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A Review of Research on the Baijiu Industry based on Knowledge Graphs

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Abstract

This study employs knowledge graph analysis to systematically examine the current research status and development trends of China's Baijiu industry, aiming to provide theoretical support and practical guidance for industry development. Using CiteSpace software, we analyze 126 core journal articles from the CNKI database published between 1999 and 2024, focusing on publication volume, research institutions, authors, and keywords to reveal research hotspots and trends. The findings indicate a fluctuating upward trend in academic publications on the Baijiu industry, with challenges such as a lack of cross-regional cooperation, a loosely connected author network, and a fragmented research focus. Research hotspots include topics such as the "Baijiu Golden Triangle," "sauce-flavored Baijiu," and "industrial cluster." The study concludes that future research should enhance the exploration of different aroma types of Baijiu. Additionally, emphasis should be placed on regional characteristics and development strategies, systematic research on industrial integration and innovation strategies, and strengthening cross-regional and university-enterprise collaboration to drive the industry's quality enhancement, internationalization, and intelligent development, thereby achieving industrial upgrading and sustainable development.

Keywords

Baijiu Industry; Review; Knowledge Graph; CiteSpace.

1. Introduction

The Baijiu industry, as a traditional and distinctive sector in China, embodies profound cultural heritage and substantial economic value. With a history of thousands of years, it maintains a unique position in the global beverage market. From the perspective of brewing techniques, Baijiu production integrates sophisticated craftsmanship, including multi-grain selection, solid-state fermentation, and continuous fermentation in aged pits[1]. Different aroma types of Baijiu exhibit distinct flavor profiles due to unique microbial communities, fermentation conditions[2], and proprietary blending formulas[3], all of which involve complex biochemical processes and historical evolution.Over time, the Baijiu industry has undergone a transformation from a planned economy to a market-driven model, experiencing key developmental stages such as consumption upgrades and intensified brand competition. The industry has continuously expanded in scale, diversified its consumption scenarios, and evolved into a highly stratified and competitive market[4]. Furthermore, it is significantly influenced by policy orientations, shifts in consumer preferences[5], and the regional foundation of brands[6]. The concept of production regions has become increasingly prominent, with Maotai Town being synonymous with sauce-flavored Baijiu and Yibin and Luzhou renowned for strong-flavored Baijiu. This geographical clustering has fostered quality recognition and industrial agglomeration advantages[7].

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Driven by the wave of digitalization, the application of knowledge graph technology offers new perspectives for Baijiu industry research. This technology integrates structured knowledge by transforming complex textual data into clear and intuitive representations of "entities," "relationships," and "attributes"[8], thereby breaking information silos and facilitating in-depth analysis of industry structures and hidden patterns. This review constructs a knowledge graph for the Baijiu industry to analyze its research landscape, summarize existing findings, identify research challenges, and explore future directions. The objective is to uncover the intrinsic developmental logic and potential of the Baijiu industry, support breakthroughs in industry research, drive industrial transformation and upgrading, and ultimately achieve high-quality development.

2. Data Sources and Research Methods

2.1. Data Sources

The study retrieves data from the CNKI database using “Baijiu industry” as the keyword. Only core journal articles are selected, excluding conference papers, news articles, and unrelated documents. A total of 126 studies from 1999 to 2024 are analyzed. The selection of core journals ensures academic rigor, as these journals are filtered based on citation rates, reprint rates, and abstracting rates. This dataset provides valuable insights into the industry's research landscape and evolution.

2.2. Research Tools

This study utilizes the CNKI academic database as the primary data source and CiteSpace 6.3 software for analysis. CiteSpace enables clustering and relevance analysis based on research institutions, author keywords, and citation networks. The software employs advanced algorithms and set-theoretic standardization methods to measure similarities between knowledge units, thereby constructing intuitive knowledge graphs. Additionally, Excel is used to enhance data visualization, ensuring clarity and accessibility of analytical results.

3. Research Status and Trends

3.1. Analysis of Publication Trends

By analyzing the number of publications across different years, we can examine the annual research trends in the Baijiu industry. As shown in Figure 1, the number of publications peaked in 2014. During this period, the Baijiu industry faced dual challenges: consumption upgrading and intensified market competition. The rising consumer demand for higher-quality products and stronger brand recognition drove the industry to enhance its offerings. Meanwhile, fierce competition compelled baijiu enterprises to explore new development strategies and marketing approaches[9]. These industry transformations created numerous research-worthy topics, significantly stimulating scholarly interest and leading to a surge in academic publications in 2014. Although the number of publications fluctuated after 2014, overall academic interest in the Baijiu industry has remained consistent. Following the peak, the publication volume experienced a decline but later exhibited a resurgence, which may be attributed to the industry's deep restructuring and transition period. The emergence of digital transformation, internationalization strategies, and integration with the tourism sector has sparked a new wave of academic research. In 2023 and 2024, the number of publications stood at 10 and 7, respectively, indicating sustained scholarly attention to the Baijiu industry. Recent research focuses on a multidimensional analysis of industry development, encompassing regional branding studies[10], discussions on regional industrial growth[11], financial empowerment in support of Baijiu industry clusters[12], and macro-level investigations into the coupling and coordination of technological innovation with high-quality industry

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development[13]. These research themes collectively highlight the key strategic focal points in the industry, aiming to enhance industrial upgrading, optimize sectoral layout, and promote sustainable development. These phase-specific shifts not only reveal the evolving research trends in the Baijiu industry but also reflect how industry transformations influence the focus and intensity of academic research.

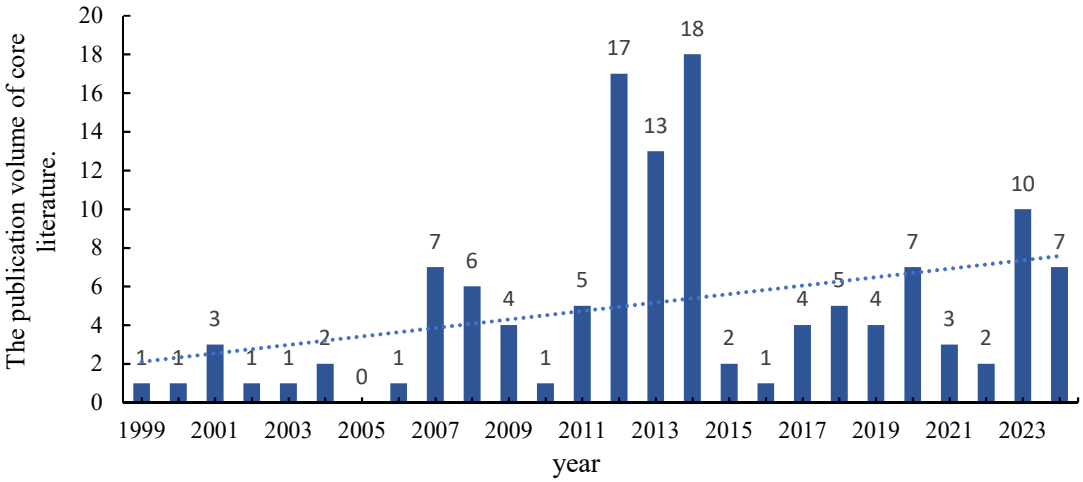

Figure 1. Trend Chart of the Number of Core Literature Publications in the Baijiu Industry from 1999 to 2024

3.2. Research Institutions and Author Collaboration

3.2.1. Institutional Contributions

To standardize the names of research institutions, this study adopts a systematic approach by simplifying institutional names to the university level. For instance, the "Sichuan University of Science and Engineering Baijiu Development Research Center" is simplified to "Sichuan University of Science and Engineering," and the "School of Management, Sichuan University of Science and Engineering" is also unified under "Sichuan University of Science and Engineering." This approach ensures consistency in institutional classification, providing a more reliable dataset for analyzing academic output and facilitating more accurate assessments and comparisons of research contributions across institutions.

The collaboration network consists of 96 nodes and 35 links, with a network density of 0.0077. Figure 2 presents the top 10 institutions with the largest collaborative networks. The results indicate the formation of several research clusters, primarily around Sichuan University of Science and Engineering, Guizhou University of Commerce, Yibin University, Guizhou Institute of Light Industry Science, and Guizhou University, while some institutions conduct research independently. Research collaborations among Chinese institutions tend to be regionally concentrated (e.g., Sichuan Liquor & Tea Investment Group Co., Ltd.—Sichuan University of Science and Engineering—Yibin Cuiping District Municipal Construction Engineering Center). However, cross-regional collaborations also exist (e.g., Yibin University—Chengdu Normal University). The research is predominantly concentrated in universities with regional advantages in the Baijiu industry, and institutions with higher publication volumes typically have strong disciplinary expertise in baijiu and fermentation-related fields.

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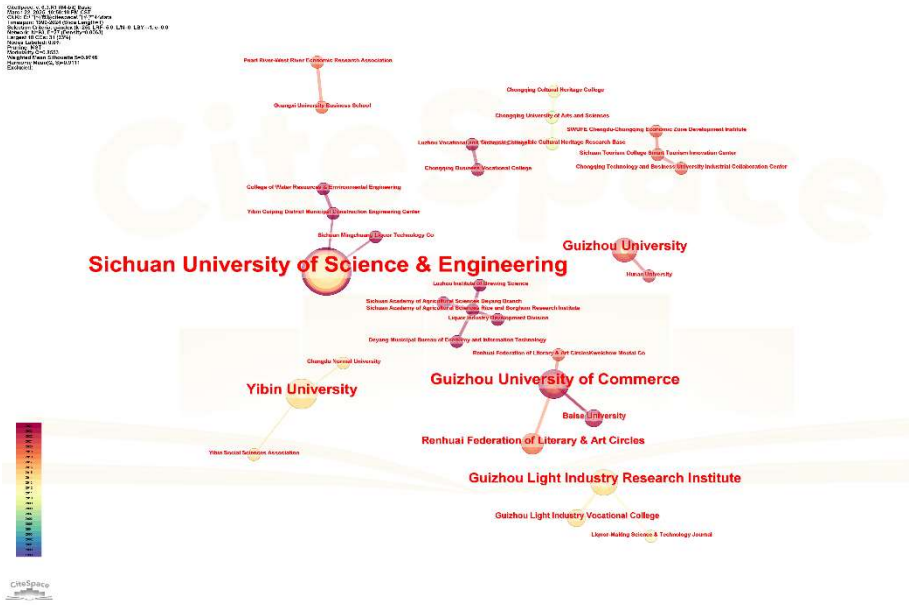

Figure 2. Collinearity of Research Institutions

Additionally, there are numerous university-industry collaborations, such as Yibin Vocational and Technical College-Wuliangye Group Technology Center, and Yelang Gu Liquor Co., Ltd.-Sichuan University of Science and Engineering. These partnerships not only strengthen the integration of academic research with industrial practice but also facilitate the transformation of research outcomes and industry innovation through financial support provided by enterprises. Nevertheless, the extent of collaboration still has room for improvement, particularly with small and medium-sized enterprises, which could expand the research network and enhance both the breadth and depth of studies.

As shown in Table 1, Sichuan University of Science and Engineering ranks first in terms of publication volume, followed by Moutai Institute, Guizhou University of Commerce, Yibin University, Guizhou Institute of Light Industry Science, and Guizhou University. Sichuan University of Science and Engineering's leading position in publication output can be attributed to two key factors. First, its strong disciplinary focus: its “Brewing Engineering” program ranks sixth nationwide among similar programs, and the university hosts multiple liquor research centers and provincial key laboratories. In this study, the total number of publications from the university reached 18, with the “Baijiu Development Research Center” alone contributing 9 papers. Second, its geographical advantage: the Yibin campus of Sichuan University of Science and Engineering, as the first university branch to settle in Yibin University Town, enjoys the reputation of being the “China Baijiu Academy.” Its School of Bioengineering-Wuliangye Baijiu Academy maintains a close collaboration with Wuliangye Group, fostering an industry-academia-research synergy that creates a conducive environment for academic output and significantly advances the university's research progress in baijiu-related fields.

Table 1. Institutional Publication Volume

Institution Name	Number of Publications	Earliest Publication Year
Sichuan University of Science & Engineering	18	2007
Moutai Institute	8	2019
Guizhou University of Finance and Economics	7	2018
Yibin University	6	2011
Guizhou Academy of Light Industry Science	5	2012
Guizhou University	5	2007

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3.2.2. Author Collaboration

By analyzing the results of CiteSpace, we can gain a deeper understanding of author publication volume and research characteristics in the Baijiu industry.

As shown in Figure 3, the author collaboration network comprises 198 nodes, 123 links, and a network density of 0.0063. The figure highlights the four largest collaborative networks, with the most extensive network centered around Guoping Qie, followed by Zhiguo Huang, Xu Guo, and Yongguang Huang. Although most scholars engage in collaborative research and exhibit strong intra-team cohesion, the overall collaboration network remains highly fragmented, with insufficiently diverse team compositions. Many scholars have yet to establish cooperative relationships, and cross-team collaborations are rare. A significant number of researchers continue to work independently. It is recommended that scholars actively build research teams, foster cross-team and interdisciplinary collaborations, and establish diversified cooperative networks to advance baijiu research and contribute higher-quality academic outputs to the industry.

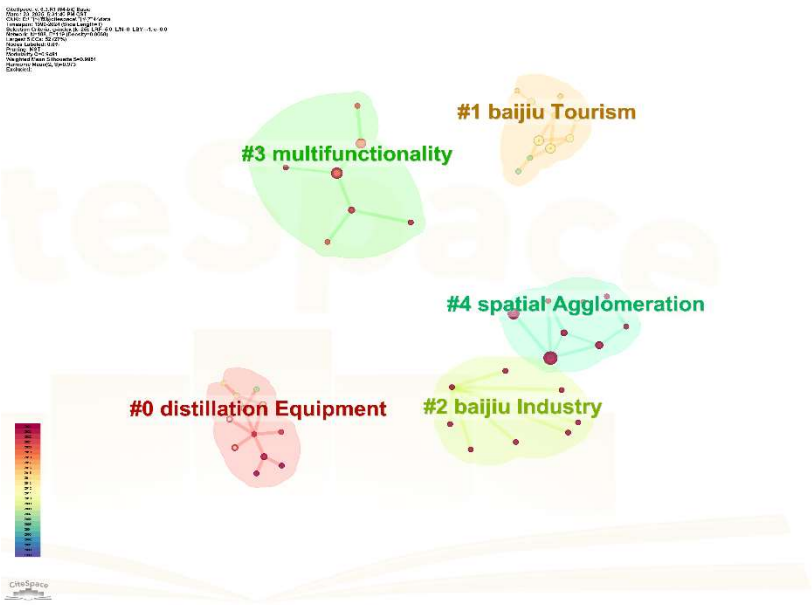

Figure 3. Author Collaboration Network

Figure 4. Clustering of Author Collaboration Network

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To further investigate the primary research directions of author teams, a clustering analysis of keywords was conducted based on the author collaboration network. Using a one-year time slicing approach in CiteSpace, clustering was performed by selecting the "K" clustering option in the software toolbar, which categorizes keywords into different groups. The modularity (Q value) is a key metric for evaluating the effectiveness of keyword clustering, reflecting the significance of the cluster structure. The Q value ranges from 0 to 1, with higher values indicating more distinct clustering structures-i.e., stronger intra-cluster keyword associations and weaker inter-cluster connections. A Q value greater than 0.3 is typically considered indicative of a well-defined clustering structure, meaning that keywords have been effectively grouped. The silhouette coefficient (S value) measures the clustering quality, ranging from -1 to 1, where higher values signify better clustering effectiveness. Generally, an S value above 0.7 indicates a highly credible clustering result[14]. As illustrated in Figure 4, the clustering analysis produced a Q value of 0.9529 and an S value of 0.9984, confirming the robustness and reliability of the clustering outcomes.

The keyword clustering analysis of the author collaboration network identified the primary research directions of author teams. Lower cluster numbers indicate clusters with a greater number of contributing authors. The major research topics include #0 Distillation Equipment, #1 Baijiu Tourism, #2 Baijiu industry, #3 Multifunctionality, and #4 Spatial Agglomeration.

Currently, research on the Baijiu industry is diverse and in-depth. The team led by Zhiguo Huang focuses on "distillation equipment," reviewing the development and current status of Chinese baijiu distillation apparatus. Their research provides an in-depth analysis of traditional pot stills and steaming barrels, evaluates the advantages and disadvantages of different structures, explores improvements in mechanized distillation units, and summarizes the types and structural characteristics of continuous distillation systems[15].

Guoping Qie's team primarily studies "baijiu tourism" within the Chishui River Basin and Guizhou province. Their research comprehensively examines the integration of baijiu and tourism, analyzing the current development status[16], tracing its spatial-temporal evolution[17], constructing resource evaluation systems[18], and exploring spatial characteristics and industrial distribution factors[19], contributing insights for both domestic and international market expansion.

Yongguang Huang's research centers on "the Baijiu industry," investigating the theoretical framework for establishing a Guizhou Baijiu industry technology innovation alliance. His team explores white Baijiu industry development, focusing on strategies for forming an effective technology innovation alliance in Guizhou[20]. Their studies also examine the role of baijiu culture[21], compare industrial strategies of leading baijiu-producing provinces[22], and assess the development and associated economic impact of the low-alcohol baijiu sector to drive industry growth[23].

Xu Guo's research revolves around "multifunctionality" in the Baijiu industry, emphasizing its broader economic and cultural value[24]. His team maps out innovative industry integration strategies and employs models such as Porter's Diamond Model, the Five Forces Analysis, and SWOT analysis to examine the Renhuai industrial cluster[25-27]. They analyze competitive dynamics, identify strengths and weaknesses, and explore new marketing strategies to tackle industry challenges, ultimately promoting high-quality and sustainable development.

The team led by Cengyan Deng specializes in "spatial agglomeration" within the Baijiu industry, proposing the strategic concept of establishing the Guizhou Sauce-Flavor Baijiu Golden Triangle Production Area. This research underscores the importance of leveraging Guizhou's natural conditions and industrial advantages, emphasizing enhanced production area management to strengthen the competitive edge of Guizhou's Baijiu industry and ensure its sustainable development.

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As shown in Table 2, Xu Guo ranks first in terms of publication volume, with eight papers and an average citation per paper of 24.25. His research focuses on the development of sauce-flavor baijiu, with "Research on the Marketing Strategies of Chinese Sauce-Flavor Baijiu under the New Market Environment" being his most cited paper, with 65 citations. This study examines the market characteristics of sauce-flavor baijiu in the evolving business landscape and proposes strategies such as diversified product structures, promotional campaigns, and public trading platform development to enhance market competitiveness and promote industry sustainability[28].Jiandong Bu and Guoping Qie have closely collaborated since 2022, co-authoring core journal articles. Notably, their study "Analysis of the Spatial-Temporal Evolution and Driving Mechanisms of Chinese Baijiu Tourism" investigates the development characteristics and underlying factors of baijiu tourism[17], while "Analysis of the Spatial Distribution Characteristics and Driving Forces of the Guizhou Baijiu industry" systematically examines the geographical distribution of baijiu production in Guizhou[19].Meanwhile, Liu Yang has independently published six papers, including "Research on the Development Strategies of China's Baijiu industry in the Context of Dominant Media Influence," which explores the impact of media on the Baijiu industry and proposes strategic responses for industry development[29].Yuanbin Huang's research focuses on "China's Baijiu Golden Triangle." His highly cited paper "Research on the Innovation Environment of the 'China Baijiu Golden Triangle' Industrial Cluster" provides an in-depth analysis of the region's industrial cluster innovation environment, offering strategies to enhance innovation capacity and global competitiveness, thereby promoting the development of regional baijiu branding[30]. These research contributions not only enrich academic discourse in the Baijiu industry but also provide theoretical support and strategic guidance for industry practice and development.

Table 2. The top four authors in terms of the number of publications

Ranking	Number of Publications	Percentage	Earliest Publication Year	Author	Average Citations per Paper
1	8	6.35%	2013	Guo Xu	24.25
2	7	5.56%	2019	Bu Jiandong	6.43
3	6	4.76%	2001	Yang Liu	7.83
3	6	4.76%	2022	Qie Guangping	3.17
3	6	4.76%	2011	Huang Yuanbin	5.67

3.3. Research Hotspot Distribution

Keywords are a concise expression of the theme of an article, revealing the central topics and directions of research. Analyzing keywords enables a rapid understanding of academic trends and the effective identification of research hotspots. Co-word analysis of keywords can uncover the relationships between different research themes, demonstrating how they co-occur in academic literature, thereby reflecting the knowledge structure and evolution of research trends. Meanwhile, clustering analysis groups similar keywords, helping to identify dominant themes and emerging subfields in the research.

3.3.1. Co-word Analysis of Keywords

Research hotspots reflect the issues of concern to the scientific community, and keywords extract the core content and themes of papers. CiteSpace was used to perform a co-word analysis of 126 papers, selecting "keywords" as the node type, applying the minimum spanning tree method, and keeping the other parameters as default. The co-word network of keywords is shown in Figure 5, consisting of 236 nodes and 245 edges. The larger the node, the higher the frequency of the corresponding keyword. Different colors represent different publication years.

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The current keyword co-word network is centered around terms such as "Baijiu," "Baijiu industry," "sauce-flavored Baijiu," and "Baijiu Golden Triangle," reflecting key research hotspots.

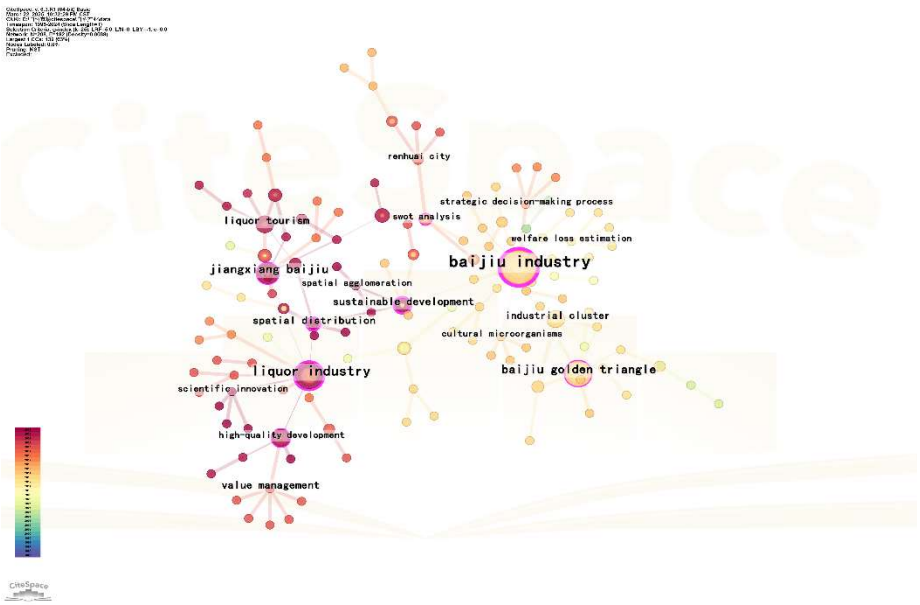

Figure 5. Collinearity Map of Keywords

The top five keywords by frequency are listed in Table 3: "Baijiu industry," "Baijiu," "Baijiu Golden Triangle," "sauce-flavored Baijiu," and "industrial cluster." The centrality of a keyword, also known as betweenness centrality, measures how often a keyword acts as a bridge connecting other keywords in the knowledge network or co-occurrence analysis[31]. Keywords with higher centrality play crucial roles as hubs, linking different research fields or topics[32]. In terms of keyword frequency, "Baijiu Golden Triangle" appears more frequently than "sauce-flavored Baijiu"; however, in terms of centrality, "sauce-flavored Baijiu" ranks higher, indicating its stronger co-occurrence with other keywords. This suggests that research on "sauce-flavored Baijiu" is more diversified, positioning it as a central theme in both academic studies and industry practice. Since the research theme itself is "Baijiu industry," the high frequency of "Baijiu industry" and "Baijiu" does not carry additional explanatory significance.

The frequent occurrence of keywords such as "Baijiu Golden Triangle," "sauce-flavored Baijiu," and "industrial cluster" reflects the development landscape of China's Baijiu industry. The "Baijiu Golden Triangle" specifically refers to the region formed by Luzhou and Yibin in Sichuan and Zunyi in Guizhou, which, due to its unique natural conditions, has become a key area for high-quality Baijiu production. This region hosts renowned Baijiu brands such as Moutai, Wuliangye, and Luzhou Laojiao, forming a strong industrial cluster that plays a significant role in regional economic growth and the internationalization of the Baijiu industry[33].

Table 3. Keyword Frequency Table

Ranking	Keyword	Frequency	Centrality	First Appearance Year
1	Baijiu industry	30	0.53	2007
2	Baijiu	17	0.42	2007
3	Baijiu Golden Triangle	9	0.17	2011
4	Sauce-flavored Baijiu	7	0.2	2018
5	Industrial cluster	5	0.03	2008

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3.3.2. Keyword Clustering Analysis

To analyze the overall keyword landscape, a clustering analysis was conducted. As shown in Figure 6, the clustering quality metrics indicate a modularity Q value of 0.8122 and a silhouette score of 0.9721, both exceeding the commonly accepted significance thresholds, suggesting a highly reliable and effective clustering result.

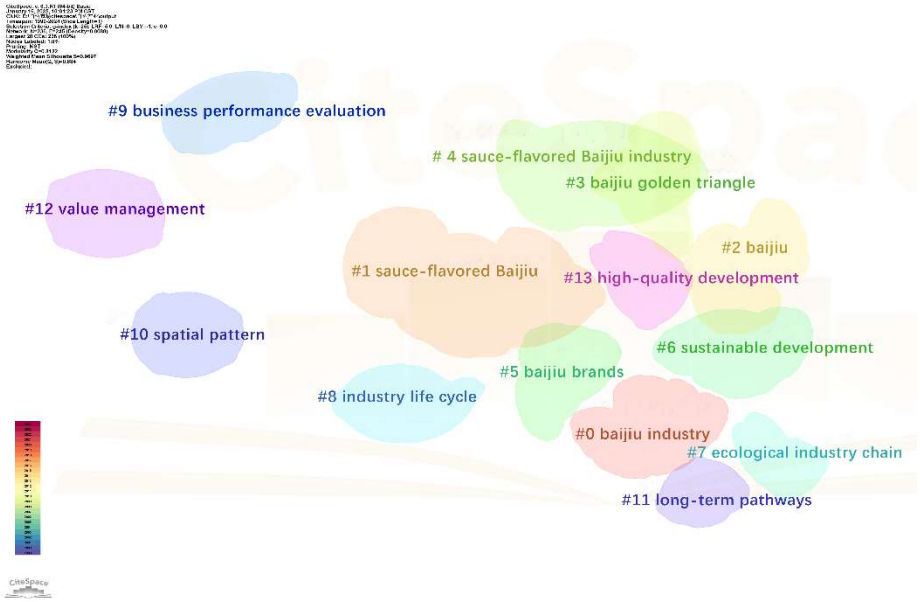

Figure 6. Clustering Map of Keywords

Table 4. Keyword Clustering Data Table

Serial Number	Keyword	Size	Contour Coefficient	Average Year
0	Baijiu industry	28	0.995	2016
1	Sauce-flavored Baijiu	26	0.939	2017
2	Baijiu	24	0.936	2014
3	Baijiu Golden Triangle	19	0.951	2012
4	Sauce-flavored Baijiu industry	17	0.963	2015
5	Baijiu Brands	14	0.973	2011
6	Sustainable Development	14	0.955	2021
7	Ecological Industry Chain	6	1	2011
8	Industry Lifecycle	6	0.951	2013
9	Business Performance Evaluation	6	1	2008
10	Spatial Pattern	5	1	2024
11	Long-term Path	5	0.995	2017
12	Value Management	5	1	2020

By further summarizing the clustering results, 14 significant clusters were identified, as listed in Table 4. The "size" in the table refers to the number of keywords within each cluster, with larger clusters indicating a broader research scope. A smaller cluster number indicates that the cluster contains more keywords and has a more comprehensive theme[34]. The silhouette coefficient, a metric used in clustering analysis, measures the compactness and separation of a cluster. A coefficient close to 1 suggests that the elements within the cluster are tightly grouped and well-separated from other clusters, indicating a high-quality clustering result[35]. The "average year" represents the mean of the first occurrence years of keywords within the cluster.

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The clustering analysis identified 14 major groups: #0 Baijiu industry, #1 sauce-flavored Baijiu, #2 Baijiu, #3 Baijiu Golden Triangle, #4 sauce-flavored Baijiu industry, #5 Baijiu brands, #6 sustainable development, #7 ecological industry chain, #8 industry life cycle, #9 business performance evaluation, #10 spatial pattern, #11 long-term pathways, #12 value management, and #13 high-quality development. Since "Baijiu industry" is the central research theme, clusters #0 "Baijiu industry" and #2 "Baijiu" do not provide additional explanatory value. According to Table 4, the clusters "#5 Baijiu brands" and "#7 ecological industry chain" have the earliest average keyword occurrence year (2011), indicating relatively mature or traditional research themes. Conversely, the clusters "#10 spatial pattern" and "#13 high-quality development" have the most recent average keyword occurrence year (2022), representing emerging research areas or trends.

Through literature review and comparative clustering analysis, the main research themes in the Baijiu industry are summarized into the following three aspects:

(1) Development Models and Pathways

This category includes clusters #6 sustainable development, #7 ecological industry chain, #11 long-term pathways, and #13 high-quality development. Keywords in cluster #6 "sustainable development" include "tourism resources," "regional economy," and "spatial distribution," reflecting research on leveraging Baijiu tourism integration to optimize layout and drive regional economic growth[36]. Cluster #7 "ecological industry chain" features keywords such as "chain-cluster relationship" and "circular economy," analyzing the potential conditions for developing an ecological industry chain in Guizhou and deriving its fundamental development strategies[37]. Cluster #11 "long-term pathways" contains keywords like "demand-side," "supply-side," and "structural reform," suggesting that China's Baijiu industry should focus on supply-side reforms, optimizing the ecological industry chain, strengthening chain-cluster relationships, and promoting circular economy practices to achieve quality-driven growth and sustainable development[38]. Cluster #13 "high-quality development" includes keywords such as "Sichuan" and "Chengdu metropolitan area," summarizing the current state and challenges of Sichuan's Baijiu industry. It proposes development strategies based on opportunities in the Chengdu metropolitan area, covering enterprise cultivation, industrial park construction, brand building, and strengthening industrial chains, providing references for Baijiu industry development in Sichuan and other provinces[11].

(2) Industry Foundation and Structure

This aspect includes clusters #1 sauce-flavored Baijiu, #3 Baijiu Golden Triangle, and #4 sauce-flavored Baijiu industry. High-frequency keywords in these clusters include "industrial integration," "Baijiu tourism," "Chishui River Basin," "Belt and Road Initiative," "spirits," "regulations," "industrial cluster," "construction," "innovation environment," "recommendations," "SWOT analysis," and "development strategy." These keywords indicate the multifaceted nature of research on the sauce-flavored Baijiu market and development strategies. They highlight the necessity of formulating coordinated development strategies in geographical indication regions[39], constructing resource evaluation systems[18], improving industry regulations and standardization[40], leveraging cluster effects[41], fostering innovation-driven growth[42], optimizing the development environment[30], providing strategic planning recommendations[25], analyzing internal and external environments, and formulating strategies based on the SWOT model[27].

(3).Business Operations and Evaluation

This aspect encompasses clusters #5 Baijiu brands, #8 industry life cycle, #9 business performance evaluation, #10 spatial pattern, and #12 value management. Keywords in cluster #5 "Baijiu brands" include "internationalization" and "culture," emphasizing the integration of traditional culture with branding to expand international markets and enhance global

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influence[43]. Cluster #8 "industry life cycle" contains keywords like "countermeasures" and "regulation," analyzing the challenges of China's Baijiu industry in its late-mature stage and proposing policy recommendations[44]. Cluster #9 "business performance evaluation" focuses on "Baijiu industry" and "technical efficiency," aiming to develop comprehensive evaluation systems incorporating financial and non-financial metrics to objectively assess enterprise performance and support decision-making and management improvements[45]. Cluster #10 "spatial pattern" examines regional branding and spatial optimization strategies, using Henan Baijiu as a case study to optimize brand spatial distribution, plan production, sales, and logistics efficiently, reduce costs, improve efficiency, and promote regional coordinated development[10]. Cluster #12 "value management" focuses on "value distribution" and "value creation," advocating for balanced stakeholder interests and value-driven growth strategies to achieve long-term and stable enterprise development[46].

3.4. Trend Analysis

In CiteSpace software, the Keyword Burst Chart (BurstTerms) is primarily used to determine shifts in research hotspots or trends over a specific period. The "Year" represents the first appearance of a keyword; "Strength" indicates the intensity of the keyword burst, with a higher value signifying a more rapid increase in research interest during the corresponding period; "Begin" marks the starting year of the keyword burst, denoting when it became a research hotspot; and "End" signifies the year when the keyword burst ceased, indicating the decline of its research interest.

Figure 7 presents 12 keywords that experienced a surge in usage frequency over a certain period. Through an analysis of the keyword bursts in literature related to the "Baijiu industry," this study illustrates the evolution of research hotspots in this field. The burst intensity and duration of keywords reflect the concentration and persistence of research at different stages, providing valuable insights for forecasting future trends.

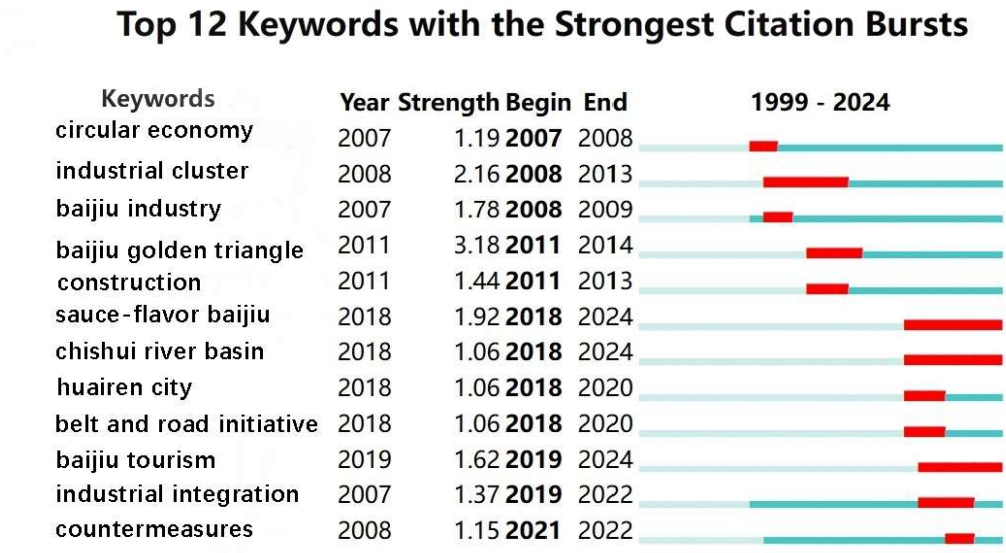

Figure 7. Burst Map of Keywords in the Baijiu Industry

In terms of burst intensity, the top three keywords are "Baijiu Golden Triangle" (3.18), "Industrial Cluster" (2.16), and "Sauce-Flavor Baijiu" (1.44). The burst intensity of these keywords indicates the high level of academic attention these topics have received during specific periods. Regarding burst duration, over the past decade, the keywords "Sauce-Flavor Baijiu," "Chishui River Basin," and "Baijiu Tourism" have shown prolonged burst periods,

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demonstrating sustained and profound research interest in these areas. The Chishui River Basin, located at the junction of Guizhou and Sichuan provinces, is well known for its pristine water sources, which are rich in minerals. This unique natural environment has made the region the core production area for Sauce-Flavor Baijiu. Maotai Town, situated within the Chishui River Basin, is home to many prestigious Sauce-Flavor Baijiu brands. This concentration of renowned Baijiu producers has fostered a strong industrial cluster effect. Conversely, keywords with the shortest burst duration include "Construction" and "Countermeasures." In academic research, trending topics are often influenced by policy directives, market fluctuations, and technological advancements. Studies on "Construction" and "Countermeasures" typically address specific and urgent issues at a given time. Once the construction objectives are achieved or the problems are effectively resolved, research focus naturally shifts to other areas. The persistent bursts of "Sauce-Flavor Baijiu," "Chishui River Basin," and "Baijiu Tourism" indicate that these fields are currently hot research topics and are likely to continue shaping future research directions. The burst intensity and duration of these keywords provide insights into the evolving research trends in the Baijiu industry, reflecting a shift in focus from traditional production techniques and regional resource conservation to new development models that integrate the Baijiu industry with tourism.

Based on data from 2007 to 2024, the evolution of research in this field can be divided into three distinct stages: The first phase, from 2007 to 2009, primarily focused on the fundamental aspects of industry and circular economy. The academic community initially explored the sustainable development of the Baijiu industry and circular economy models. Simultaneously, research on "Industrial Integration" began to emerge, signaling early efforts to investigate cross-industry synergies. The second phase, from 2011 to 2014, concentrated on regional branding and cluster development. Scholars emphasized the construction of regional brands and industrial cluster, highlighting the critical role of infrastructure and strategic planning in the growth of the Baijiu industry. The third phase, covering the period from 2018 to 2020, was characterized by the integration of geographical and cultural factors. Studies during this period underscored the importance of geography and cultural heritage in shaping the development trajectory of the Baijiu industry. Additionally, researchers examined the Baijiu industry's potential role in national strategic initiatives. From 2021 to 2024, research trends have shifted towards innovation and sustainable development. Scholars are now focusing on industrial innovation and strategies for adapting to market changes. A significant research trend involves the integration of the Baijiu industry with tourism, aiming to explore new growth opportunities and expansion strategies.

In summary, future research in the Baijiu industry will focus on deepening the exploration of the unique brewing techniques of Sauce-Flavor Baijiu to enhance product quality and health benefits [47], while also strengthening ecological conservation and resource management in key production regions such as the Baijiu Golden Triangle to ensure sustainable development[7]. As regional brands like the Baijiu Golden Triangle accelerate their internationalization, research will increasingly focus on leveraging cultural heritage and innovation to enhance Baijiu's global market competitiveness [48]. Furthermore, the integration of the Baijiu industry with tourism will become a significant research hotspot[49], investigating how Baijiu cultural tourism can enhance consumer experiences and expand industry boundaries. In the era of digitalization and intelligence, research will also explore the application of advanced technologies to optimize production processes, improve industry-wide efficiency, and enhance responsiveness to market dynamics[50]. Collectively, these trends indicate that the Baijiu industry will continue to progress toward high quality, internationalization, and smart development, driving the sector toward an efficient, sustainable, and diversified future.

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4. Conclusion and Outlook

Through an in-depth analysis of the current research status, challenges, and future trends of the Baijiu industry, it is evident that this traditional industry, with its rich cultural heritage and significant economic value, is at a historical turning point. Facing a globalized market environment, increasingly diverse consumer demands, and waves of technological innovation, the Baijiu industry is confronted with both opportunities and challenges.

4.1. Conclusion

Based on an analysis of publication volume, research institutions, authors, and keywords, several key characteristics of Baijiu industry research have been identified:

(1) From 1999 to 2024, the volume of academic publications on the Baijiu industry has exhibited an overall upward trend with fluctuations, reflecting the growing research interest in this field and its close correlation with industry transformations. Despite the increasing enthusiasm, variations in publication volume suggest imbalances in research depth and breadth, particularly during industry transition periods, where research concentration and continuity require improvement.

(2) At the institutional level, universities such as Sichuan University of Light Industry, Maotai College, and Guizhou Business College have demonstrated strong regional collaboration and university-enterprise partnerships. However, limited cross-regional cooperation has hindered the integration of diverse research perspectives, constraining innovation and limiting progress to higher levels. Additionally, university-enterprise cooperation needs further enhancement, with major Baijiu enterprises expected to take the lead, while small and medium-sized enterprises (SMEs) should also actively engage despite their limited scale.

(3) In terms of author collaboration networks, although a preliminary framework has been established, its internal structure remains loose, and there is a lack of efficient cross-team collaboration mechanisms. This deficiency impedes the effective integration of interdisciplinary resources.

(4) Keyword analysis has pinpointed the core research areas of the Baijiu industry, emphasizing aspects such as aroma classification and regional clusters. However, the fragmented nature of research focus has resulted in a lack of in-depth exploration of key issues, limiting the field's long-term, stable academic development.

4.2. Outlook

While substantial progress has been made in Baijiu industry research, several critical challenges remain unresolved. Addressing these issues will unlock new growth opportunities for the industry.

(1) Regional Characteristics and Development Strategies

Current research is heavily concentrated on sauce-flavor Baijiu, whereas studies on strong-flavored Baijiu remain relatively scarce. Future research should expand to encompass diverse aroma types. Particularly, Sichuan's Yibin region, a key production area for strong-flavored Baijiu, requires more strategic studies, covering aspects such as industrial chain development, brand building, and global market expansion.

(2) Industry Integration and Innovation

The integration of the Baijiu industry with tourism is a growing research hotspot. However, existing studies lack systematic frameworks. Governments, enterprises, and academic institutions should collaborate to establish research alliances, investigate successful and failed industry integration cases, and develop empirical models to guide future innovation.

(3) Strengthening Interregional Cooperation and University-Enterprise Collaboration

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In the process of enhancing university-enterprise cooperation, large-scale Baijiu companies must take the lead and set an example. With their strong financial strength, advanced technological reserves, and extensive industry experience, they should actively engage in deep strategic collaborations with renowned universities and authoritative research institutions. Together, they can establish industry-influential R&D centers. Focus should be placed on core areas closely aligned with the long-term development needs of enterprises, such as optimizing brewing processes, developing innovative products, and building intelligent production systems. Carefully planned and efficiently executed cooperation projects should be promoted, leveraging industry advantages to provide practical platforms and sufficient project funding for partners, ensuring the smooth progress of research work. Meanwhile, small and medium-sized enterprises should follow the lead of large companies, actively seeking cooperation opportunities with local universities or professional research teams. Based on their unique characteristics and market positioning, they should focus on critical aspects such as the fine development of specialty products, precise segmentation of niche markets, and efficient cost control, which are key to their survival and development. By utilizing external professional intellectual resources, these enterprises can continuously enhance their innovation capacity and market competitiveness. Through this collaborative model, with large companies leading and small and medium-sized enterprises actively participating, a comprehensive deep integration of universities, research institutions, and enterprises can be promoted. This will effectively improve the research level and innovation capabilities of the Baijiu industry, driving its sustained and stable development and injecting continuous vitality and momentum into the prosperity of the Baijiu industry.

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