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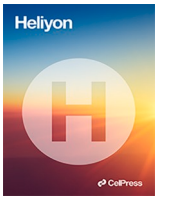

Review article

Exploring the impact of coffee consumption on liver health: A comprehensive bibliometric analysis

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ABSTRACT

The study indicates that while research has demonstrated the potential of coffee to mitigate liver damage, a comprehensive quantitative analysis of its effects has yet to be conducted. This study seeks to explore the current landscape and focal points of research on coffee consumption's impact on the liver from 2013 to 2023. Articles published within this timeframe were retrieved from the Web of Science database and subjected to analysis using R software, VOSviewer, and CiteSpace software. A total of 1106 articles primarily focused on coffee's impact on liver health were analyzed. The frequency of publication exhibited a significant increase from 2013 to 2023. The United States emerged as the leading contributor in publications and international collaborations, particularly with institutions such as Harvard Medical School and Harvard T.H. Chan School of Public Health. Noteworthy journals in this domain included "Nutrients" and "Hepatology" Commonly occurring keywords encompassed components, chlorogenic acids, oxidative stress, and liver. The study highlighted coffee's potential benefits in preventing cardiovascular and liver diseases, attributed to mechanisms such as antioxidant activity and modulation of hepatic cells. Through bibliometric analysis, this study offers valuable insights into the research status and emphasis on coffee's effects on liver health, serving as a significant reference for future investigations in this area.

1. Introduction

Liver, a crucial organ in the human body, is involved in important physiological processes like metabolism, nutrient storage, detoxification, blood volume regulation, immune system support, and maintenance of lipid and cholesterol homeostasis [1,2] Liver health is vital for overall physiological functioning, and we should pay attention to liver protection and prevention of liver diseases [3]. Liver conditions, including hepatitis B virus (HBV) and Hepatitis C virus (HCV) infections, autoimmune liver disease (ALD), nonalcoholic fatty liver disease (NAFLD), cirrhosis, liver failure, and hepatocellular carcinoma (HCC) [4], poses a huge threat to global

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health [5]. Among them, hepatitis and cirrhosis are highly prevalent disease in the Chinese population, and liver cancer is the second leading cause of cancer death in China [6,7]. Coffee, a beverage with globally leading sales, has been demonstrated in recent studies to exhibit significant bioactive effects beneficial to human health, particularly in the context of liver health [8]. Studies suggests that coffee has anti-fibrotic properties [9], enhances glutathione synthesis [10], and affects angiogenesis and liver hemodynamics [11]. Recent studies also have shown that moderate coffee consumption may be effective in preventing various liver diseases and reducing the incidence, including fatty liver, liver fibrosis, and HCC, *ect* [7,9,12–14]. However, research on the effects of coffee on liver health has some shortcomings that cannot be ignored. Many studies have relatively small sample sizes and participants often come from specific geographical locations or demographics, limiting the universality and extrapolation of the results [15]. In addition, although existing research suggests that coffee may protect the liver through multiple mechanisms, such as reducing liver cell damage, anti-inflammatory, and antioxidant effects, the specific pathways of these mechanisms still need further investigation to be elucidated. Bibliometric analysis enables the identification of historical trends, current hotspots, and potential future directions in the research concerning coffee and liver health. This facilitates the uncovering of topics within this field that have been extensively explored as well as those that remain insufficiently investigated. Such insights are particularly crucial for understanding the scientific contributions and practical application value of research into the effects of coffee on liver health.

Bibliometric analysis, as defined by Pritchard (1969), involves the "use of mathematical and statistical methods in the study of books and other means of communication". This definition was further elaborated by Hawkins (2001), who described it as the "quantitative evaluation of bibliographic elements" [16]. This method is increasingly utilized across various disciplines to swiftly discern cutting-edge research and emerging trends in diverse fields. Two main advantages of bibliometric analysis are its domain independence and comprehensive examination of publications[17]. Descriptive bibliometrics is typically employed to analyze the spatial and productivity characteristics of published material libraries, while bibliometric mapping visualizes the structure and mode of literature production in the form of scientific landscapes[18]. However, despite the increasing volume of scholarly articles on the topic, there is currently a lack of exhaustive bibliometric studies examining the relationship between coffee consumption and liver health. As a result, a comprehensive understanding of the overarching trends, primary research foci, and the trajectory of knowledge evolution in this domain remains elusive.

This study sets out to perform a comprehensive bibliometric analysis on the body of literature concerning the relationship between coffee and liver health, leveraging analytical tools such as R software, VOSviewer, and CiteSpace. The goal is to examine the evolution of research hotspots pertaining to coffee and liver health from 2013 to 2023, uncover potential avenues for future investigation, and deepen our understanding of the current knowledge and possibilities of using coffee in the prevention of liver diseases. This endeavor is essential for the sustainable advancement of this research area. By mapping out the landscape of existing studies, highlighting trends, gaps, and connections within the literature, we aim to elucidate the role of coffee consumption in liver health more clearly. Ultimately, this research is expected to contribute positively toward the development of coffee as a preventive measure against liver diseases, offering new insights and directions for healthcare research and dietary recommendations.

2. Materials and methods

2.1. Data collection

The data used in this study were retrieved and downloaded from WoS (Guilin Medical College Edition) on July 20, 2023. The search formula is ((((TS=(Caffeine OR coffee)) AND TS=(Hepatic OR Hepatocyte OR liver OR Hepatology)) AND DT=(Article OR Review)) AND LA=(English)) AND DOP=(2013-01-01/2023-07-20). Duplicate documents were removed, and the remaining retrieved articles were saved in plain text format and their cited references were exported as complete records.

2.2. Data analysis

For the analysis of annual publication trends, Origin 2018 software was utilized. The analysis and visualization of bibliometric data were conducted using R software (version 3.6.3) with the bibliometrix package (version 4.0)[19], VOSviewer (version 1.6.17) [20], and CiteSpace (version 6.1.4) [21]. These tools were selected to ensure the accuracy and reliability of data extraction and analytical processes.

VOSviewer was employed for creating visualizations such as co-authorship networks of countries and institutions, co-citation analysis, and keyword co-occurrence networks. Specific criteria were applied for these analyses: a minimum of 5 documents for a country and 6 for an organization were required for inclusion in the co-authorship network analysis. For co-citation analysis, only sources cited at least 42 times were considered. In keyword co-occurrence analysis, keywords needed to appear in at least 5 documents to be included, with the terms "coffee" and "liver" being deliberately excluded from this analysis. The Journal Impact Factor (IF) data was sourced from the 2022 Journal Citation Reports (JCR).

3. Results

3.1. Overview of the research literature production on coffee and liver

After conducting a search in the WoS database, we identified a total of 1106 publications related to coffee consumption and liver health. The trend in publications over time, as illustrated in Fig. 1A, shows a clear increase in research interest in this area. Between

2012 and 2016, there was a steady growth in the number of publications, establishing a solid base for future studies. Despite a minor drop in publications in 2017 and 2018, the period from 2019 to 2023 saw a resurgence in research activity, peaking with 128 publications in 2022. This indicates a continuing interest and investigation into the topic, culminating in 1106 publications by July 2022.

An analysis based on the country of the corresponding authors' affiliations revealed that China (216 publications) led in research output, followed by the United States (153), South Korea (215), Japan (76), and Brazil (71). The United States, notably, had a higher rate of international co-authorship (31.4 %) than China (17.1 %) and South Korea (5.3 %), indicating a broader international collaboration network, as shown in Fig. 1B and Table 1.

Fig. 2A visually represents the extensive international collaboration network led by the United States in studying the effects of coffee on liver health. The collaboration network maps further highlight Udice-French Research Universities (184 collaborations) and Universite Paris Cite (93 collaborations) as key nodes of research cooperation (Fig. 2B–Table 2). The significant role of these institutions emphasizes the value of academic partnerships in advancing research on coffee consumption and liver health. Additionally, the leading funding bodies for this research area include Udice-French Research Universities, Universite Paris Cite, Assistance Publique Hopitaux Paris (APHP), Harvard University, the French National Institute of Health and Medical Research (Inserm), and Sorbonne Universite, with the most substantial funding support originating from the United States.

Funding project analysis helps identify research trends, assess the influence of funding agencies, guide research investment, promote international cooperation, enhance research transparency, and support policy making. In this study, we analyzed the 20 agencies that fund the most coffee and liver research. As showed in Table 3, the National Natural Science Foundation of China (NSFC) leads with the highest record count of 105, indicating a significant investment in research within China. Following closely are the United States Department of Health and Human Services (89 records) and the National Institutes of Health (NIH) in the USA (85 records), highlighting the substantial contribution of these agencies to scientific endeavors, particularly in health-related fields. In summary, the analysis underscores the global landscape of research funding, with diverse agencies from different countries and regions playing crucial roles in supporting scientific endeavors across various disciplines. Such insights provide valuable information for policymakers, researchers, and stakeholders in understanding the dynamics of research funding and collaboration on a global scale.

3.2. Journals and co-cited journals

The analysis of journals with the highest publication output and citations in the field was conducted using the Bibliometrix and ggplot2 packages in R software (version 3.6.3). As shown in Table 4 and Fig. 3A, "Nutrients" (n = 57, IF = 5.90), "Xenobiotica" (n = 19, IF = 1.80), "Plos One" (n = 17, IF = 3.70), and "Scientific Reports" (n = 17, IF = 4.60) emerged as the top journals in terms of the number of published articles. On the other hand, the journal with the highest citations is "Hepatology" (n = 1793, IF = 13.50), followed by "Journal of Hepatology" (n = 1064, IF = 25.70), "Journal of Agricultural and Food Chemistry" (n = 1012, IF = 6.10), "British Journal of Nutrition" (n = 929, IF = 3.60), and "Gastroenterology" (n = 927, IF = 29.40) (Table 5, Fig. 3B). These findings indicate that while some journals publish a larger volume of articles, others have a greater scholarly impact, as evidenced by citation counts.

For co-cited journal analysis, VOSviewer (version 1.6.17) was employed, revealing a total of 1106 documents published across 510 academic journals. The network analysis of co-citation patterns, depicted in Fig. 4, highlights "Hepatology" and "Journal of Hepatology" as central collaborative hubs. The identification of these journals as central collaborative hubs underscores their pivotal role in shaping the discourse and direction of research on coffee consumption and liver health. However, it's evident from current observations that there is a lack of articles in top-tier journals concerning relevant research on coffee and liver disease. This emphasizes the need to prioritize the depth and quality of research in this crucial area.

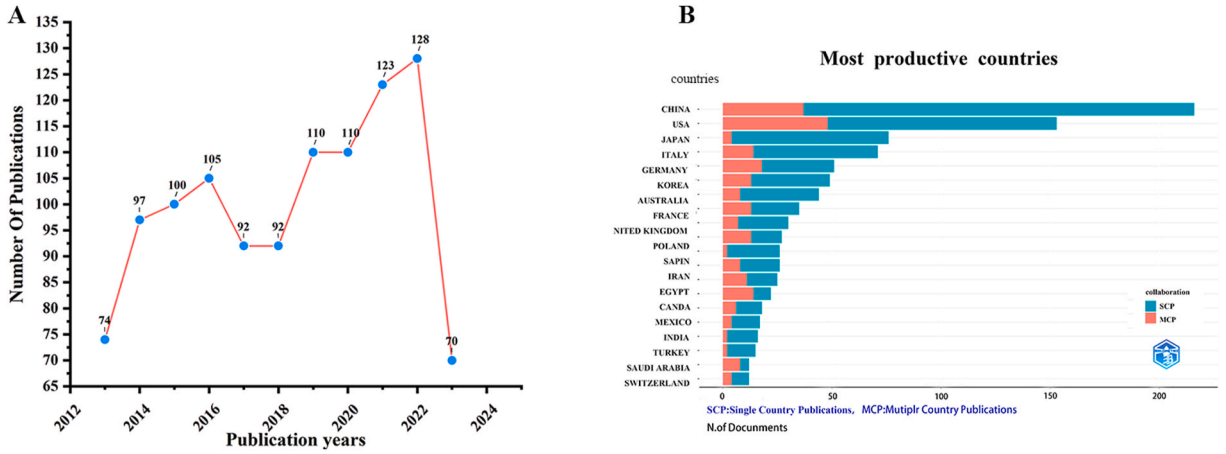

Fig. 1. Trends in annual publication outputs for coffee and liver research from 2013 to 2023. (A) Trends of annual publication outputs. (B) Distribution of corresponding authors' countries and cooperation.

Table 1
Most relevant countries by corresponding authors in coffee and liver research.

Country	Articles	SCP	MCP	Freq	MCP_Ratio
China	216	179	37	0.195	0.171
USA	153	105	48	0.138	0.314
Japan	76	72	4	0.069	0.053
Brazil	71	57	14	0.064	0.197
Italy	51	33	18	0.046	0.353
Germany	49	36	13	0.044	0.265
Korea	44	36	8	0.04	0.182
Australia	35	22	13	0.032	0.371
France	30	23	7	0.027	0.233
United Kingdom	27	14	13	0.024	0.481
Poland	26	24	2	0.024	0.077
Spain	26	18	8	0.024	0.308
Iran	25	14	11	0.023	0.44
Egypt	22	8	14	0.02	0.636
Canada	18	12	6	0.016	0.333
Mexico	17	13	4	0.015	0.235
India	16	14	2	0.014	0.125
Turkey	15	13	2	0.014	0.133
Saudi Arabia	12	4	8	0.011	0.667
Switzerland	12	8	4	0.011	0.333
Romania	10	7	3	0.009	0.3
Thailand	10	9	1	0.009	0.1
Denmark	9	7	2	0.008	0.222
Finland	9	7	2	0.008	0.222
Netherlands	9	7	2	0.008	0.222

Note: SCP: Single Country Publications, MCP: Multiple Country Publications, MCP_Ratio = MCP/Articles.

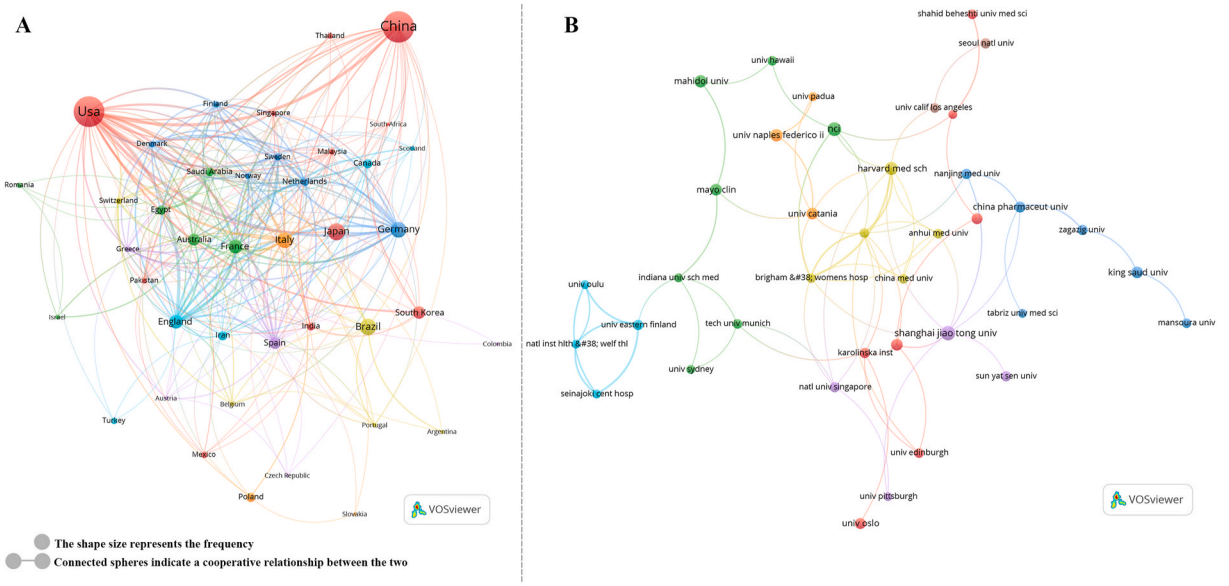

Fig. 2. Map of countries/regions and institutions for coffee and liver research from 2013 to 2023. (A) Map of cooperation between different countries. (B) Map of cooperation between different institutions.

3.3. Most cited references and reference burst

We utilized the bibliometrix package within the R software framework to ascertain the top 20 most cited references in the domain of coffee's preventive role in liver disease (Table 6). Our analysis reveals that these references have garnered citation counts exceeding 170 instances and span across 22 distinct journals, indicating a notable lack of substantial breakthroughs within this field. It is noteworthy that no dominant journal emerges within the list of the top 20 most cited references. Specifically, the top three highly cited references are "The Global Burden of Liver Disease: The Major Impact of China", "Chlorogenic Acid (CGA): A Pharmacological Review and Call for further research", and "Global Epidemiology of hepatocellular carcinoma: an emphasis on demographic and regional

Table 2
Most relevant affiliations in coffee and liver research.

Affiliation	Articles(n)
Udice-French Research Universities	184
Universite Paris Cite	93
Assistance Publique Hopitaux Paris (Aphp)	85
Harvard University	68
Institut National De La Sante Et De La Recherche Medicale (Inserm)	65
Sorbonne Universite	59
Egyptian Knowledge Bank (Ekb)	51
Hopital Universitaire Hotel-Dieu - Aphp	46
Hopital Universitaire Paul-Brousse - Aphp	43
Helmholtz Association	35
Hopital Universitaire Cochin - Aphp	35
Hopital Universitaire Saint-Antoine - Aphp	32
National Institutes Of Health (Nih) - Usa	32
Hopital Universitaire Saint-Louis - Aphp	30
University Of California System	28
Nih National Cancer Institute (Nci)	27
Aix-Marseille Universite	24
Harvard T.H. Chan School Of Public Health	24
Harvard Medical School	22
Universite De Bordeaux	22
Erasmus Mc	20
University Of Naples Federico Ii	20
Imperial College London	19
Shanghai Jiao Tong University	19
University Of Toronto	19

Table 3
The top 20 funding agencies in the field of coffee and liver research.

Funding Agencies	Record Count
National Natural Science Foundation of China Nsfc	105
United States Department of Health Human Services	89
National Institutes of Health Nih Usa	85
Conselho Nacional De Desenvolvimento Cientifico E Tecnologico Cnpq	44
Ministry of Education Culture Sports Science and Technology Japan Mext	44
Coordenacao De Aperfeicoamento De Pessoal De Nivel Superior Capes	39
Japan Society for The Promotion of Science	36
Grants In Aid for Scientific Research Kakenhi	35
European Union Eu	30
Spanish Government	23
Nih National Cancer Institute Nci	19
Fundacao De Amparo A Pesquisa Do Estado De Sao Paulo Fapesp	17
Nih National Institute of Diabetes Digestive Kidney Diseases Niddk	16
National Key Research and Development Program of China	15
Uk Research Innovation Ukri	14
German Research Foundation Dfg	13
Medical Research Council Uk Mrc	13
Federal Ministry of Education Research Bmbf	12
Agence Nationale De La Recherche Anr	11
Consejo Nacional De Ciencia Y Tecnologia Conacyt	11

variability". Nevertheless, upon meticulous examination, we observe that these references predominantly concentrate on delineating the global burden of liver diseases and elucidating the potential mechanisms underlying coffee's preventive effect on liver ailments. It is imperative to emphasize that these references do not delve extensively into the intricate mechanisms through which coffee exerts its preventive influence in the context of liver disease.

To identify prominent citation burst patterns in the realm of coffee's preventive role against liver disease, we employed CiteSpace (criteria: top 25; state count: 2; minimum duration: 2). Several citations were generated, 25 of which are shown in Fig. 5, among them shown that " Association of coffee and caffeine consumption with fatty liver disease, nonalcoholic steatohepatitis, and degree of hepatic fibrosis (strength: 12.89)", "Increased caffeine consumption is associated with reduced hepatic fibrosis (strength: 10.62)", and "Coffee consumption and health: umbrella review of meta-analyses of multiple health outcomes (strength: 9.96)" were emerged as the three most dynamically cited references. Notably, the titles of the three cutting-edge citation burst publications are "Coffee prevents fatty liver disease induced by a high-fat diet by modulating pathways of the gut–liver axis" and "The effect of coffee consumption on the non-alcoholic fatty liver disease and liver fibrosis: A meta-analysis of 11 epidemiological studies".

To gain deeper insights into the research frontiers and hotspots concerning coffee's preventive role in liver disease, we correlated

Table 4
Top 10 journals with the most published articles.

Journal	Documents	IF (2022)	Cites
NUTRIENTS	57	5.9	710
XENOBIOTICA	19	1.8	225
PLOS ONE	17	3.7	828
SCIENTIFIC REPORTS	17	4.6	0
INTERNATIONAL JOURNAL OF MOLECULAR SCIENCES	15	5.6	0
FOOD & FUNCTION	14	6.1	1
JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY	12	6.1	0
MOLECULES	12	4.6	234
LIVER INTERNATIONAL	11	6.7	0
BIOMEDICINE & PHARMACOTHERAPY	10	7.5	0

Note: IF: Impact Factor.

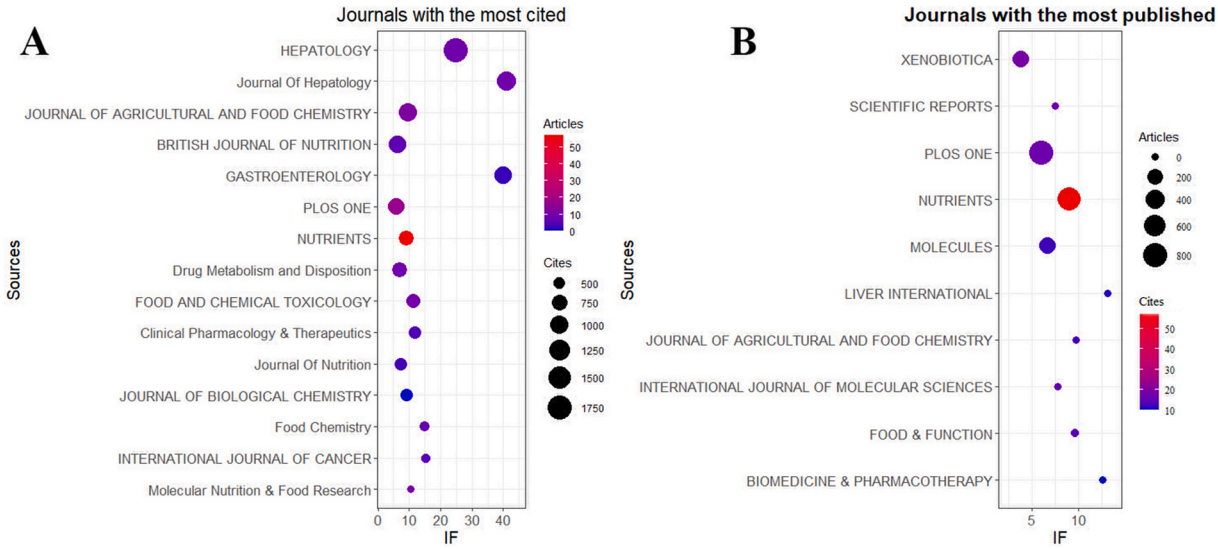

Fig. 3. Journal with the largest number of articles published and the journal with the largest number of citations. (A) Journal with the largest number of articles published. (B) Journals with the largest number of citations.

Table 5
Top 10 journals with the most cited journals.

Journal	Cites	IF (2022)	Document
HEPATOLOGY	1793	13.5	9
Journal Of Hepatology	1064	25.7	9
JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY	1012	6.1	12
BRITISH JOURNAL OF NUTRITION	929	3.6	6
GASTROENTEROLOGY	927	29.4	2
PLOS ONE	828	3.7	17
NUTRIENTS	710	5.9	57
Drug Metabolism and Disposition	692	3.9	9
FOOD AND CHEMICAL TOXICOLOGY	652	4.3	10
Clinical Pharmacology & Therapeutics	542	6.7	4
Journal Of Nutrition	536	4.2	3
JOURNAL OF BIOLOGICAL CHEMISTRY	529	4.8	0
Food Chemistry	469	8.8	7
INTERNATIONAL JOURNAL OF CANCER	444	6.4	5
Molecular Nutrition & Food Research	440	5.2	10

Note: IF: Impact Factor.

the digital object identifiers (DOIs) of the 25 citations in Fig. 5 with the titles in **Annex 1** Among these citations. "Effects of Coffee and Caffeine on Liver Diseases" comprised the largest proportion (60.98 %), followed by literature on "Relationship Between Coffee and Liver Cancer" (31.71 %). The dominance of these areas in the research citations reflects their importance as current research frontiers

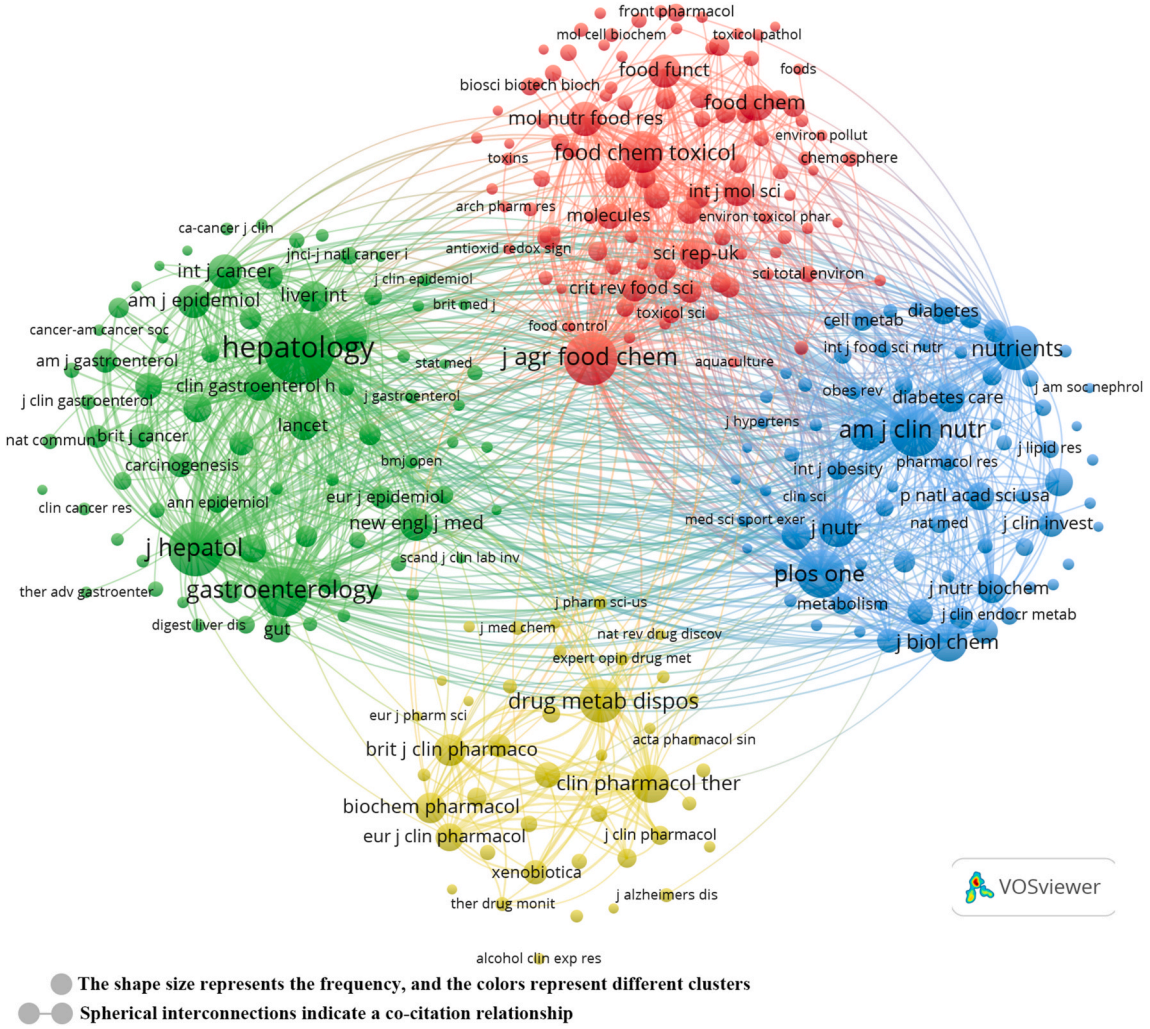

Fig. 4. Co-cited journals involved in coffee and liver research.

and hotspots. The emphasis on both general liver diseases and liver cancer specifically indicates a broad interest in the protective roles of coffee and caffeine against a spectrum of liver-related health issues. The high proportion of literature in these areas suggests that they are key topics of interest and debate in the scientific community, likely due to the global prevalence of liver diseases and liver cancer, and the widespread consumption of coffee. Although there has been progress in the study of coffee and liver disease, further research needed to elucidate the exact mechanism. In summary, this field of study offers significant scientific support for understanding the preventive role of coffee in liver disease, and in recent years, it has emerged as a prominent and vital research topic.

3.4. Keyword clusters and evolution

In the realm of academic inquiry, keyword clusters emerge as a pivotal methodology for delineating prevalent research orientations and developmental trajectories within a specified scholarly domain. This investigation identified an aggregation of 5442 keywords via the application of the VOSviewer analytical tool. As delineated in Table 7, the preeminent 20 keywords manifested a frequency surpassing 51 instances. Paramount among these were terms such as 'risk' (n = 165), 'oxidative stress' (n = 113), 'consumption' (n = 110), 'coffee consumption' (n = 103), 'liver' (n = 94), 'insulin resistance' (n = 87), and 'metabolism' (n = 87).

Subsequently, a subset comprising 201 keywords was meticulously selected, adhering to the criterion of a 'minimum keyword occurrence ≥8' (Fig. 6). This subset constituted the foundation for the construction of visual representations of keyword clustering, as illustrated in Fig. 6. The resultant visual schema revealed five distinct clusters, each demarcated by a unique chromatic scheme. Notably, the cluster focusing on caffeine and liver metabolism by red dots, encompassed 59 keywords, encompassing terms such as 'caffeine', 'cyp1a2', 'drug-metabolism', 'metabolism', and 'inhibition'. The cluster addressing coffee and liver health, represented by green dots, comprised 58 keywords including 'liver-disease', 'fatty liver-disease', 'genome-wide association'. The cluster pertaining to coffee and liver health caffeine Intake and liver diseases, marked by blue dots, included 45 keywords such as 'cirrhosis', 'chronic

Table 6
Top 20 cited references related to the coffee and liver research.

Paper	DOI	Total Citations	TC per Year
WANG FS, 2014, HEPATOLOGY	10.1002/hep.27406	817	81.70
NAVEED M, 2018, BIOMED PHARMACOTHER	10.1016/j.biopha.2017.10.064	655	109.17
MCGLYNN KA, 2015, CLIN LIVER DIS	10.1016/j.cld.2015.01.001	548	60.89
SINGAL AG, 2020, J HEPATOL	10.1016/j.jhep.2019.08.025	454	113.50
BOSETTI C, 2014, BEST PRACT RES CL GA	10.1016/j.bpg.2014.08.007	408	40.80
POOLE R, 2017, BMJ-BRIT MED J	10.1136/bmj.j5024	401	57.29
SINGAL AG, 2015, CLIN GASTROENTEROL H	10.1016/j.cgh.2015.08.014	367	40.78
TAJIK N, 2017, EUR J NUTR	10.1007/s00394-017-1379-1	365	52.14
MENG SX, 2013, EVID-BASED COMPL ALT	10.1155/2013/801457	333	30.27
KIM Y, 2016, NUTRIENTS	10.3390/nu8010017	274	34.25
GROSSO G, 2017, ANNU REV NUTR	10.1146/annurev-nutr-071816-064941	272	38.86
ONG KW, 2013, BIOCHEM PHARMACOL	10.1016/j.bcp.2013.02.008	259	23.55
LAZARIDIS KN, 2016, NEW ENGL J MED	10.1056/NEJMra1506330	259	32.38
LIANG NJ, 2014, MOLECULES	10.3390/molecules191119180	254	25.40
SINHA RA, 2014, HEPATOLOGY	10.1002/hep.26667	235	23.50
YANG CS, 2016, MOL NUTR FOOD RES	10.1002/mnfr.201500428	227	28.38
DI LORENZO C, 2021, NUTRIENTS	10.3390/nu13010273	226	75.33
SINGH S, 2014, NAT REV GASTRO HEPAT	10.1038/nrgastro.2013.143	224	22.40
RINELLA ME, 2016, NAT REV GASTRO HEPAT	10.1038/nrgastro.2016.3	223	27.88
NEHLIG A, 2018, PHARMACOL REV	10.1124/pr.117.014407	214	35.67
CANO-MARQUINA A, 2013, MATURITAS	10.1016/j.maturitas.2013.02.002	201	18.27
SHI HT, 2013, TOXICOLOGY	10.1016/j.tox.2012.10.025	183	16.64
SALOMONE F, 2016, LIVER INT	10.1111/liv.12975	175	21.88
SIM SC, 2013, PHARMACOGENOMICS J	10.1038/tpj.2012.45	175	15.91
CORNELIS MC, 2015, MOL PSYCHIATR	10.1038/mp.2014.107	172	19.11

Note: DOI: Digital Object Identifier.

hepatitis', 'cancer risk'. The cluster concerning protective ingredients and mechanisms of action in coffee, indicated by yellow dots, incorporated 29 keywords, including 'antioxidant activity', 'chlorogenic acid', 'induced oxidative stress', 'NF-kappa-b' and 'phenolic-compounds'. Lastly, the cluster related to liver fibrosis and treatment, highlighted with purple dots, contained a total of seven keywords, namely 'fibrosis', 'pathogenesis', and 'therapy' so on (**Annex 2**).

Furthermore, the study employed the bibliometrix package within the R software environment for the generation of a trend topics graph (Fig. 7). A meticulous analysis of the trend topics graph, as depicted in Fig. 7, permitted the tracing of developmental stages and the dynamic shifts in research focus concerning coffee's role in liver health and the prevention of liver diseases. Our findings suggest an initial research emphasis on the chemical constituents of coffee and consumption patterns commencing from the year 2013, subsequently evolving towards explorations of the interrelationships between specific coffee components, their consumption, and corresponding diseases, alongside the mechanisms underpinning these associations.

In a broader perspective, our exploration of keyword clusters and their temporal evolution intimates that significant research avenues pertaining to coffee's preventive role in liver disease predominantly orbit around elucidating the intricate nexus between coffee and its constituents in relation to human health. This focal point primarily encompasses strategies aimed at mitigating risks linked to chronic diseases, modulating cellular proliferation pathways, and augmenting antioxidative capacities. These thematic cores intersect at the convergence of nutritional science, disease prevention methodologies, and cellular biology.

4. Discussion

4.1. General information

In order to gain insights into research priorities and trends regarding the relationship between coffee and liver disease, we conducted a bibliometric and visual analysis of relevant studies spanning from 2013 to 2023. Our analysis encompassed a total of 1106 papers published within this timeframe. Our findings reveal a notable increase in the number of papers focused on the role of coffee in preventing liver disease, particularly evident over the past five years. This indicates a growing attention among researchers towards exploring coffee's potential protective effects on liver health.

In terms of geographical distribution, China emerged as the leading contributor with the highest number of published papers (216). This trend may be attributed to China's ongoing battle against liver diseases, which have become a significant cause of mortality in the country. Notably, other leading countries in terms of publications include the USA, Japan, Brazil, and Italy. Furthermore, an examination of the institutions publishing the most articles indicates a predominance of institutions from France. In addition, funding project analysis showed that the NSFC leads with the highest record count in coffee and liver research. Interestingly, among the top 25 institutions with the highest publication output, only one hails from China. This suggests a dispersed involvement of Chinese institutions in this research area, implying widespread dissemination of research efforts both within China and across other countries.

A total of 1106 papers were dispersed across 510 journals, with notable contributions from leading journals such as "Nutrients", "Xenobiotica", "Plos One", "Scientific Reports", and "International Journal of Molecular Sciences". It's worth noting that "Nutrients" and

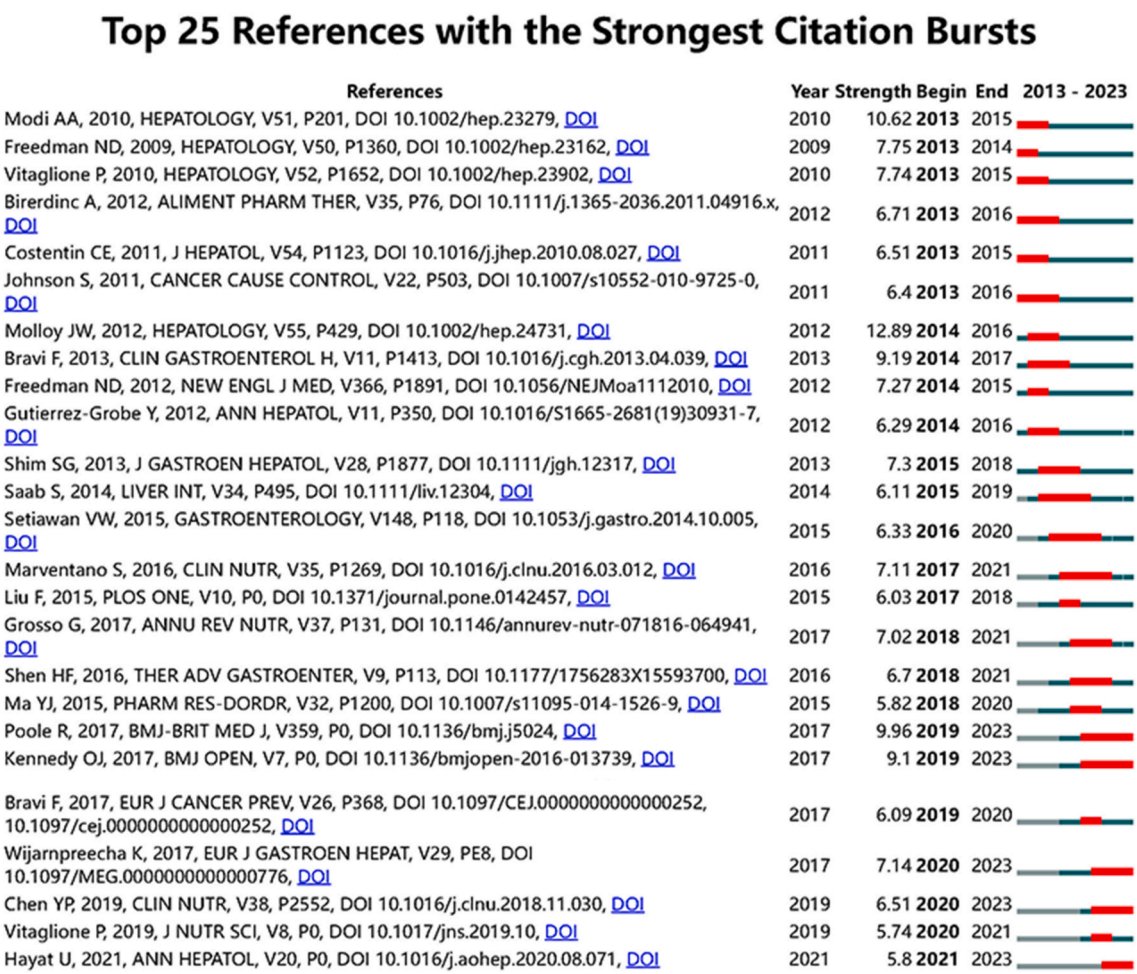

Fig. 5. Top 25 references with the strongest citation bursts on coffee and liver research.

Table 7
Top 20 keywords related to coffee and liver research.

Rank	Words	Occurrences
1	risk	165
2	oxidative stress	113
3	consumption	110
4	coffee consumption	103
5	liver	94
6	insulin-resistance	87
7	metabolism	87
8	expression	85
9	chlorogenic acid	77
10	hepatocellular-carcinoma	77
11	disease	76
12	association	72
13	caffeine consumption	57
14	in-vitro	56
15	metabolic syndrome	55
16	green tea	54
17	fatty liver-disease	51
18	metaanalysis	51
19	tea consumption	47
20	cardiovascular-disease	45

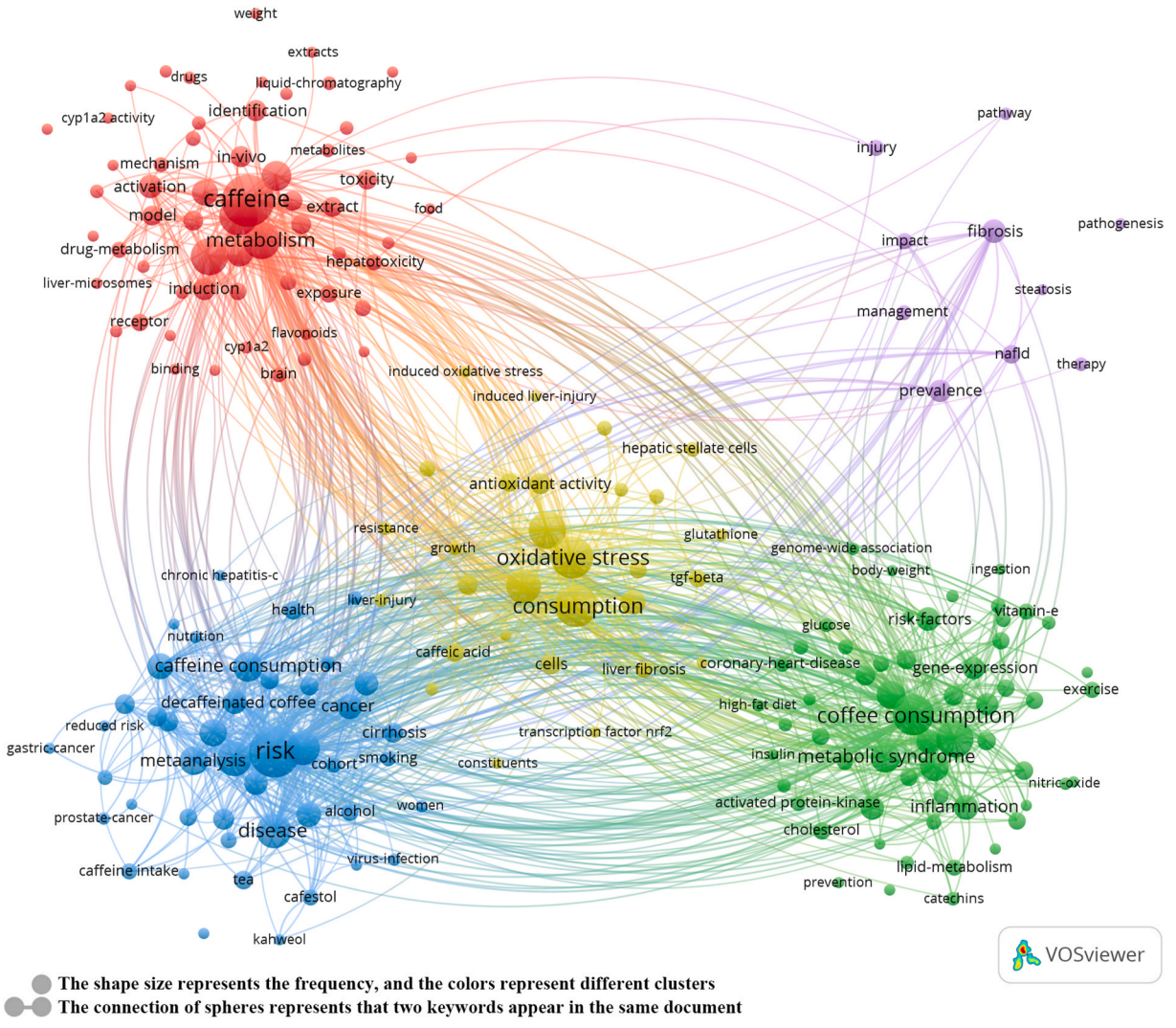

Fig. 6. Keyword co-occurrence map of publications on coffee and liver research.

"Plos One" are among the most cited journals, underscoring their significance within this research domain.

4.2. Hotspots and development trends

Through an analysis of highly cited references, citation bursts, keyword clustering, and trends in keyword themes, we have established a close correlation between our investigation on the impact of coffee on liver health and prevailing global healthcare trends. We have identified and delineated the research hotspots and frontiers in the domain of coffee's role in liver disease prevention. Our study underscores several noteworthy aspects of coffee's significance in the arena of liver disease prevention.

Firstly, the types and categories of liver diseases preventable by coffee. Through keyword clustering analysis, we find that the main types of liver diseases targeted for prevention in this field broadly include 'nonalcoholic fatty liver', 'nonalcoholic steatohepatitis', 'fatty liver disease', 'steatohepatitis', and 'chronic hepatitis C'. Indeed, our study easily uncovers a substantial body of research confirming the significant role of coffee in preventing these types of liver diseases, and elucidates the mechanisms of action for this prevention. For instance, research by Constance E. Ruhl *et al.* indicates that higher coffee consumption is crucial for preventing chronic liver diseases such as hepatitis B and C [22]. Similarly, a study by Tverdal and colleagues shows a negative correlation between coffee intake and the likelihood of cirrhosis [23]. Regarding the prevention of nonalcoholic fatty liver disease, research by A. Birerdinc et al. suggests that coffee consumption can effectively prevent this type of disease [24]. Existing studies have demonstrated that obesity significantly increases the incidence of nonalcoholic fatty liver disease [25], and coffee consumption can effectively reduce the occurrence of obesity [26], thereby lowering the incidence rate of nonalcoholic fatty liver disease.

Secondly, when we shift our focus to which substances suppress the liver diseases discussed above, thereby offering hepatoprotective effects, keyword analysis reveals that the effective components are mainly concentrated on "caffeine", "chlorogenic acid

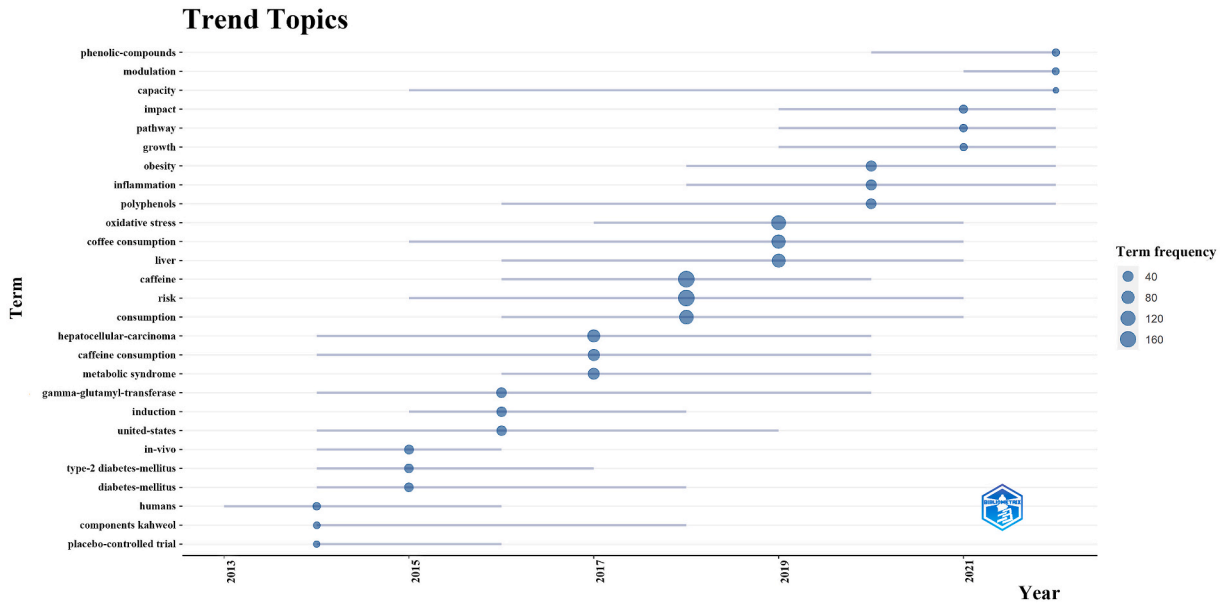

Fig. 7. Trend topics on coffee and liver research.

(CGA)", and "diterpenes". CGA has been found to improve conditions like drug-induced liver injury, alcoholic liver disease [27], and metabolic-associated fatty liver disease [27]. Recent studies indicate that liver fibrosis can lead to cirrhosis, ultimately resulting in liver cancer or liver failure [28]. Research also shows that CGA can effectively inhibit liver fibrosis [29], thereby playing a significant role in liver protection. Caffeine not only inhibits the action of adenosine but also suppresses liver fibrosis and the proliferation of liver cancer cells through mechanisms such as upregulating Antioxidant Response Elements (ARE) and activating detoxifying enzymes [30–32]. Diterpenes in coffee, present as fatty acid esters, are known for their properties of raising cholesterol levels and offering anti-inflammatory and antioxidant benefits, thus preventing damage to liver cells caused by reactive oxygen species [33].

Lastly, regarding the principles or metabolic mechanisms of coffee's hepatoprotective effects, our analysis indicates that most studies focus on aspects like "liver metabolic regulation", "TGF-beta", "antioxidant activity", and "signaling pathways". Current research has demonstrated that reactive oxygen species (ROS) primarily target the liver [34]. An excess of ROS leads to oxidative stress reactions, consequently causing hepatic damage [35]. Oxidative stress constitutes the physiological basis for many chronic liver diseases [36,37] Some components of coffee can alleviate oxidative stress by reducing ROS, thereby mitigating the harm caused by intrinsic oxidative stress in liver cells [38]. Caffeine attenuates Alcoholic Liver Disease (ALD) through pathways like cAMP/PKA/CREB and cAMP/PKA/SRC/ERK1/2/P38 MAPK, thereby inhibiting the activation and proliferation of hepatic stellate cells induced by acetaldehyde and thus suppressing alcoholic liver disease [39]. It can also alleviate liver fibrosis by inhibiting the expression of TGF-β and modulating the extracellular matrix and other mechanisms [40]. Therefore, we can confirm that the current understanding of coffee's hepatoprotective mechanism primarily involves altering the expression of related genes, its antioxidant effects, and the inhibition of pathways such as TGF-beta.

4.3. Strengths and limitations

This study may aid researchers in gaining a better understanding of the field and exploring new directions. However, several limitations must be addressed. Firstly, we solely used the WoS database as our data source, which might result in the exclusion of some publications. Nevertheless, the WoS database is widely recognized as a high-quality digital literature database and is considered one of the most suitable databases for bibliometric analysis [41–43]. Therefore, our choice of data source is reliable. Secondly, we only analyzed English-language publications, which could introduce source bias. In conclusion, despite these limitations, our study provides a comprehensive overview of the overall situation, hotspots, and research trends in this field.

5. Conclusion

Our comprehensive bibliometric analysis elucidates the principal trends and focal points of research on the impact of coffee on liver health. The following are key findings and potential future research directions in this field, as deduced from our analysis:

a. From 2013 to 2023, there has been a significant increase in the number of research papers, with China, the United States, and South Korea being the primary contributors. International collaboration, particularly with the United States, has been prominent.

b. Journals such as 'Nutrients' and 'Xenobiotica' have published the most articles in this field, indicating their forefront position in disseminating influential research. 'Hepatology' has emerged as the most cited journal, highlighting its pivotal role in liver health research.
c. The research primarily revolves around the preventive effects of coffee on various liver diseases and its hepatoprotective properties, including HBV and HCV infections, ALD, NAFLD, cirrhosis, liver failure, and HCC.
d. Researchers in this field have mainly focused on the hepatoprotective effects of coffee constituents such as 'caffeine', 'chlorogenic acid (CGA)', and 'diterpenes'.
e. 'Liver metabolic regulation', 'TGF-β', 'antioxidant activity', and 'signaling pathways' are the hotspots and main research trends in coffee's prevention of liver diseases. Furthermore, mechanisms such as cellular regulation to alleviate liver diseases also represent a significant research focus and trend.

In summary, this study comprehensively outlines the current research on the impact of coffee on liver health, emphasizing the significant advancements in understanding its protective role against liver diseases. This analysis offers valuable guidance for future research directions in this important field. Our article provides researchers with relevant knowledge and trending topics in this domain, enabling them to better grasp research directions and identify innovative opportunities.

Data availability statement

Data included in article/supplementary material/referenced in article.

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CRediT authorship contribution statement

Zonghuai Li: Software, Resources, Methodology, Formal analysis, Data curation. **Xin Liao:** Software, Resources, Methodology, Formal analysis, Data curation. **Yunyun Qin:** Software, Resources, Methodology, Formal analysis, Data curation. **Chenshu Jiang:** Supervision. **Yuanchu Lian:** Supervision, Software, Resources. **Xiaoxin Lin:** Supervision, Software, Resources. **Jiang'an Huang:** Supervision, Software, Resources. **Bo Zhang:** Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Zhongwen Feng:** Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing 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.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e31132.

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