for its anti-diabetic properties and immunomodulatory effects[54]. To date, numerous bioactive compounds have been isolated from *Gynostemma pentaphyllum*. However, certain aspects of its composition remain unclear[55,56]. Although *Gynostemma pentaphyllum* is a popular herbal tea in the market, the presence of various varieties and counterfeit products necessitates ongoing research to address these issues. Consequently, relevant studies are still underway[57]. *Artemisia annua*, a traditional herbal tea utilized for the treatment of various infectious diseases, including malaria, boasts a history spanning over 2,000 years[58]. Moreover, since the awarding of the 2015 Nobel Prize in Physiology or Medicine to Youyou Tu, a Chinese pharmacologist credited with the initial isolation of artemisinin[59], an effective antimalarial compound found in *Artemisia annua*, research on this herbal tea has remained a focal point. Scholars have consistently explored its advantages and safety in the context of herbal tea applications[60,61]. *Chrysanthemum morifolium*, a herbal tea with a history of popularity in China spanning approximately 2,000 years[62], has gained a broad following due to its various functions, including heat-clearing, liver-nourishing, eye-brightening, and detoxification properties[63]. The diverse array of *chrysanthemum* varieties has led to varying levels of application and attention. Consequently, research focused on the chemical composition and pharmacological effects of each *chrysanthemum* variety remains ongoing[64]. The popularity of herbal tea naturally draws the attention of scholars for study. The widespread acceptance and significant role of herbal tea contribute to the increased volume of research on this subject. Nevertheless, the number of studies conducted remains comparatively fewer when compared to the myriad of herbal tea varieties that are explored and investigated by established scholars and

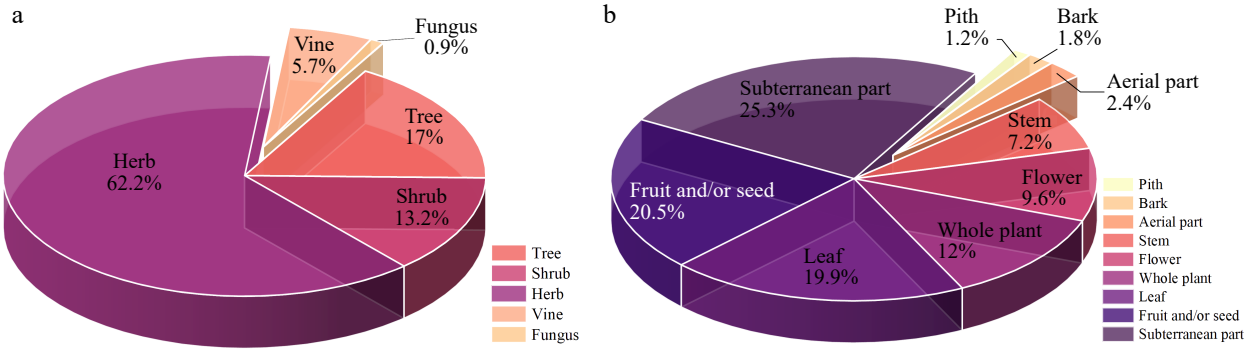

Fig. 5 (a) Parts used in herbal tea and their proportion, (b) plant morphology and proportion of herbal tea.

institutional teams. Consequently, fostering greater collaboration holds substantial importance for the research topics of value within the realm of herbal tea.

Security and regulation of herbal tea

Consuming herbal tea should not be undertaken without caution, as it can potentially lead to adverse reactions, including liver and kidney damage[65]. Furthermore, the presence of chemical contaminants in herbal tea can result in the enrichment of trace elements, which poses health risks. Homemade herbal teas that have not undergone commercial processing may contain toxic or excessive levels of trace elements. The enrichment of these trace elements is influenced by various environmental factors, including soil background values, rainfall, and temperature[66]. Moreover, it's essential to note that even when consumed for health benefits, excessive intake of specific herbal teas can lead to adverse effects. For instance, excessive consumption of *Artemisia argyi* and *Reynoutria japonica* tea may result in symptoms like fainting and vomiting, while excessive intake of *Reynoutria multiflora* may lead to liver toxicity[6]. Additionally, consuming unapproved herbal tea products may pose health risks. Therefore, the use of herbal teas should adhere to established and recognized safe formulations and usage guidelines. There are considerable variations in the regulation of herbal tea across different countries, and according to applicable classification regulations, herbal tea is generally used as a 'supplement' to improve health.

In China, selecting safe herbal teas for consumption can be guided by the Catalogue of Homologous Substances of Medicine and Food, issued by the National Health Commission, accessible through this link (http://www.nhc.gov.cn/). This catalogue comprises substances that serve both as food and Chinese medicinal herbs, and they are defined as 'substances traditionally used for both food and listed in the Pharmacopoeia of the People's Republic of China'. These substances have a traditional history of consumption as food and are subjected to stringent regulation. Based on existing evidence, the substances are generally recognized as safe in China. The quality of herbal tea products available in the market is overseen by the China Food and Drug Administration (CFDA), with all herbal tea products required to adhere to relevant regulations[6].

'Dietary supplements (DS)' is defined by the United States as botanicals, plant concentrates, metabolites, constituents, extracts, or any combination of these products, including herb products. It's regulated by the Federal Food, Drug, and Cosmetic Act and falls under the jurisdiction of the US Food and Drug Administration (FDA). There are two categories of DS, the first one includes the ingredients that were developed before October 15, 1994. These ingredients have a history of safe use or are listed as Generally Recognized as Safe (GRAS), and are presumed to be safe and grandfathered in by the Dietary Supplement Health and Education Act (DSHEA). The American Herbal Products Association (AHPA) maintains a subscription-based New Dietary Ingredient (NDI) database for herbs, which contains a partial list of acceptable NDIs. The association has documented more than 800 NDIs submitted to the FDA. The second category of DS ingredients did not exist in the market before October 15, 1994, and must adhere to the FDA's NDI submission regulations. Manufacturers must submit NDI notifications to the FDA before marketing their products and provide information that demonstrates safety. Submission of an NDI to the FDA does not guarantee its approval. If the ingredient is synthetic or lacks safety data, it is considered adulterated[67]. Aftermarket surveillance serves as a regulatory mechanism for ensuring product safety. To obtain reliable information, users may conveniently access the websites of the Office of Dietary Supplements website (www.ods.nih) and the National Center for Complementary and Integrative Health (NCCIH) website (www.nccih.factsheets)[68].

In Japan, one of the countries where herbal products are highly popular, foods are categorized as either general foods or foods with health claims. The latter category includes Foods with Nutrient Function Claims (FNFC) consisting mainly of vitamins and minerals, Foods for Specified Health Uses (FOSHU), and Foods with Functional Claims (FFC). These categories are regulated under different pathways. In terms of herbal teas, they may adhere to the FOSHU system, mandating details regarding dietetic use and health benefits in their labels, necessitating review and approval from Japan's Consumer Affairs Agency (CAA) before they are allowed to enter the market. A less stringent alternative, FFC, was introduced in 2015, encompassing functional foods that rely on self-reported data supporting safety and efficacy provided to CAA, leaving the responsibility up to the manufacturer[69,70].

In the European Union (EU), the term 'supplements' refers to products that are regulated centrally as food items, as defined in Directive 2002/46/EC (EU Commission). Member states have the right to be informed about the introduction of food supplements within their territory to enable competent authority oversight[69]. The EU has created a regulatory framework for herbal products (HMPs). The European Union monograph, established by the Committee on Herbal Medicinal Products (HMPC), succeeded the Community Herbal monograph. This

committee is one of the scientific committees of the European Medicines Agency (EMA), established according to the Directive 2004/24/EC. The HMPC is in charge of creating an EU monograph for mature and traditional use HMP and making a list of herbal substances and preparations for traditional use HMP after scientifically evaluating existing safety and efficacy data. The recent documents of the HMPC show a good agreement between their assessment work and the evaluation of the applications of HMPs in Member States. All the guidance documents and monographs developed by HMPC have been recommended and accepted by the pharmaceutical industry and national drug regulatory agencies[71]. The EU monograph is a powerful recommendation or carries legal weight in member states. Together with the European Pharmacopoeia, which outlines the basic quality requirements for HMPs, it creates a comprehensive system for regulating these products. This system is an excellent example of multi-country coordination in the regulatory environment for herbal and traditional medicines[72].

South Africa boasts unique herbal tea products like rooibos, which has recently been granted international protected status as an African food by the EU and is widely consumed worldwide, subject to global food safety standards and established standards. However, local regulatory constraints on herbal tea in South Africa remain inadequate[73]. More research and regulations currently exist for quality, commercialization, and biodiversity protection, rather than safety, with limited and outdated information available[74,75].

Conclusions

Herbal tea, characterized by its extensive historical use and diverse applications, is progressively revealing its potential through modern research interpretation. Bibliometrics, employing statistical techniques for the analysis of published data, serves as a valuable tool for measuring and assessing scholarly information output. It finds applications in in-depth analysis, mapping, and data visualization across various disciplines[76]. One notable advantage of employing bibliometric techniques is their capacity to distill a substantial body of literature and unearth fresh opportunities for research and development by delving into existing scholarship. The outcomes of such research can effectively showcase the prevailing research focal points within a given field, quantifying the results obtained. It furnishes a means to recognize and elucidate trends and challenges prevalent in the literature[77]. Through bibliometric analysis, researchers can gain deeper insights into the knowledge structure, evolution, and current hotspots within the field of herbal tea. This method enables the identification of potential collaborative opportunities, serving as an invaluable tool for comprehending the overall trajectory and the latest research frontiers. Defining the academic domain of 'herbal tea' using search queries can pose certain challenges, and there might be biases arising from instances where the article title, abstract, or keywords fail to include the subject term. Such subjectivity should be acknowledged. Hence, it's crucial to remain mindful of the presence of noise in the results of bibliometric analysis, as these results may not always precisely mirror the ground reality, necessitating careful consideration[78].

In this study, we conducted a comprehensive search for herbal tea-related documents spanning from 2000 to 2023 in the WOS database and employed CiteSpace for analysis. Our objective was to discern emerging trends and recent developments in the realm of herbal tea. Our trend analysis of all the published literature unveiled an overarching upward trajectory marked by fluctuations. Key contributors to this field emanate from China, the United States, Europe, and various other countries and regions. Notably, Chinese institutions are the principal contributors; however, it is the research team led by Joubert E from South Africa that has exhibited the highest activity. This analysis underscores the pivotal role played by authors and institutional teams in advancing research. For other scholars with a vested interest in the field but possessing lesser research impact, it is clear that bolstering collaborative efforts can propel their research endeavors forward. Research in the field of herbal tea is primarily centered around pharmacological activities, safety, and nutritional aspects. Recent research trends indicate a burgeoning interest in the chemical composition of herbal tea, with a particular emphasis on fruit tea. Furthermore, this study has collated information on the various forms of herbal tea and the plant parts used in their preparation, elucidating key patterns and guidelines to serve as a precise reference for further research.

Herbal tea, a highly beneficial and healthful beverage, is replete with diverse bioactive components, with phenols garnering the most attention. Herbal tea exhibits significant pharmacological effects, particularly as potent antioxidants and anti-inflammatory agents, making it a valuable tool in the prevention and treatment of various chronic diseases. Despite its demonstrated health benefits, international attention to herbal tea remains insufficient, and there's a dearth of comprehensive research and evaluation. While the pharmacological effects and chemical components of herbal tea have garnered substantial attention, enhanced collaboration is essential to facilitate more efficient progress in this field. Due to the complexity of its raw materials sourced from plants, the health benefits of herbal tea remain understudied despite the numerous varieties used in its production. As advances in chemical component research continue, the mechanisms behind the functionality and utilization patterns of herbal tea merit greater investigation by scholars in the field to address knowledge gaps. Safety considerations for herbal tea represent an increasingly important aspect of research. The inappropriate application of herbal tea has been linked to issues such as liver and kidney damage, highlighting the need for safer methods of utilization. Due to the lack of specialized regulations for herbal tea at the national level, scholars around the world are encouraged to focus on this area, conduct related research and propose regulatory recommendations to strengthen the safety assurance system for herbal tea. Especially in the context of its usage as a drinkable food item, responsible regulation should be researched, proposed, and improved. A comprehensive examination of the safety aspects can further expand the application of herbal tea, making it a valuable dietary inclusion that offers not only health benefits but also a safe, effective, affordable, and convenient herbal tea experience that bridges the gap between medicine and food. This is a promising avenue for the wider adoption of herbal tea globally.

Author contributions

The authors confirm contribution to the paper as follows: data curation: Kong W; formal analysis: Kong W, Jiang L, Xu J;

investigation & visualization: Kong W, Jiang L; Writing - original draft: Kong W, Jiang L; conceptualization, funding acquisition, project administration, writing - review & editing: Cui Q, Liu J; supervision: Cui Q, Yuan Q, Liu J; methodology: Kong W; software: Kong W, Xu J; visualization: Xu J, Liu J. All authors reviewed the results and approved the final version of the manuscript.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Conflict of interest

The authors declare that they have no conflict of interest.

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