

Visual Analysis of the Application and Development Trend of Cinnamon in the Field of Traditional Chinese Medicine Based on CiteSpace

Changbang CHEN, Ruitian ZHANG, Yongxi LAI, Yang YANG, Tianying LAN, Xiangling LI, Ning LIANG*

Guangxi University of Chinese Medicine, Nanning 530001, China

Abstract [**Objectives**] This study was conducted to explore the application and development trend of Chinese medicinal material cinnamon in the field of traditional Chinese medicine. [**Methods**] Articles published from 2008 to 2023 were exported using "cinnamon" as the subject word in the Chinese database of CNKI. Knowledge graphs were drawn by CiteSpace software on the number of articles published, the institutions publishing articles, and keyword clustering, and the data were sorted by Excel. Combined with the extracted information, the application of cinnamon in traditional Chinese medicine and integrated traditional Chinese and Western medicine was analyzed, and its development trend was discussed and prospected, providing further reference for researchers. [**Results**] The number of articles published showed an overall upward trend and maintained a high number of articles. In the analysis of the journals publishing articles, the journal with the largest number of articles was *West China Journal of Pharmaceutical Sciences*, which had certain representativeness. In the analysis of institutions publishing articles, the institution with the largest number of articles was Beijing University of Chinese Medicine, and most institutions had little cooperation. Four categories were obtained in keyword clustering, respectively, general research, component identification, production process and product development of cinnamon. "Glycyrrhizin" was the keyword with the earliest burst time, and the hot words that have received much attention in recent years are "medication law" and "data mining". [**Conclusions**] The application of cinnamon in the field of traditional Chinese medicine is mainly to treat diseases and as raw materials for traditional Chinese medicine products. The development trend is "quality control" and "product research and development". Further research and development of cinnamon in traditional Chinese medicine need to promote the participation of more institutions to participate, and cooperation and communication between institutions should be strengthened to promote the deep integration of production, research and academia.

Key words Cinnamon; CiteSpace; Application and development trend; Visual analysis; Traditional Chinese medicine; Knowledge graph

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The original name of cinnamon is "Yugui" and "Mugui", and cinnamon in China refers to the dry bark of *Cinnamomum cassia* Presl, a Lauraceae plant. The name "cinnamon" has been used since *Tang materia medica*^[1]. Because of its important edible and medicinal value, large market demand and objective economic benefits, it is mostly produced in Guangdong and Guangxi, of which Guangxi is the largest planting area of cinnamon, with cinnamon planting area and output accounting for over 50% of the total in China^[2]. According to *Chinese Pharmacopoeia*, cinnamon is mainly used to treat impotence, cold uterus, cold pain in waist and knees, asthma due to kidney deficiency, etc., and has the effects of tonifying fire and helping yang, guiding fire to origin, dispelling cold to stop pain, and warming meridians^[3]. It is often combined with other traditional Chinese medicines to relieve symptoms such as yang deficiency and exterior cold. As a traditional Chinese medicine with homology of medicine and food, cinnamon

trees are a treasure all over the body. The bark, branches and fruit of cinnamon trees all can be used as medicines^[4], and cinnamon can also be used as spice to improve the taste of food. Cinnamon is a characteristic traditional Chinese medicine with dual functions of medicine and food, which has high research value and good development prospects. In this study, with cinnamon as the key word, Chinese literatures of traditional Chinese medicine from 2008 to 2023 were collected, and the application and development trend of cinnamon in recent 15 years were visually analyzed using the visual literature analysis software CiteSpace.

With the in-depth research in the field of cinnamon in recent 15 years, there are a large number of documents in the Chinese database of China National Knowledge Infrastructure (CNKI). Therefore, CiteSpace, a scientific metrology software, is used for visual analysis, and Excel forms are used for data collation. CiteSpace is a citation visualization analysis software^[5], which focuses on analyzing potential knowledge contained in scientific literature and gradually develops under the background of scientometrics and data visualization. It can produce detailed scientific maps, objectively reflect the development frontier and direction of cinnamon, and mine information such as the amount of articles, publishing institutions and keywords from the time and space dimensions^[6]. Excel forms can process huge data analyzed by CiteSpace and sort out needed information. The combination of the two softwares provided objective information for the writing of this paper, and the application and development trend of cinnamon in

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Changbang CHEN (2002 -), male, P. R. China, major: devoted to research about application of traditional Chinese medicine.

* Corresponding author. Ning LIANG (1974 -), female, P. R. China, associate professor, devoted to research about immunomodulatory effect of traditional Chinese medicine and ethnic medicine.

the field of traditional Chinese medicine was discussed more scientifically.

Materials and Methods

Data source and search strategy

The documents were searched from the Chinese database of CNKI, with a professional search strategy of $SU\% = \text{'Cinnamon'}$ and $\text{'Chinese medicine'}$ or $\text{'traditional Chinese medicine'}$ or $\text{'Chinese medicine'}$ or $\text{'medicinal materials'}$. The search spanned from January 1, 2008 to December 31, 2023, while excluding non-research literature such as conference papers, guidelines, scientific and technological achievements, and popular science lectures. Subjects were selected as traditional Chinese medicine, Chinese pharmacy, and integrated traditional Chinese and Western medicine. A total of 2 184 academic papers and dissertations were retrieved. The retrieved literatures were imported into NoteExpress software for independent screening, and the screened literatures were exported as Refworks format files. The data were processed by CiteSpace(6.3. R1), and a total of 1 787 available literatures were obtained.

Data visualization

CiteSpace is an important research tool of bibliometrics, which can visually display a large amount of literature knowledge in a certain discipline through the form of knowledge map^[7]. Through CiteSpace(6.3. R1), the Refworks format references downloaded from CNKI were transformed into papers recognizable by the software to make visual analysis. The specific parameters were set as follows: (1) the time was from January 2008 to December 2023, and the time slice was one year; (2) the node screening method g -index set the k value to 10; (3) node type: keywords and institutions were selected respectively for analysis; and (4) for Pruning, pruning sliced networks was selected. As to the drawing of keyword clustering graph, keywords were extracted by the log-likelihood ratio (LLR) algorithm, and the clustering module value $Q > 0.3$ and the clustering average contour value $S > 0.5$ indicated a reasonable clustering^[7].

Data processing

The documents were exported in the format of "Refworks", and the texts were renamed as "download_XXX" in turn, and copied to the folder named "input". Then, the texts in the data folder were imported into the visual analysis software Citespace for translation, and the translated texts were copied to the folder named "data". Parameter setting of CiteSpace: The time partition was set from January 2008 to December 2023, and the time slice was set to one year, and the threshold was 10. Other settings remained unchanged, and keywords, authors and institutions were selected in turn for visual analysis.

Results and Analysis

Trend of the number of articles published

The annual number and trend of published articles reflect the research scale, development speed and attention in this field to a

certain extent, and are important indicators to measure the academic research in this field^[7]. In this study, the articles on cinnamon research from 2008 to 2023 in CNKI database were statistically analyzed, as shown in Fig. 1. Generally speaking, the number of published articles in this field has roughly experienced three stages: rapid growth stage, stable stage, and rapid decline stage. From 2008 to 2012, it was a rapid growth stage, during which the number of published articles increased annually, and the highest number published was observed in 2011. The period from 2012 to 2020 was a stable stage, with an average of more than 100 articles published annually, and a peak value of 135 was reached in 2016. The period from 2020 to 2023 was a rapid decline stage, during which the overall number of published articles showed a downward trend, with a large range, but the annual number of published articles exceeded 50.

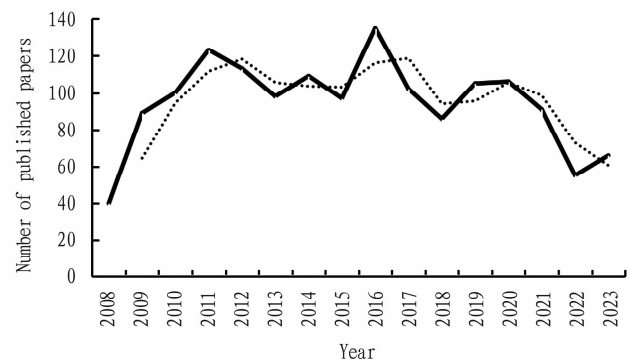


Fig. 1 Trend of the number of papers published on cinnamon from 2008 to 2023

Journals publishing articles

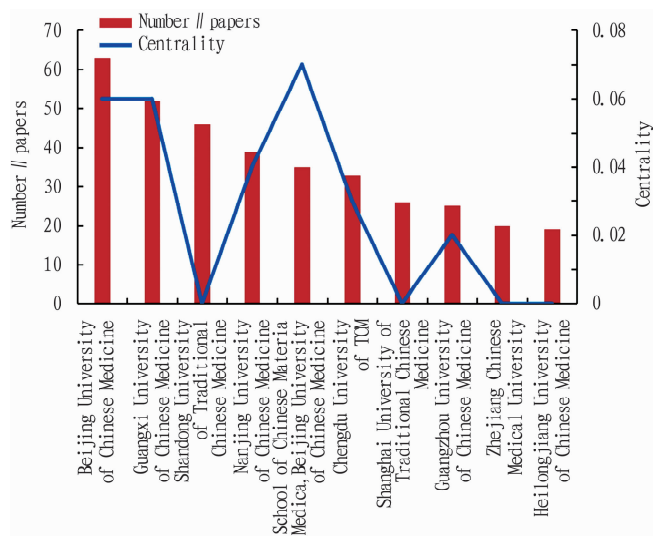
The rank of research journals is an important tool to measure the quality of research^[8]. The top 10 journals publishing articles on cinnamon in CNKI database were selected for statistical analysis, and the data are shown in Table 1. In the field of traditional Chinese medicine, the top three Chinese journals were West China Journal of Pharmaceutical Sciences (20 articles), Journal of Practical Traditional Chinese Internal Medicine (13 articles) and Journal of Shaanxi University of Chinese Medicine (5 articles). The journal with the largest number of articles was West China Journal of Pharmaceutical Sciences, and the number of articles published showed a discontinuous distribution. Among the top 10 journals, only West China Journal of Pharmaceutical Sciences, Food Research and Development and Applied Chemical Industry are core journals. In 2023, the top three journals with comprehensive impact factors were Food Research and Development (1.747), Journal of Tianjin University of Traditional Chinese Medicine (1.302) and Modern Journal of Integrated Traditional Chinese and Western Medicine (1.281). The number of articles published in these three journals was small, but the research was representative and the academic attainments were high. Among the top 10 journals, only three journals are at the core level of science and technology, which shows that the research of cinnamon in the field of traditional Chinese medicine is still less concerned by the mainstream of scientific research.

Table 1 Statistics of the top 10 journals publishing articles on cinnamon in CNKI

No.	Journal	Level	Impact factor	Number of papers published	Proportion//%
1	<i>West China Journal of Pharmaceutical Sciences</i>	CSSCI	1.231	20	35.09
2	<i>Journal of Practical Traditional Chinese Internal Medicine</i>	–	0.855	13	22.81
3	<i>Modern Journal of Integrated Traditional Chinese and Western Medicine</i>	–	1.281	5	8.77
4	<i>Journal of Shaanxi University of Chinese Medicine</i>	–	0.856	5	8.77
5	<i>Journal of Tianjin University of Traditional Chinese Medicine</i>	–	1.302	4	7.02
6	<i>Journal of Gansu University of Chinese Medicine</i>	–	0.787	3	5.26
7	<i>Food Research and Development</i>	CSSCI	1.747	2	3.51
8	<i>Applied Chemical Industry</i>	CSSCI, CSCD	1.139	2	3.51
9	<i>Western Journal of Chinese Medicine</i>	–	1.018	2	3.51
10	<i>Jiangxi Food Industry</i>	–	–	–	1.75

Statistics of institutions publishing articles

Statistics on institutions publishing articles will help to quickly find the teams at the forefront of research^[9]. The visual literature analysis software CiteSpace(6.3.R1) was employed to make preliminary statistics and visual analysis, and a co-occurrence network of research institutions was obtained, as shown in Fig. 2. The size of nodes represents the total number of papers published by specific institution on the research of cinnamon, and the annual rings represent the number of papers published in corresponding time period. Judging from research institutions that published the papers (Fig. 3), there were 199 institutions involved in the scientific research of cinnamon, mainly universities and medical institutions, among which Beijing University of Chinese Medicine showed the largest number of papers, reaching 63, and the research time span was also relatively large. Guangxi University of Chinese Medicine published 52 articles, which was the second most. The outermost ring of Heilongjiang University of Chinese Medicine was dark and wide, indicating that the number of articles on cinnamon published by this university was larger than that of other universities in recent years. School of Chinese Materia Medica, Beijing University of Chinese Medicine published 35 articles, and it only showed a large number of articles, but also the highest centrality (0.07), indicating that it had the most cooperative relationship with other research institutions in the publication of articles on the research of cinnamon.

**Fig. 2** Visualization of institutions publishing articles**Fig. 3** Statistics on number and centrality of articles published by institutions

Keyword clustering analysis

The keyword clustering of cinnamon literature is shown in Fig. 4. There are ten effective clusters, and the cluster numbers range from #0 to #9. The smaller the number, the larger the scale of literature research under this cluster. The analysis results showed $Q = 0.5359$, $S = 0.8457$, and the clustering module value $Q > 0.3$ and the clustering average contour value $S > 0.5$ indicated that the clustering was reasonable. According to different application categories of cinnamon, the 10 clusters could be divided into four categories.

#6 cinnamon belongs to a category, the main basis of which is the general study of cinnamon. Cinnamon is the dried bark of *Cinnamomum cassia* belonging to Lauraceae, mainly produced in Guangxi and Guangdong, and its medicinal value is high. Different parts of cinnamon trees can be used as medicinal materials, with different names, and it has the reputation of "all the body is treasure"^[5]. Knowing the value of cinnamon trees will help to determine the development mode of *C. cassia* and also help to identify the quality of cinnamon.

Cinnamic acid #0, chemical components #3, phenolic acids #5 and volatile oil #7 belong to one category, which is mainly based on the component identification of cinnamon. With the gradual deepening of modern science's understanding of cinnamon, its

chemical composition, pharmacological action and clinical application are gradually getting clear^[10]. The research content is no longer limited to the records in ancient medical books^[11], but has gradually been studied at the molecular level. It has been recognized that cinnamon contains many functional components such as volatile oil, cinnamic acid and coumarin, and has multiple pharmacological effects such as vasodilation, antioxidation and bacteriostasis^[11]. The identification and understanding of cinnamon components are of great guiding significance for product development and clinical application.

#1 extraction process and #9 quality control belong to the same category, which is mainly based on the production process of cinnamon. With the development of economy and the popularization of medical knowledge, people's awareness of health has become increasingly strong, and the demand for the medicinal herb cinnamon has also grown^[12]. At present, there are many problems such as high loss of cinnamon produced by traditional processing techniques and poor quality of artificially-cultivated cinnamon, and the output of cinnamon cannot fully meet the needs of all people. Therefore, how to completely extract effective components of cinnamon and ensure its quality is a concern in the context of the healthy era^[13].

#2 medication law, #4 Jiaotai Pills and #8 *Coptis chinensis* belong to one category, which is mainly based on the utilization of cinnamon and product development. Cinnamon has the effects of warming spleen and stomach for dispelling cold and promoting qi circulation to relieve pain^[14]. The use of single cinnamon can also have a good curative effect, but in the face of many stubborn diseases, combining cinnamon with other medicinal materials can really exert the greatest curative effect and minimize the occurrence of adverse reactions^[15].

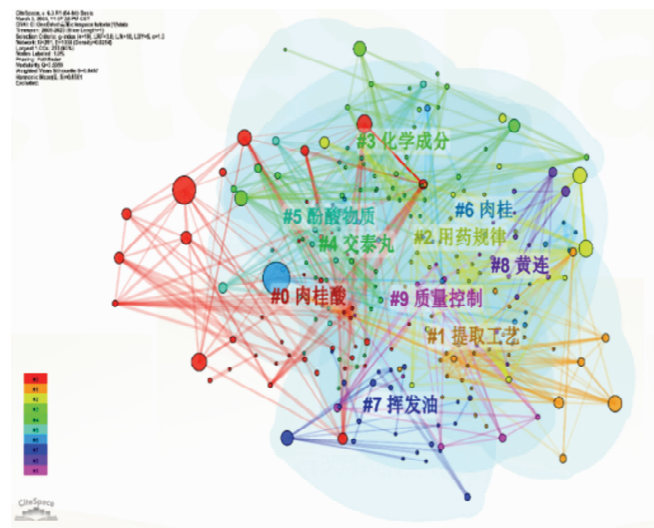


Fig. 4 Keyword clustering diagram of cinnamon articles

Research field analysis

The latest research hotspot can be determined by keyword analysis of cinnamon literature from 2008 to 2023, and the keywords with top 10 burst intensity are shown in Fig. 5. The burst rate of keywords can show the research hotspots, research directions and

development trends of cinnamon in different time periods. The top 10 research frontier terms in keywords of Chinese documents were extracted by using the burst detection algorithm of CiteSpace software, and a burst diagram of keywords in Chinese documents was obtained. The red line indicates the duration of burst keywords, and the blue line indicates the time period when the node begins to appear. The keyword 'glycyrrhizin' bursted from 2008 and lasted until 2011, making it the earliest bursted keyword. The keyword "thin layer chromatography" bursted from 2009, and the burst continued until the end of 2014. It was one of the keywords with the longest burst time. The keyword "data mining" had the highest burst intensity, indicating that it was the most popular word in a certain period of time. The burst intensity of the keyword "medication law" was second only to "data mining". The words with close burst time indicated the topics that have attracted much attention in recent years, such as "medication law", "data mining" and "intestinal flora".

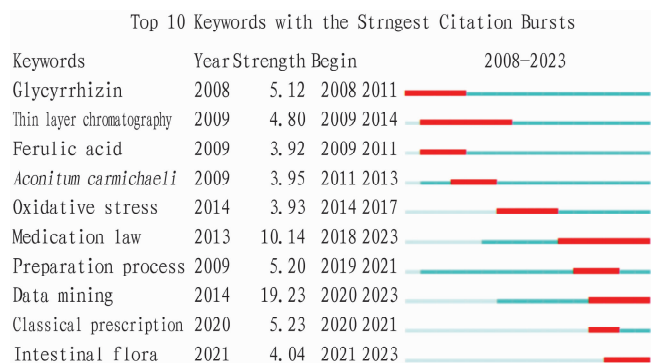


Fig. 5 Burst keyword diagram

Discussion

In this study, a total of 2 184 papers on cinnamon in the field of traditional Chinese medicine were collected from CNKI. The collected documents were visually analyzed to describe the research situation of cinnamon in the field of traditional Chinese medicine, and to deeply explore the application and development trend of cinnamon.

Cinnamon resources

C. cassia is a tropical and subtropical evergreen tree species belonging to *Cinnamomum* of Lauraceae^[16]. Its origin comes from Herbal Medicine of *Tang materia medica*. The bark of *Cinnamomum cassia* is used as medicine^[17]. Its bark is grayish brown and fragrant. It is not only a famous spice, but also a valuable Chinese medicine. Cinnamon in China is mainly distributed in Guangdong, Guangxi, Sichuan, Fujian and other regions, and the planting area of cinnamon in Guangxi and Guangdong accounts for more than 95% of the country^[18]. After long-term artificial cultivation and natural selection, cinnamon plants have formed many varieties or lines. According to different processing methods, cinnamon can be divided into Bangui, Yougui and Guitong^[19]. According to the different producing areas, cinnamon can also be divided into many types. For example, in Guangxi, cinnamon can be divided into "Dongxing Gui" and "Xijiang Gui", and Dongxing Gui is also

called "Fangcheng Gui", which is mainly planted in Fangcheng, Shangsi, Longzhou, Daxin and other places in Guangxi. Xijiang Gui, also known as Xungui in ancient times, is mainly cultivated in Pingnan, tengxian and Guiping^[20]. With the increasing demand of cinnamon, wild cinnamon trees can no longer meet the market demand. At present, they are mainly planted manually. With the promotion of healthy China policy^[21], the planting and processing of cinnamon will be strictly controlled in the future. Understanding the distribution of cinnamon tree species and processing techniques will play an important role in the development of cinnamon industry.

Application value and chemical composition of cinnamon

Cinnamon is classified as a medicine for warming the interior in the classification of *Traditional Chinese Pharmacology*^[22], which has the effects of warming spleen and stomach for dispelling cold and promoting qi circulation to relieve pain. Cinnamon trees are a combination of spices, medicinal materials and timber^[23]. The bark is peeled into cinnamon, which warms the middle warmer, tonifies the kidney, dispels cold and relieves pain. The tender branches are cassia twigs, which perspires and relieves muscles, and warms and unblocks meridians^[24]. Guizhi Decoction is one of the most classic prescriptions in Zhang Zhongjing's *Treatise on Febrile Diseases*. Hypocarp (Guizhong) and fruit (Guizi)^[25] treat stomach pain due to deficiency cold. Cinnamon oil can be distilled from branches and leaves, and its main chemical components are cinnamaldehyde, cinnamyl acetate, ethyl cinnamate, 2-methylcinnamaldehyde, benzaldehyde and coumarin^[26]. Cinnamon oil is an important spice, and it is also used as a medicine, as well as for Coca-Cola chocolate cigarette ingredients and other daily necessities^[27]. In addition, a large amount of cinnamon wood is produced after cinnamon is harvested. According to the characteristics of cinnamon fiber and the volatile aromatic components such as cinnamaldehyde contained in cinnamon wood, it can be used to develop products such as health pillows and health mats^[28], and cinnamon sawdust^[29] can be used as a substrate for cultivating edible fungi with high nutritional value.

Cinnamon contains volatile components such as cinnamaldehyde and non-volatile components such as polysaccharides, diterpenes, polyphenols and flavonoids. Modern pharmacological research shows that cinnamon has many pharmacological effects, such as lowering blood sugar, lowering blood fat, resisting tumor, resisting oxidation, resisting bacteria and viruses, relieving stomach injury and improving learning and memory ability. At present, it is commonly used in the treatment of osteoporosis, reproductive system, metabolic syndrome, tumor, cardiovascular and nervous system diseases^[30], and has become the focus of research at home and abroad in recent years because of its wide application and good pharmacological effects.

Visual analysis of cinnamon

According to the annual number of articles published, during the period from 2008 to 2023, the number of articles published on cinnamon in CNKI generally showed an upward trend. Except that the number of articles published decreased for the influence of COVID-19 epidemic in 2020 – 2023, the popularity of cinnamon literature has always remained high. Various institutions and

people at home and abroad have been involved in the research in this field, which shows that cinnamon has many fields to be studied and developed.

According to the data of research institutions analyzed by CiteSpace(6.3.R1), the main research subjects in this field are mainly secondary colleges under the control of Chinese medicine universities in China, followed by the affiliated hospitals of Chinese medicine universities and laboratories at provincial and municipal levels. Beijing University of Chinese Medicine and Guangxi University of Chinese Medicine have made outstanding achievements in this field, with the largest number of papers published. The document *Study on formula and syndrome research of Chaihu Guizhi Decoction* by Beijing University of Chinese Medicine^[31] and *Ye Tianshi's Nature and Flavor Research Theory* by Shandong University of Traditional Chinese Medicine^[32] are famous, and they are also cited the most frequently. Generally speaking, there are a large number of papers published by research institutions, but few universities cooperate with each other, and many universities still conduct research in this field by "going it alone". In addition, the degree of participation of affiliated hospitals, laboratories and enterprises in this field is relatively low, and the data of clinical medication and market sales are relatively scarce, which shows that all institutions should strengthen exchanges and cooperation, sort out and mine more information, and further improve the research level in this field.

Combined keyword clustering with keyword burst, it could be seen that current research on cinnamon still maintains a high level of popularity. In the past 15 years, there are mainly three categories: component determination, quality control and product development of cinnamon, among which the keyword of component determination appeared the earliest, but it came to an abrupt end in 2014, and the research focus in recent five years was mainly on quality control and product development. It shows that with the improvement of national policies, the improvement of people's concept of high quality and the constant change of diseases, the current prescriptions involving cinnamon can no longer meet the treatment needs of contemporary people, and the future research direction may develop towards the two hot spots of "quality control" and "product research and development", which is also a reasonable change in line with the characteristics of real medical development^[33].

Limitations

This study has some shortcomings. First of all, there are a large number of literatures on the subject of cinnamon. If all the literatures are exported for visual analysis, the topics will not be concentrated, which will affect the accuracy of their keywords. Therefore, only Chinese literatures of cinnamon in the field of traditional Chinese medicine were exported from the authoritative comprehensive database in CNKI. In most English core databases, such as Web Of Science and Pub Med, there are few literatures about cinnamon in the field of traditional Chinese medicine, and the influencing factors are low, English literatures were not introduced. Secondly, CiteSpace(6.3.R1) is a visual document analysis software^[34], which only analyzes derived citations, but does not analyze the contents of whole documents in detail, so there are

some omissions in the overall detection of documents. Thirdly, it took a long time to collect documents, and different documents might have different opinions on the definition, composition and application of cinnamon, which might lead to the deviation of the keywords analyzed. Despite the aforementioned shortcomings, the discussion on the future application and development trend of cinnamon in this study is still scientific, which can provide some reference for the next research.

Summary and Prospects

In recent 15 years, there are a large number of Chinese literatures on the subject of cinnamon, and the research directions are different, and there are different hot spots at different stages, but they are mainly concentrated in four aspects: literature research, component determination, quality control and product development. With the gradual thorough understanding of the main components and curative effects of cinnamon, the future development direction of cinnamon tends to be quality control and product research and development. However, how to promote the research in this field with higher efficiency and quality requires the country to improve relevant policies and encourage more institutions to participate in the research, so as to accelerate the development speed of this field, and provide reference for the clinical application and product development of cinnamon in the future, as well as a basis for high-level research in the next step.

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