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Original Article

Analysis on patents of health care products with substances of medicine food homology in China

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ABSTRACT

Objective: The concept of substances of medicine food homology (SMFH) has garnered significant attention in recent years. This study conducts a systematic analysis of patent literature related to SMFH, and elucidates the development trends, technical hotspots, and the overall patent protection landscape of SMFH in China over the past two decades.

Methods: The patent search focused on the SMFH varieties as the objects of inquiry, with retrieval conducted in patent databases. Subsequently, the acquired data underwent processing, analysis, and visualization.

Results: While the technical threshold for pharmaceutical applications surpasses that of the food service sector, the former may assume a prominent role in the future. Research and development (R&D) activities in the southeast of China demonstrate robust activity than other regions. Colleges and scientific research institutions exhibit substantial advantages in patent applications compared with individuals and hold greater potential for future development.

Conclusion: The findings of this patent analysis indicate that China's SMFH industry are presently undergoing a transition from an extensive model to a high-quality model. The quality and technical standards of SMFH products are consistently improving. Consequently, there is a need for more stringent patent application requirements to align with the evolving development needs.

1. Introduction

Health food products are in high demand worldwide, and the names vary from country to country due to cultural differences (Fan et al., 2012). For example, it was called "healthy foods" in Europe and United States of America (USA), and "functional foods" in Japan. According to statistics, in 2021, the global health food market reached 2 441.4 billion yuan (RMB). It is predicted that the market size of health food will grow to 3 885.4 billion yuan in 2028, of which the largest production is in USA, followed by Europe and Japan.

"Substances of medicine food homology" (SMFH), referring to substances traditionally used as food and listed in the *Pharmacopoeia*, have the characteristics of both food and medicine (Chen, 2023; Hou & Jiang, 2013). As an important part of the traditional Chinese medicine (TCM) health industry, the development of SMFH products in China has become a new economic growth point for the TCM industry (Xia, Yao, Lai, Xue, & Hu, 2022; Zou, 2016). According to the research results of the Chinese Academy of Social Sciences, the safety and effectiveness of SMFH products have made people gradually shift from reliance on drugs to food therapy (Qu, Yu, Ma, & Wang, 2023). Till 2019, the national health care products market, including the output value of SMFH products, has reached more than 300 billion yuan, with an annual growth rate of 14%.

The research and development (R&D) of food, pharmaceuticals and health care products has always been a typically technology-intensive industry, which means that it is in a highly competitive market environment (Gong, Ji, Xu, Zhang, & Li, 2020). China enacted the *Patent Law* in 1985, and formally implemented product patent protection for drugs and chemical substances in 1993. The establishment of the intellectual property rights system provides a favorable legal environment for the innovative R&D and the transformation of the research fruits in food, drugs and health product industry (Du, Deng, & Chen, 2022). The patents on SMFH have been accumulated into a significant quantity, thus formed a type of important scientific and technological literature resources.

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In-depth mining of patent information is important for reducing the cost of R&D, expanding the world market and protecting the intellectual property rights of TCM in China.

In recent years, with the background of healthy China policy, the inheritance and utilization of SMFH resource have become a hot spot concerned by both society and market (Gong, Ji, Xu, Zhang, & Li, 2020; Xia, Yao, Lai, Xue, & Hu, 2022). In addition, the adjustment and expansion of the catalog of SMFH present more development opportunities of the technological innovation, product research and upgrading for the traditional enterprises (Hou & Jiang, 2013). Therefore, it is necessary to conduct an in-depth patent analysis to outline the development trend and industrial pattern of SMFH. This study summarizes the patent application data of the SMFH products in the last 20 years, and analyzes the development trend, technical hotspots and layout of patents, so as to provide reference for the technological development, market development and industrial application of the SMFH products industry, and to provide a data basis for the strategy of high-quality development of China's TCM health industry (Morikawa, 2022).

2. Data sources and search methods

2.1. Patent information sources and search range

A retrieval of the patents on SMFH products had been carried via the Runtong Patent Database (https://www.rainpat.com/). The retrieval was limited to invention patents. The time range was from January 1, 2002 to December 1, 2022.

As to the territory of the patents, the Derwent Innovations Index has been employed to conduct a pre-retrieval of the patents overseas, including Japan, the USA, Korea, and other countries, as well as the European Patent Office (EPO) and the World Intellectual Property Organization (WIPO). The total number of foreign patents related to SMFH is much lower than that of China. Thus, the territory is limited to China to reduce information interference.

2.2. Patent retrieval strategy

The substances listed in the two lists of "materials that are both food and medicine" and "materials that can be used in health food" stipulated in the *Notice of the Ministry of Health on Further Standardization of the Management of Health Food Ingredients* ([2002] No. 51) were used as the key words in the retrieval formula, which included 87 species in the former list and 114 species in the latter.

Generally, for the patent search of a specific TCM material, it is usually necessary to include the plant Latin name, English name, material Latin name, and pinyin name as key words. While in this study, only Chinese patent database was used in retrieval. According to the actual situation, only Chinese proper names and common synonyms were used as key terms for each SMFH variety.

During the search process, the patents of main ingredients or extracts were excluded. There were some cases in which the names of materials appear in the main ingredients, such as rhodiroside, rhodiol, and rhodioside in *Rhodiola rosea* L., which inevitably appear in the search results. This situation was removed by manual cleaning. The terms inducing much more false results, such as ginsenoside and maltodextrin, were specifically excluded via the search formula.

In terms of the technical points of patent protection, this study focused on the patents on food, pharmaceuticals, and other types of health care product, thus the patents on cultivation, harvesting, storage, production, and process flow had been excluded, which was achieved by setting International Patent Classification (IPC) numbers in the search formula. A search formula was constructed using the above search strategy, and a total of 33 457 patent records were retrieved.

2.3. Data cleaning

The obtained patents were exported from the patent database for data cleaning. First, the patents that did not meet the requirements were eliminated by a combination of manual and software methods. After that, the information such as the name of the patent owner, patent number, application number, various dates, IPC classification number, etc. were standardized separately to facilitate the following statistical analysis. After data cleaning, total 32 789 patent records were remained as the data set for the following analysis.

2.4. Data management and analysis tools

The cleaned patent data are stored and managed using MS Excel and Access. The analysis and data visualization were carried using MS Excel and R language.

3. Statistical analysis

3.1. Analysis of development trend

The annual patent application status can visually outline the development history of R&D of SMFH in general. As shown in Fig. 1, in the past 20 years, the number of patent applications for the SMFH has shown a wave-shaped development, reaching a historical peak in 2016, when the number of patent applications reached 4 434.

The development of SMFH can be divided into four stages based on the perspective of patent application. In the initial development period (2002–2010), the average number of annual applications in this stage was around 600. In the rapid development period (2011–2016), this phase saw a spurt of patent applications in six years, with the annual number of applications rising steeply from 1 100 to 4 400 and peaking in 2016, with an overall increase of three times. The decline period (2017–2019), in which the annual application volume dropped steeply back to the 2011 level from the peak in 2016 due to the influence of the national patent application policy. Adjustment period (2020–2022), during which the annual application volume was around 1 000 pieces.

From the viewpoint of growth rate, before 2017, the SMFH industry was basically in incremental development. In 2003, the starting stage, the growth rate even reached 700%, and the growth rates in 2005 and 2012 both exceeded 70%. After 2017, the growth rates of patent application of the whole industry were in negative values, and in 2019, it even reached −57%, which implyed that the industry R&D activity entered a low period.

3.2. Geographical distribution

The technology source region is the province and region, where the inventor is located, and thus is the location of R&D. The number of patent applications in each province can, to a certain extent, reflect the active degree of technological innovation in the region. As shown in Table 1, patent applications for SMFH products in China mainly come from developed coastal provinces such as Anhui, Jiangsu, Shandong, Guangdong and Guangxi. Among them, Anhui Province has a very prominent application volume, which is worthy of in-depth study.

It is noteworthy that Xinjiang, Qinghai, Hainan, Ningxia, Inner Mongolia and Xizang, the six provinces inhabited by ethnic minorities, all ranked at the bottom of the application of patents for

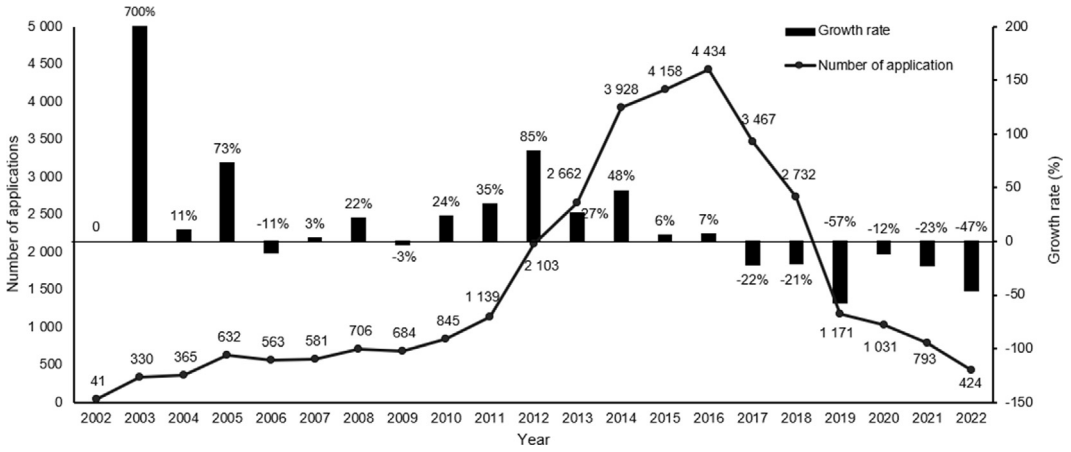

Fig. 1. Patent application status of SMFH products.

Table 1
Amount of SMFH patents by provinces and regions, China.

ID	Provinces	Application	ID	Provinces	Application	ID	Provinces	Application
1	Anhui	5 116	12	Hunan	809	23	Jiangxi	384
2	Jiangsu	3 682	13	Guizhou	755	24	Chongqing	370
3	Shandong	3 266	14	Shaanxi	720	25	Shanxi	367
4	Guangdong	2 656	15	Shanghai	595	26	Xinjiang	171
5	Guangxi	2 300	16	Tianjin	570	27	Qinghai	151
6	Zhejiang	1 681	17	Jilin	562	28	Hainan	131
7	Beijing	1 363	18	Fujian	541	29	Ningxia	122
8	Henan	1 354	19	Yunnan	535	30	Inner Mongolia	120
9	Liaoning	994	20	Heilongjiang	521	31	Hong Kong, Macau and Taiwan	71
10	Sichuan	944	21	Hebei	448	32	Xizang	40
11	Hubei	813	22	Gansu	429			

SMFH, and the overall application volumes of the six provinces were within 200 pieces. The advantages of ethnic medicine and medicinal plant resources in these provinces have not been fully explored, and the R&D level of related health care products is low, which may indicate a greater development potential.

From Figs. 2 and 3, the overall time distribution of domestic provinces in terms of the application of SMFH patents is consistent with the trend in Fig. 1, but there are also a few differences. The three provinces, Jiangsu, Henan and Beijing, entered the rapid growth of application volume slightly earlier than other provinces, indicating that these three provinces noticed the health care value of SMFH earlier. The other provinces represented by Guangdong and Sichuan, whose application peak is slightly later than other provinces, but the development shows a relatively better continuity.

The overall application volume from foreign, Hong Kong, Macao and Taiwan institutions on SMFH products in China is less than 200, and the annual application volume is at the level of a dozen or so. Although far less than that of most domestic provinces, the patent application volume of these two sources has been maintaining an upward trend on the whole, which is relatively different from the domestic wave-shaped curve (Fig. 4). The foreign, Hong Kong, Macao and Taiwan research institutions seem paying more and more attention to the health products market in mainland China and are gradually investing more R&D efforts.

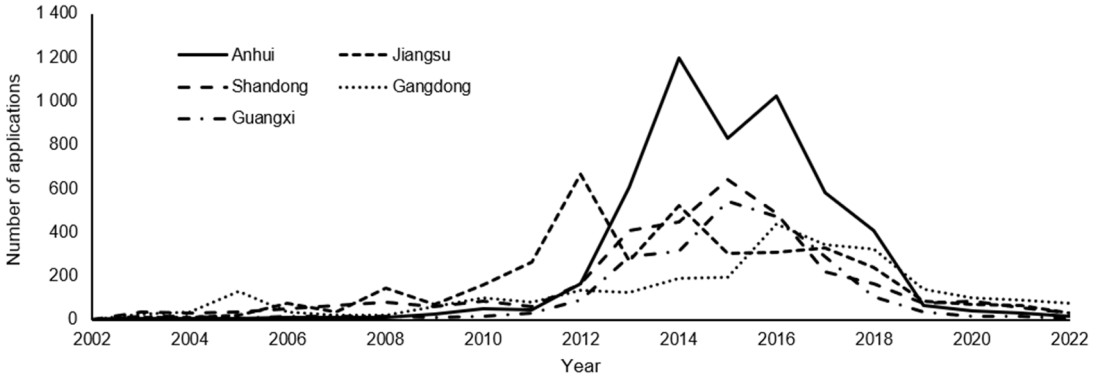

Fig. 2. Key provinces' patent application status for SMFH over years (Top 5).

Provinces	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Anhui	0	5	3	3	8	10	10	27	50	45	162	604	1 195	828	1 025	583	405	66	42	30	15
Jiangsu	2	11	10	19	75	35	146	72	160	265	666	268	523	305	309	329	241	84	70	64	28
Shandong	1	34	31	34	49	65	82	59	86	59	162	406	447	641	485	220	166	74	84	53	28
Gangdong	1	25	35	129	37	18	22	59	102	82	135	123	191	194	435	341	324	141	98	90	74
Guangxi	2	14	16	7	15	15	15	12	13	28	89	286	315	539	474	288	103	34	15	15	5
Zhejiang	3	23	34	150	47	15	33	30	28	63	80	86	148	295	179	199	102	55	50	43	18
Beijing	13	16	26	21	33	132	71	54	51	82	111	67	86	81	127	94	104	63	65	44	22
Henan	1	12	18	13	29	33	41	54	42	30	82	116	181	195	153	117	111	44	42	26	14
Liaoning	2	21	25	33	29	50	39	21	34	98	68	113	92	48	91	94	57	27	27	13	12
Sichuan	1	9	11	17	23	15	30	32	20	35	25	53	59	101	122	154	95	38	46	37	21
Hubei	0	9	7	12	20	11	29	26	23	17	35	49	32	53	99	113	118	44	65	33	18
Hunan	1	14	15	14	13	18	22	13	21	23	23	36	68	70	104	86	109	62	58	28	11
Guizhou	1	5	4	7	14	8	3	3	13	14	36	26	75	83	126	126	134	27	24	21	5
Shaanxi	3	12	8	9	9	17	13	22	11	24	66	56	42	76	51	133	101	26	22	12	7
Shanghai	3	17	19	16	20	12	10	19	12	25	46	24	27	47	71	44	49	31	32	35	36
Tianjin	3	17	2	12	39	30	23	35	11	23	44	36	44	60	60	31	44	13	15	22	6
Jilin	1	6	6	15	14	9	15	18	29	27	34	38	39	61	65	47	48	25	38	21	6
Fujian	0	3	10	7	6	10	4	15	13	23	18	51	43	69	83	64	40	19	25	27	11
Yunnan	0	11	13	13	15	11	14	17	14	35	28	27	41	39	49	50	58	37	24	24	15
Heilongjiang	1	10	12	29	17	13	14	16	9	15	28	21	80	62	43	37	25	28	27	22	12

Fig. 3. Heat map of patent applications by provinces, China for SMFH (top 20). (Dark gray: high; Medium gray: medium; Light gray: low).

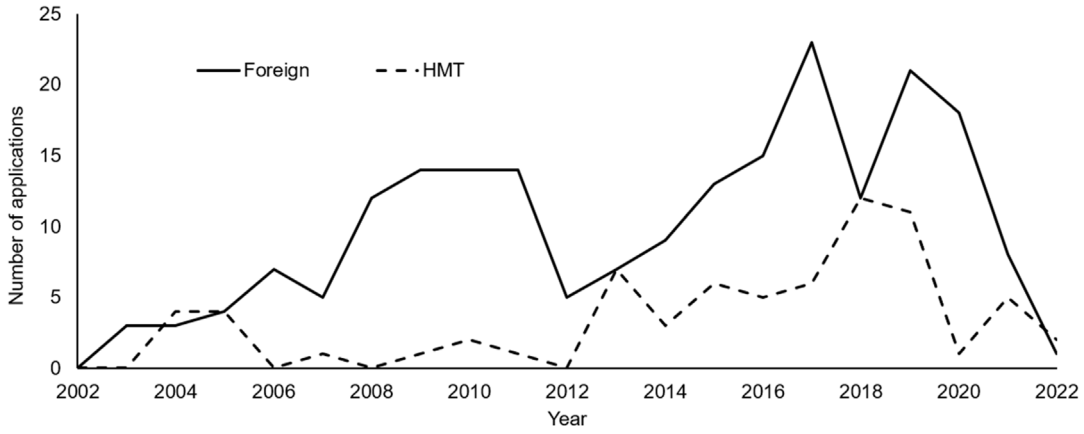

Fig. 4. Foreign and HMT (Hong Kong, Macao and Taiwan, China)'s application over years.

3.3. Technical theme analysis

3.3.1. IPC class distribution

The distribution of technical categories of patents in the field of SMFH can be effectively outlined by the information of the IPC. In this study, the statistical analysis is based on the information of the main classification numbers of the collected patents. Fig. 5 shows the distribution on class level. The Top5 of the largest classes are: A23 food (18 527, 57%); A61 medical or pharmacy (9 470, 29%); C12 beverage (3 941, 12%); A47 household goods (702, 2%); and A43 footwear (149, 0.2%). Food is the main body of new product development for health care products (Table 2).

As shown in Fig. 5, the number of patent applications in the food category underwent a rapid rise and a rapid fall between 2012 and 2019, with a much higher fluctuation than the other four categories of patents. Therefore, the fluctuating changes in patent applications shown in Fig. 1 are mainly determined by the changes of applications in the food field. In contrast, the changes of pharmaceutical patents are relatively calm. After 2020, they have implicitly overtaken food patents to become the largest field of SMFH patents, showing great potential in development. The R&D of pharmaceutical products has higher technological content and is the backbone of technological development in the field of SMFH. The R&D of food and beverage products is more influenced by external factors such as market and policies, thus is prone to substantial fluctuations.

3.3.2. IPC subclass distribution

Fig. 6 shows the distribution of patent application time at the subclass level. The top five subclasses are: A23L food patents, 13 887 (42%); A61K medical or pharmaceutical patents, 9 470 (29%); A23F coffee and tea patents, 4 640 (14%); C12G fruit and wine patents, 3 455 (11%); and A47G patents related to household goods, 702 (2%) (Table 2). The trend of each subclass is basically the same as that of the class categories. It is worth noting that tea and fruit wine patents had a booming "golden decade" during

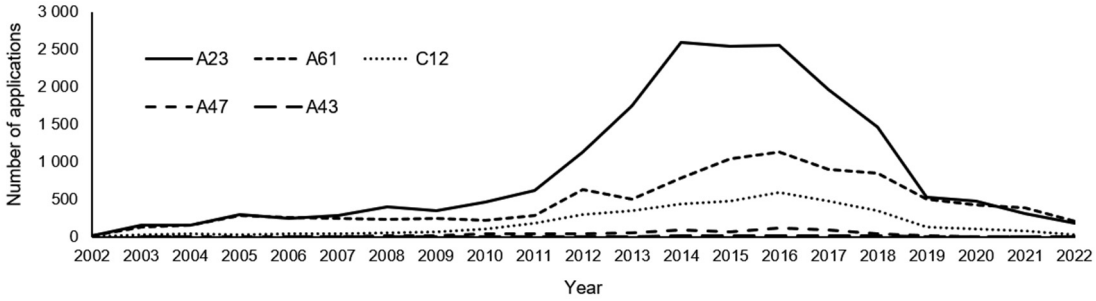

Fig. 5. Time distribution of top 5 IPC class categories.

Table 2
Amount and proportion of top5 IPC class and subclass categories.

		Meaning	Total amount	Percentage (%)
Class	A23	Other types of food or foodstuffs and their handling	18 527	57
	A61	Medicine or veterinary medicine; health science	9 470	29
	C12	Biochemistry; beer; spirits; juice wine; vinegar; microbiology; enzymology; mutation or genetic engineering	3 941	12
	A47	Furniture; articles or equipment for household use; coffee mills; spice mills; general vacuum cleaners	702	2
	A43	Footwear	149	0.2
Subclass	A23L	Foodstuffs, edibles or non-alcoholic beverages not included in subcategories A21D or A23B to A23J; their preparation or treatment, such as cooking, improvement of nutritional quality, physical treatment	13 887	42
	A61K	Medical, dental or grooming preparations	9 355	29
	A23F	Coffee; tea; its substitutes; their manufacture	4 640	14
	C12G	Juice wine; other alcoholic beverages	3 455	11
	A47G	Houseware or tableware	702	2

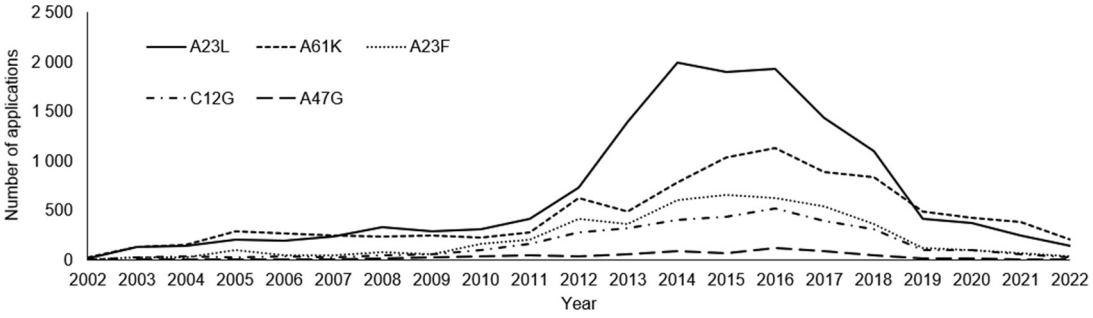

Fig. 6. Time distribution of top5 IPC subclass categories.

2009–2019, and then returned to the situation of 10 years ago. Whether it is the real rapid development of the relevant industries, or the false prosperity triggered by certain policies and wind gusts, it is worth studying.

The analysis of the proportion of IPC subclasses of SMFH patents can reflect the characteristics of the industrial structure of each province. We selected nine representative provinces (Table 3), which are divided into four categories: (1) the provinces with more

Table 3
Proportion of IPC subclass in representative provinces, China.

Provinces	A23F	A23L	A61K	C12G	A47G	Others
Anhui	844 (16.5%)*	3 025 (59.1%)	493 (9.6%)	546 (10.7%)	86 (1.7%)	122 (2.4%)
Jiangsu	686 (18.6%)	1 147 (31.2%)	1 132 (30.7%)	502 (13.6%)	144 (3.9%)	71 (1.9%)
Shandong	424 (13.0%)	1 586 (48.6%)	831 (25.4%)	305 (9.3%)	64 (2.0%)	56 (1.7%)
Guangxi	418 (18.2%)	1 041 (45.3%)	389 (16.9%)	372 (16.2%)	44 (1.9%)	36 (1.6%)
Zhejiang	312 (18.6%)	792 (47.1%)	384 (22.8%)	78 (4.6%)	65 (3.9%)	50 (3.0%)
Guangdong	267 (10.1%)	1 011 (38.1%)	1 056 (39.8%)	204 (7.7%)	60 (2.3%)	58 (2.2%)
Beijing	99 (7.3%)	535 (39.3%)	654 (48.0%)	52 (3.8%)	8 (0.6%)	15 (1.1%)
Shanghai	33 (5.5%)	215 (36.1%)	312 (52.4%)	23 (3.9%)	3 (0.5%)	9 (1.5%)
Jilin	49 (8.7%)	260 (46.3%)	209 (37.2%)	39 (6.9%)	0 (0.0%)	5 (0.9%)

* Totol amount (percentage/%).

food patent, represented by Anhui, where the proportion of food patents exceeds 50% and tea beverage patents also have a significant proportion; (2) the provinces with food products as the mainstay and wine products as the characteristics, including Zhejiang and Guangxi; (3) the provinces with pharmaceutical patents as the mainstay, including Shanghai, Beijing and Jilin; (4) the provinces with balanced structure, where food, tea beverage, wine and pharmaceutical and other types of varieties of balanced development, including Jiangsu and other provinces.

3.4. Technology lifecycle analysis

The technology life cycle, generally divided into four stages: budding, growth, maturity and decline, is used to evaluate the total market changes of similar technologies or the performance of technologies. According to the changes in the number of patent applications and patent applicants over the years, the technology life cycle diagrams of individuals and institutions are drawn respectively (Fig. 7). The R&D activity of individual applicants in the SMFH reached the maturity period in 2014, entered the decline period after 2016, and has now regressed to the level of 2003. Institutional applicants reached the maturity stage in 2016 and have retreated since then, but the situation is relatively optimistic.

3.5. Patent owner analysis

A statistical analysis of patent owners provides information on the overall competitive dynamics in the R&D activity of SMFH. Statistics show that there are 9 304 institutional and 7 940 individual patent owners for the period 2002–2022. The technical conditions required for R&D of SMFH products are relatively high, while the resources that individuals can mobilize are very limited, therefore the quality of patents and the level of technical achievements are much inferior comparing to those of institutional applicants. The excessive number of individual applicants occupied a large amount of patent examination resources and generated too many low-quality patents, which was a serious problem in China in the past decades.

As shown in Fig. 8, the number of individual applications was slightly more than that of institutions before 2013, but the difference was not significant. The number of institutional applications greatly exceeded that of individual applications after 2013, and the difference in the number of the two reached the maximum in 2016. Since then, although the number of both applications has fallen, the ratio of institutional applications to individual applications has a tendency to increase continuously, indicating that institutional applicants have developed into the main body of R&D for SMFH.

The changes in the number of applications from various types of institution applicants were presented in Fig. 9. Enterprises have always been the main source of patent applications, much higher than other types of institutions, with a peak in applications during 2011–2019. Among other institutions, colleges and research institutions have filed more applications, and the overall trend of change is more moderate.

Six representative provinces were selected for applicant type analysis (Table 4). In the highest number of patent applications in Anhui, Jiangsu and Guangxi, enterprises and individuals are the main body of applicants. Compared with them, colleges and research institutions in Beijing, Shanghai and Jilin provinces occupy a higher proportion.

3.6. Legal status analysis

Analysis of the legal status can inform the patent granting situation of R&D in SMFH, and therefore is an important reference for the patent layout. As shown in Table 5, the proportion of patents in the status of being under review and valid is over 50% for both applicants from enterprises, followed by patents from individuals. As to the invalid patent, the proportion of individuals is the highest, reaching 48%, and that of enterprises is 42%, both of which account for the majority of the share. The applicants with a larger

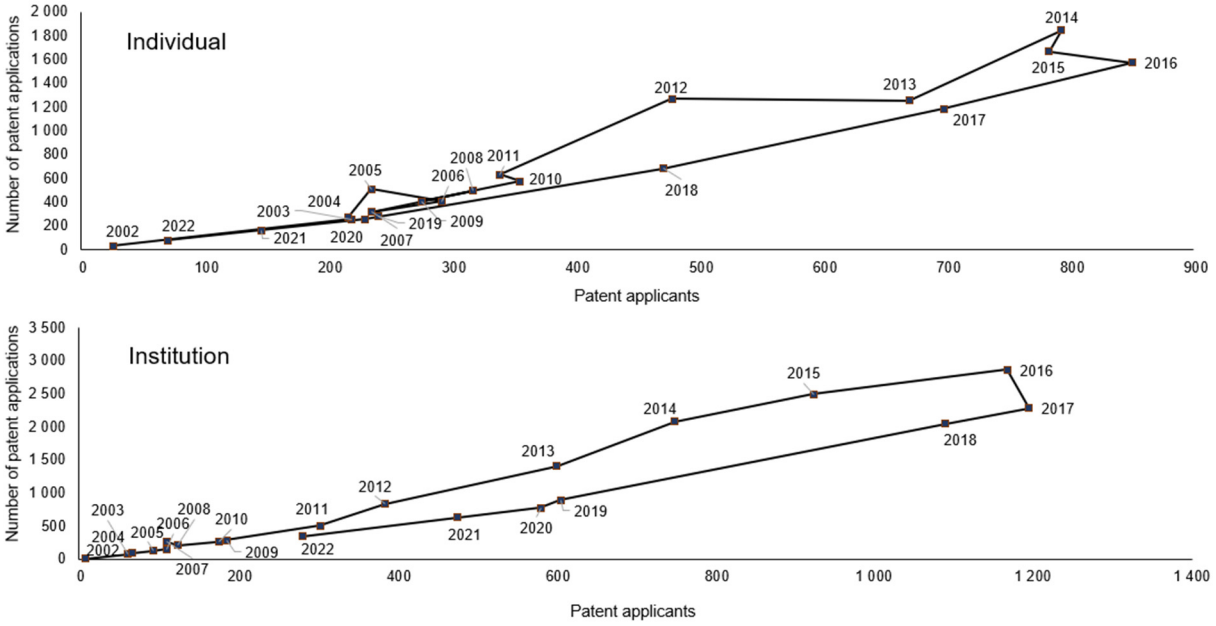

Fig. 7. Technology life cycle diagram of patents.

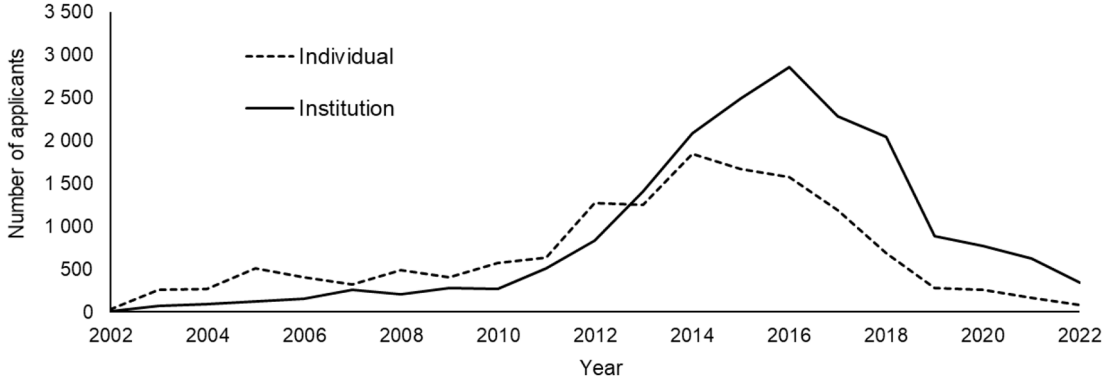

Fig. 8. Time distribution of individual and institutional applicants.

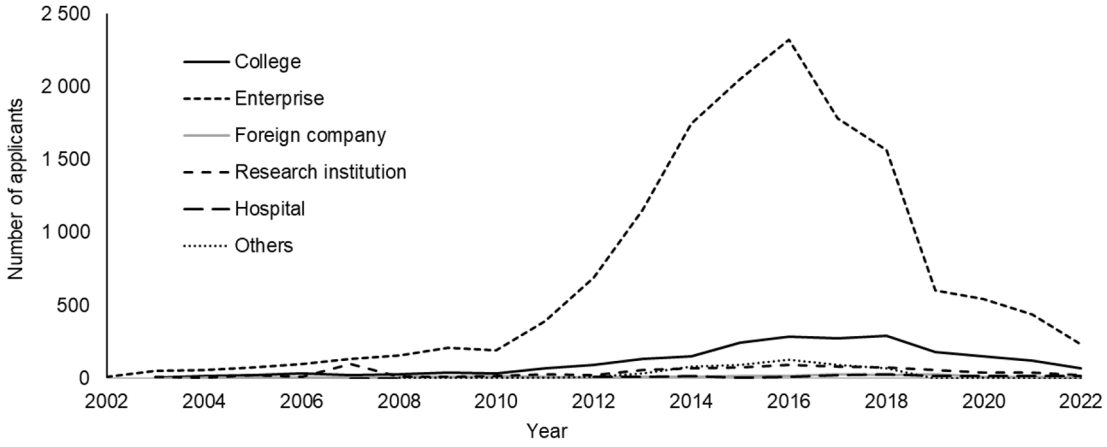

Fig. 9. Time distribution of applicant volume by types of institution.

Table 4
Applicant types in representative provinces.

Provinces	Individuals	Enterprises	Colleges	Institutions	Hospitals	Others
Anhui	1 832 (35.8%)*	2 933 (57.3%)	89 (1.7%)	9 (0.2%)	2 (0.0%)	251 (4.9%)
Jiangsu	2 074 (56.3%)	1 265 (34.4%)	226 (6.1%)	84 (2.3%)	8 (0.2%)	25 (0.7%)
Shandong	1 425 (43.6%)	1 640 (50.2%)	135 (4.1%)	48 (1.5%)	11 (0.3%)	7 (0.2%)
Guangdong	1 062 (40.0%)	1 289 (48.5%)	211 (7.9%)	76 (2.9%)	16 (0.6%)	2 (0.1%)
Guangxi	1 266 (55.0%)	734 (31.9%)	173 (7.5%)	37 (1.6%)	6 (0.3%)	84 (3.7%)
Zhejiang	808 (48.1%)	722 (43.0%)	112 (6.7%)	34 (2.0%)	4 (0.2%)	1 (0.1%)
Beijing	517 (37.9%)	596 (43.7%)	57 (4.2%)	165 (12.1%)	22 (1.6%)	6 (0.4%)
Shanghai	140 (23.5%)	306 (51.4%)	94 (15.8%)	22 (3.7%)	32 (5.4%)	1 (0.2%)
Jilin	194 (34.5%)	205 (36.5%)	128 (22.8%)	33 (5.9%)	0 (0.0%)	2 (0.4%)

* Totol amount (percentage/%).

share of valid patents are enterprises, with colleges and research institutions also accounting for a higher share.

The patent under examination can reflect the activity of recent R&D, and the valid patent can reflect the technical level of the applicant. The enterprises are more active in the application of SMFH as well as the technical strength, level and scale of operation (Table 5). The proportion of colleges and research institutions in valid patents is much larger than that in invalid patents, indicating that these two types of applicants apply for higher quality patents and obtain a higher proportion of grant.

Based on the time distribution of individual and institutional patents granted in Fig. 10, it can be found that the number of

Table 5
Applicant categories in each legal status patent.

Applicant categories	Under review	Valid	Invalid
Colleges	487 (14.8%)*	469 (13.5%)	1 329 (5.1%)
Others	11 (0.3%)	14 (0.4%)	522 (2.0%)
Enterprises	1 747 (53.1%)	1 784 (51.5%)	10 989 (42.2%)
Foreign companies	90 (2.7%)	56 (1.6%)	93 (0.4%)
Institutions	145 (4.4%)	180 (5.2%)	536 (2.1%)
Hospitals	57 (1.7%)	44 (1.3%)	80 (0.3%)
Individuals	752 (22.9%)	918 (26.5%)	12 486 (48.0%)
Total	3 289	3 465	26 035

* Totol amount (percentage/%).

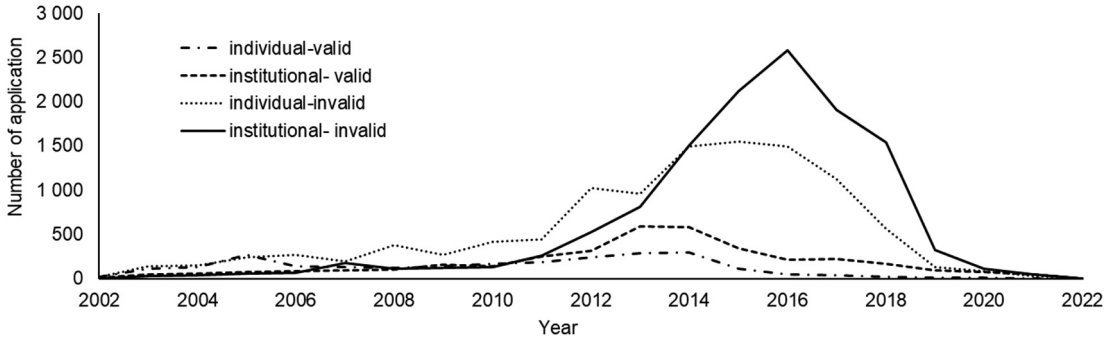

Fig. 10. Time distribution of individual and institutional patent grant status.

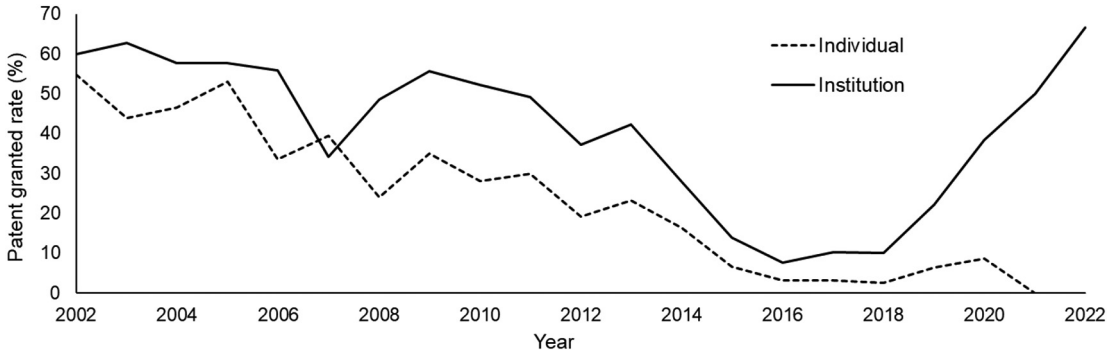

Fig. 11. Time distribution of individual and institutional patent granted rate.

"institutional-invalid" and "individual-invalid" patents has a large variation, among which the number of "institutional- invalid" patents has the largest variation. From 2014 to 2020, the number of "institutional- invalid" patents is higher than that of "individual- invalid" patents.

As can be seen from Fig. 11, the granted rate of individual patents has been in a downward trend overall, and the granted rate of institutions was in a downward trend between 2002 and 2016, after which it rapidly pulled up, and the granted rate of institutions was higher than that of individuals overall. During 2013 to 2016, there was a large downward in the granted rates for both individuals and institutions, which may be the main reason for which the patent application largely declined after 2016.

Based on the legal status of patents in each province (Table 6), the proportion of invalid patents is higher in Anhui, Jiangsu and Guangxi provinces, which is all around 90%. In Beijing, Shanghai and Jilin, the three patent states are relative in balance. The reasons for the invalid patents include the expiration of the validity period, non-payment of maintenance fee, limitation, revocation, and withdrawal of an application.

3.7. Keyword analysis

According to the word frequency analysis of patent names and abstract, it can be found that the SMFH patents mainly revolve around tea, wine, health foods and other beverages, which indicates the innovations of manufacturing techniques, therapeutic effects, formula and taste. Various kinds of tea drinks and extracts of Chinese herbal ingredients occupy half of the SMFH patents, and the key word "nourishment" appears more often, indicating that SMFH products are widely used in improving human immunity, supplementing the nutrition required by human body and preventing diseases (Fig. 12).

4. Discussion

Based on the various results of this study, the following conclusions can be obtained: (1) In terms of the overall trend, the SMFH patents in China have gone through four stages of germination, development, explosion and adjustment in the past 20 years. The

Table 6
Legal status of SMFH patent by province.

Provinces	Under review	Invalid	Valid	Total
Anhui	129 (2.5%)*	4 668 (91.2%)	319 (6.2%)	5 116
Jiangsu	258 (7.0%)	3 168 (86.0%)	256 (7.0%)	3 682
Guangxi	60 (2.6%)	2 117 (92.0%)	123 (5.3%)	2 300
Shanghai	131 (22.0%)	367 (61.7%)	97 (16.3%)	595
Beijing	190 (13.9%)	869 (63.8%)	304 (22.3%)	1 363
Jilin	79 (14.1%)	348 (61.9%)	135 (24.0%)	562

* Totol amount (percentage/%).

Fig. 12. Word frequency analysis of patent name (A) and abstract (B).

development in SMFH industry, which has also gone through a similar process, is currently in a period of transformation from a rough development mode to a high-quality development mode. The next climax is likely to come in the near future. (2) From the perspective of technology, food and medicine are the two key areas of SMFH's R&D. Food products are of low technology level and have entered the rapid development period earlier, with individuals and enterprises being the main body of R&D. Medicine and health care products are of high technology level, with enterprises, colleges and scientific research institutions being the main body of R&D. Although a little later than food's development, there is sufficient momentum in medicine and health care field, which may be the main field of SMFH's future development. (3) Geographically, the R&D activities in the southeastern provinces are relatively much more active, comparing with that in the central and western regions, especially in the minority-focused provinces. The ethnic medicine resources have not been fully explored, which may become a potential hotspot of R&D. (4) As to the type of patent applicants, individuals and enterprises were once the main sources of SMFH patents, while the quality of patents is worrying, and speculation cannot be ruled out. The situation has been greatly improved after 2016, colleges and research institutions have greater development potential and may become the main sources of high-quality and core patents.

Based on the above research findings, the author presents the following recommendations: (1) Improving the quality of patents via the control on application process (Li & Feng, 2016). Half of the patent owners in China are individuals. What's more, patent content is written by R&D personnel. These situations lead to a large number of low-quality patents. Therefore, it is necessary to improve the writing quality of patent from the application process. Focus on the inventions that are better suited to the market and technology development direction, and making reasonable layout of technical features and subject distribution. The product system should be cross-linked and the technical features are complementary to each other to form a high-value patent system. (2) Strengthening the R&D of SMFH, improving the technical level of the products, and conducting in-depth research on the most used SMFH species. Identifying the nutritional composition, refining the consumption dosage, method, frequency and applicable people of the relevant products, etc. The research should be tailored to meet the needs of the market. (3) Encouraging colleges and research institutions to carry out R&D activities, strengthening the links between research institutions, enterprises and the market, and promoting the industrialization of scientific research fruits through the deep integration of the industrial and innovation chain. (4) As to the local industries, which have formed regional advantages, the awareness of intellectual property protection should be strengthened through guidance by local governments and industry associations. Promoting the enterprises to modify the patent layout, driving the improvement of patent quality, and ensuring the incentive and protection for technological innovation. (5) Enhancing the scientific guidance of SMFH industry. The advanced IT technology should be introduced to supervise the aspects, including cultivation, production, circulation and product development, to achieve traceability and to guarantee product quality and safety. Establishing internationalization and branding to serve both international and domestic markets.

CRediT authorship contribution statement

Haibo Liu: Conceptualization, Data curation, Validation, Writing – original draft, Writing – review & editing. **Yanfeng Wang:** Writing – review & editing. **Jiali Huang:** Writing – review & editing. **Zhengqi Dong:** Project administration. **Peigen Xiao:** Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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