

## Research Article

## Global ginseng research

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## 초 록

지금까지 Web of Science의 core collection에 나타난 인삼 관련 연구논문의 수를 분석하였다. 인삼논문이 처음 나타난 1905년부터 2019년까지 전세계에서 총 8,090편의 SCI(E) 논문이 출판된 것으로 나타났다. 그중 최근 24년, 즉, 1996년부터 2019년까지의 논문이 7,385편이었다. 1980년 18편에 불과했던 인삼 논문이 1990년에는 53편, 2000년에는 97편, 2010년에는 369편, 2019년에는 678편으로 비약적으로 증가하였다. Web of Science의 core collection에 수재된 전체 학술논문에서 인삼 논문이 차지하는 비중도 1970년 0.0008%, 1980년 0.0044%, 1990년 0.101%, 2000년 0.0141%에서 2019년에는 0.0422%로 비약적으로 증가하였다.

지난 24년간 출판된 인삼 연구논문 중 원보(노트 포함)는 7,099편, 리뷰는 286편이었다. 총 78개국 3,286개 기관에서 연구가 이루어졌으며, 1,274개 학술잡지에 논문이 수재되었다. 전체 논문 중 중국에서 연구된 논문이 40.3%로 가장 높았고, 대한민국에서 연구된 논문이 34.7%로 한국과 중국의 연구가 전체의 75%를 차지하였다. 그 다음은 미국(6.0%), 일본(4.1%), 캐나다(2.9%) 순이었다. 2013년까지는 한국에서 연구된 논문이 가장 많았으나 2014년부터 중국에서 연구된 논문의 수가 더 많아졌다. 지난 24년간 인삼은 전세계에서 가장 많이 연구된 약용식물로 인삼 다음으로는 차(6,499편), 마늘(3,641편), 은행(2,590편), 생강(1,945편) 순이었다.

**주제어:** 인삼, 연구논문의 수, web of science

## Abstract

We conducted a comprehensive analysis of research papers on ginseng to provide an overview of global ginseng research. The qualitative and quantitative interpretation was carried out using collected data of Panax species and six other herbal plants from the Web of Science™ Core Collection. We summarized and classified them by country/territory and institutions based on the corresponding author's institution.

The first ginseng paper appeared in 1905 and since then, 8,090 papers have been published until 2019. Among them 7,385 papers were published in recent 24 years from 1996 to 2019. It was 18 papers in 1980, 53 in 1990, 97 in 2000, 369 in 2010, and increased to 678 in 2019. Proportion of ginseng papers in total number of scientific papers were also greatly increased, namely, 0.0008% in 1970, 0.0044% in 1980, 0.101% in 1990, 0.0141% in 2000, and 0.0422% in 2019.

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7,099 original research papers including notes and 286 review papers were published during last 24 years. Total 3,286 institutions in 78 countries and 1,274 journals contributed to the publication of ginseng papers. Korea was the leading country in ginseng papers up to 2013, however, China took over the top from 2014. Chinese institutions contributed 40.3% of total papers followed by Korea (34.7%), USA (6.0%), Japan (4.1%), and Canada (2.9%). Ginseng was the most studied medicinal plant during last 24 years followed by tea, garlic, ginkgo, and ginger whose number of papers were 6,499, 3,641, 2,590, and 1,945, respectively.

**Key words:** *Panax ginseng*, number of research papers, Web of Science, bibliometric

## INTRODUCTION

As demonstrated by its genus name, *Panax*, means “cure-all” in Greek, ginseng has been used in herbal remedies for more than 4000 years with the common belief that it can help patients fight a wide range of diseases<sup>1</sup>. Ginseng has been widely used in Korea, China, Japan, and other Asian countries for millennia. Although it was exported from Korea before the 5<sup>th</sup> century, it was not known in Europe until the 12<sup>th</sup> century and only received the attention of European scientists on the 17<sup>th</sup> century. In the first half of the 17<sup>th</sup> century, the East India Company imported ginseng to Europe and since then, Europeans have used ginseng to treat diseases<sup>2</sup>. The study of ginseng in the early 20<sup>th</sup> century was mainly focused on its pathology. Works on ginseng pharmacology were executed by Petkov and Brekhman from 1957 to 1969. In 1963, Shibata *et al.* reported the isolation of ginsenosides from ginseng, which triggered research in Japan. Over decades of enormous efforts, scientists have proven various benefits afforded by ginseng. Currently, more than 300 ginsenosides have been reported from *Panax* species, and each has generated multiple bioactivities<sup>3</sup>.

In terms of taxonomic hierarchy of ginseng, genus *Panax* comprises diverse species: *P. quinquefolius* and *P. trifolius* are inhabited in North America while *P. ginseng*, *P. notoginseng*, *P. pseudoginseng*, *P. japonicus*, and *P. vietnamensis* are collected in Asia<sup>4</sup>. So far thirteen *Panax* species have been accepted and recognized (<http://www.catalogueoflife.org/>). Furthermore, this herbal medicine has been under constant development regarding research and consumer marketing. Among *Panax* species, *P. ginseng*, *P. quinquefolius*, and *P. notoginseng* are the most well-known. *P. ginseng* is currently the most popular *Panax* species in the world. In addition to the three prominent *Panax* species, *P. vietnamensis* and *P. japonicus* have also been studied but account for only a small quantity of research when compared to the research on the three most popular species. *Panax* species have been consumed in many countries around the world. A recent paper reported that more than 80,000 tons of ginseng are produced worldwide and *Panax* productions were estimated to cost \$2,084 million per year, in which China, South Korea, Canada, and the United States are the top four producers with 55.9%, 34.3%, 8.1%, and 1.3%, respectively<sup>5</sup>. These figures demonstrate that the *Panax* species have been accepted by various cultures and have become the most valuable natural product. The

<sup>1</sup> Baeg IH, So SH. The world ginseng market and the ginseng (Korea). *Journal of ginseng research*. 2013 Mar;37(1):1.

<sup>2</sup> Yun TK. Brief introduction of *Panax ginseng* CA Meyer. *Journal of Korean medical science*. 2001 Dec;16(Suppl):S3.

<sup>3</sup> Paek KY, Murthy HN, Zhong JJ, editors. *Production of biomass and bioactive compounds using bioreactor technology*. Springer; 2014 Sep 30.

<sup>4</sup> Lui JH, Staba EJ. The ginsenosides of various ginseng plants and selected products. *Journal of Natural Products*. 1980 May;43(3):340-6.

<sup>5</sup> Baeg IH, So SH. The world ginseng market and the ginseng (Korea). *Journal of ginseng research*. 2013 Mar;37(1):1.

enormous consumption of *Panax* products has led to the continuous development of ginseng research.

There have been a large number of scientific papers which provides an excellent review in the cultivation, chemistry, and biology of ginseng<sup>(6),7)</sup>. Nevertheless, there is still a lack of survey regarding the qualitative and quantitative interpretation of worldwide ginseng research to provide a deeper insight into this area. That being so, we summarized and reviewed the recent advancements in ginseng research. This article mainly concentrates on the most recent 24 years, as this period contains not only the most significant number of ginseng publications but is also the period of time that has witnessed outstanding progress in the basic research of ginseng.

### GINSENG RESEARCH HAS BEEN AN ACTIVE AREA OVER THE RECENT DECADES

To examine the number of publications, we built search queries for ginseng. We limited the search results to 'Panax OR ginseng OR ginsenoside\*' in "Title" and included only Article, Review, and Letter in Document Types options. Using Web of Science™ Core Collection with the above-mentioned criteria, we gathered a total of 8,090 publications spanning 115 years. A manual data examination was conducted to increase the accuracy of the data.

The first article that discussed the chemistry and pharmacology of ginseng was published in 1905. Thereafter, only seven articles were published discontinuously until 1959. These papers focused on the pathology and pharmacological effects of ginseng. From 1961 until now, extensive and continuous efforts have been focused on ginseng research. The number of publications of ginseng research to the total scientific papers in the world has

been increased steadily, especially since 1996 (Table 1).

**Table 1.** The proportion of ginseng papers

Year	Ginseng Publications	Total Publications	Percent (%)
1961	3	111,119	0.002700
1962	2	109,518	0.001826
1963	5	113,573	0.004402
1964	4	124,645	0.003209
1965	2	145,445	0.001375
1966	6	170,221	0.003525
1967	2	187,717	0.001065
1968	2	209,784	0.000953
1969	5	240,120	0.002082
1970	2	244,290	0.000819
1971	6	265,202	0.002262
1972	8	289,552	0.002763
1973	7	289,850	0.002415
1974	11	309,871	0.003550
1975	11	303,180	0.003628
1976	10	321,336	0.003112
1977	18	377,134	0.004773
1978	19	388,951	0.004885
1979	16	395,527	0.004045
1980	18	405,293	0.004441
1981	24	426,623	0.005626
1982	26	447,050	0.005816
1983	29	477,031	0.006079
1984	29	489,536	0.005924
1985	32	494,973	0.006465
1986	31	496,269	0.006247
1987	36	508,725	0.007077
1988	34	522,418	0.006508
1989	42	533,641	0.007870
1990	53	522,432	0.010145
1991	47	538,941	0.008721
1992	25	545,196	0.004586
1993	40	547,981	0.007300
1994	43	565,100	0.007609
1995	50	582,795	0.008579
1996	104	654,754	0.015884
1997	73	647,652	0.011271
1998	92	670,844	0.013714
1999	91	685,712	0.013271
2000	97	689,885	0.014060
2001	117	690,968	0.016933
2002	110	706,962	0.015560
2003	167	732,250	0.022806
2004	149	768,427	0.019390
2005	183	806,970	0.022677
2006	238	858,942	0.027709
2007	223	927,268	0.024049
2008	267	1,004,148	0.026590
2009	293	1,058,052	0.027692
2010	369	1,109,065	0.033271
2011	410	1,193,020	0.034367
2012	454	1,265,806	0.035866
2013	487	1,341,638	0.036299
2014	502	1,385,338	0.036237
2015	535	1,429,119	0.037436
2016	542	1,480,185	0.036617
2017	572	1,531,617	0.037346
2018	632	1,601,997	0.039451
2019	678	1,605,671	0.042225

<sup>6)</sup> Liu J, Xu Y, Yang J, Wang W, Zhang J, Zhang R, Meng Q. Discovery, semisynthesis, biological activities, and metabolism of ocotillol-type saponins. *Journal of ginseng research*. 2017 Jul 1;41(3):373-8.

<sup>7)</sup> Kim DH. Chemical diversity of *Panax* ginseng, *Panax quinquefolium*, and *Panax notoginseng*. *Journal of ginseng research*. 2012 Jan;36(1):1.

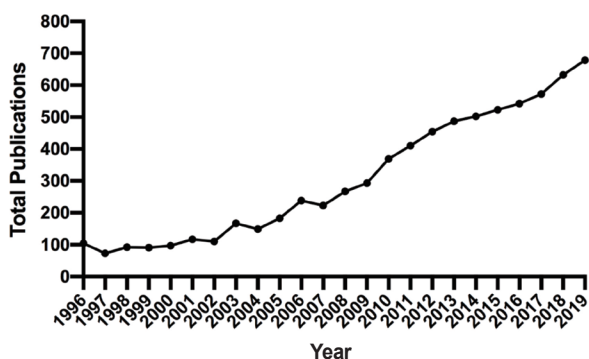


Figure 1. Total number of ginseng publications since 1996.

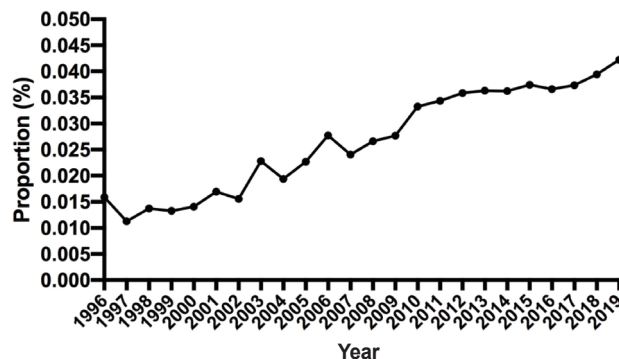


Figure 2. The proportion of ginseng publications since 1996.

Table 2. Publication characteristics of ginseng research in recent 24 years (1996 to 2019)

Main variable	Value
Total papers	7385
Paper types	<i>Original research</i> 7037 <i>Review</i> 286 <i>Letter</i> 62
Total research affiliations	3286
Total countries/territories	78
Number of publishing journals	1274

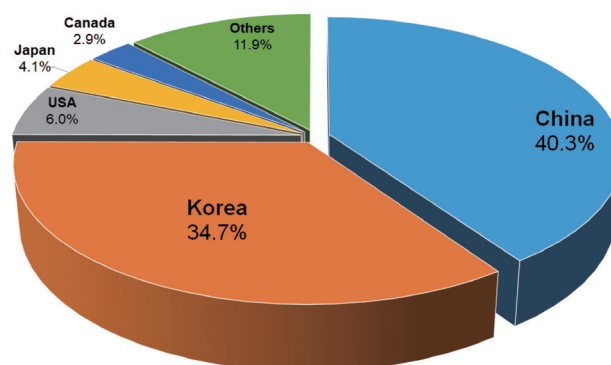


Figure 3. Top 5 countries in ginseng research. China and Korea account for 75% of the papers.<sup>8)</sup>

The ginseng publications in the most recent 24 years (1996 to 2019) are summarized. A total of 7385 publications was recorded. 104 papers were published in 1996, and then the number grew roughly 6.5-fold to 678 in 2019 (Table 1 and Figure 1).

The number of ginseng papers in 1961 accounted for 0.0027% and increased to 0.016% in 1996 before reaching its peak at 0.042% in 2019 with 678 papers out of the total 1,605,671 scientific papers in the WoS core list (Figure 2 and Table 2).

### GINSENG RESEARCH PRODUCTIVITY FROM CHINA AND KOREA HAS GROWN SIGNIFICANTLY

Korea, China, the United States, Japan, and Canada, in that order, were the top five productive countries/territories

in ginseng research (Figure 3). China took the first position with 2,973 records (40.3%), followed by Korea with 2,562 (34.7%). The United States, with 444 records (6.0%), ranked third. Japan and Canada scored 299 (4.1%) and 214 (2.9%), respectively. Although 78 countries/territories contributed to ginseng research, the top five countries/territories contributed to 88.0% of the reports. In particular, Korea and China account for 75%. The United States, Japan, and Canada experienced no noticeable growth in the number of publications during the observed period. This reflects the localization of ginseng research in a few countries/territories.

Since 2001, the number of publications from China has increased gradually. China had several unique conditions compared to other countries. Above all else, we speculate that the governmental expenditure on science

<sup>8)</sup> Grouped by the corresponding author's institution

**Table 3.** The trends of ginseng publications of the top 5 prolific countries.

Year	China	Korea	USA	Japan	Canada	Taiwan
1996	18	27	7	25	11	1
1997	10	20	6	18	3	2
1998	13	31	9	22	4	1
1999	8	29	9	14	6	1
2000	7	26	12	16	9	2
2001	28	23	15	15	10	3
2002	9	33	15	8	11	2
2003	29	54	20	10	17	4
2004	24	52	19	16	14	1
2005	43	70	21	7	8	9
2006	60	68	27	26	13	4
2007	61	72	22	21	7	6
2008	88	94	20	19	10	7
2009	97	107	30	12	4	5
2010	109	177	22	9	5	10
2011	133	172	30	10	16	4
2012	168	189	34	12	8	5
2013	186	216	19	5	12	1
2014	228	196	18	3	11	7
2015	272	172	17	3	6	6
2016	293	182	17	7	11	5
2017	312	187	19	9	8	8
2018	373	192	18	2	5	3
2019	404	173	18	10	5	7
Sum	2,973	2,562	444	299	214	104

and technology in China is the most essential factor. In Korea, ginseng research is tremendous and particularly encouraged by The Korean Society of Ginseng. *P. ginseng* is a government-sanctioned product, which makes it an even more trusted produce. Nevertheless, the number of publications from Korea decreased in 2014 and 2015, whereas the number of publications from China kept on noticeably increasing (Table 3).

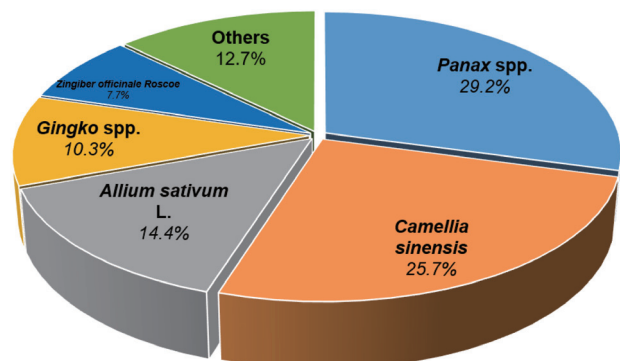
There are several reasons why Korea, China, the United States, Japan, and Canada predominated over other countries/territories in issuing ginseng publications. First, the *Panax* species can only grow in limited areas, including the abovementioned countries, because of the sensitivity of the plant to soil and temperature<sup>9</sup>. *P. ginseng* is cultivated primarily in Korea and China and has a long

history of medicinal use as a traditional herbal remedy in eastern Asia. *P. notoginseng* has been cultivated for more than several hundred years in China. Second, the long-standing history of discovery and the main usage as medicinal materials can be observed in these countries, especially Korea, China, and Japan.

### PANAX GINSENG IS THE MOST EXTENSIVELY STUDIED HERBAL MEDICINE IN THE WORLD

In general, this herbal medicine has been constantly developed in terms of research and consumer market throughout time. To examine the number of publications, we built search queries for ginseng as well as six other widely used herbal medicines having more than 1000 publications. We limited the search results to "Title" and included only Article, Review, and Letter in Document Types option. The search period was set from 1996 to 2019. The direct data showed by Web of Science™ demonstrated that ginseng was the most studied herbal medicinal plant in the observed period (7,385, 29.2%), followed by tea (6,499, 25.7%). Garlic, ginkgo, and ginger accounted for 3,641 (14.4%), 2,590 (10.3%), 1,945 (7.7%) publications, respectively (Figure 4).

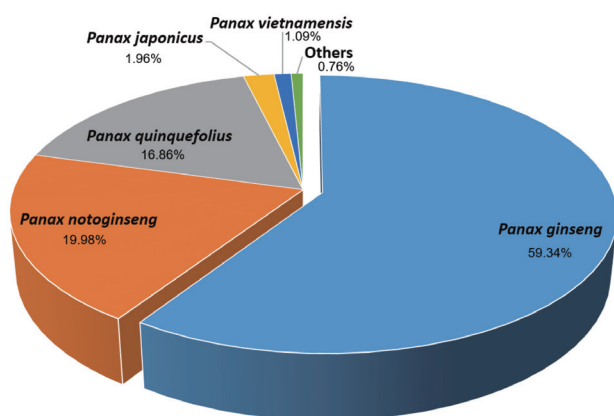
Overall, all of the mentioned herbal medicinal plants showed an upward trend, and of these plants, two types (ginseng and tea) experienced a dramatic increase in publication productivity between 1996 and 2019 (Table 4).

**Figure 4.** The proportion of publications of 5 most studied medicinal plants in 1996-2019

<sup>9</sup> Park HJ, Kim DH, Park SJ, Kim JM, Ryu JH. Ginseng in traditional herbal prescriptions. Journal of ginseng research. 2012 Jul;36(3):225.

**Table 4.** The trends of publications of the 7 most studied medicinal plants.

Year	<i>Panax sp.</i>	<i>Camellia sinensis</i>	<i>Allium sativum</i>	<i>Ginkgo biloba</i>	<i>Zingiber officinale</i>	<i>Aloe sp.</i>	<i>Hypericum perforatum</i>
1996	104	57	88	40	13	34	9
1997	73	84	77	54	12	26	14
1998	92	103	77	56	20	28	35
1999	91	80	84	61	20	17	47
2000	97	112	87	68	22	28	80
2001	117	145	94	66	26	25	79
2002	110	144	116	108	23	30	93
2003	167	147	106	96	37	34	79
2004	149	189	111	119	38	46	85
2005	183	230	127	95	59	44	68
2006	238	250	130	112	49	42	70
2007	223	273	149	126	58	71	62
2008	267	290	144	100	63	69	59
2009	293	322	168	131	77	93	54
2010	369	300	184	95	101	102	63
2011	410	360	243	129	125	97	77
2012	454	381	187	128	125	119	56
2013	487	364	182	142	128	125	49
2014	502	375	187	114	132	117	63
2015	535	398	197	146	127	112	44
2016	542	407	219	148	147	142	47
2017	572	472	214	124	159	150	45
2018	632	496	207	163	177	125	37
2019	678	520	263	169	207	149	61
Sum	7,385	6,499	3,641	2,590	1,945	1,825	1,376

**Figure 5.** *Panax ginseng* is the most studied species of ginseng

Among the *Panax* species, *P. ginseng*, *P. notoginseng*, and *P. quinquefolius* shared the proportions of 59.3%, 20.0%, and 16.9%, respectively, regarding the scientific output (Figure 5). Other species only shared a very humble portion.

## THE MOST PROLIFIC INSTITUTIONS ARE LOCATED IN KOREA AND CHINA

Among 3,286 institutions that published ginseng papers as recorded by Web of Science™, the top 30 most prolific institutions accounted for 65.5% of the publications during the recent 24 years. These institutions were mainly from Korea and China (Table 5). Kyung Hee University (8.1%), Seoul National University (4.7%), Chinese Academy of Sciences (3.9%), Jilin University (3.7%), and Konkuk University (3.4%) were the top five most productive universities/institutions in ginseng research.

Among the 30 most prolific institutions, 18 were located in Korea, 11 were located in China, and only one was located in the USA. The prominent number of institutions from Korea and China reflects and reinforces the above discussion. It should be noted again that only the

**Table 5.** Top 30 most active universities/institutions in recent years (1996 to 2019).<sup>10)</sup>

No.	University/Research center	Country / Territory	Records	%
1	Kyung Hee University	Korea	597	8.1
2	Seoul National University	Korea	350	4.7
3	Chinese Academy of Sciences	China	286	3.9
4	Jilin University	China	273	3.7
5	Konkuk University	Korea	251	3.4
6	Chungnam National University	Korea	169	2.3
7	Chungbuk National University	Korea	166	2.2
8	Jilin Agricultural University	China	164	2.2
9	Kangwon National University	Korea	163	2.2
10	Peking Union Medical College	China	161	2.2
11	China Pharmaceutical University	China	146	2.0
12	China Academy of Chinese Medical Sciences	China	143	1.9
13	Rural Development Administration	Korea	138	1.9
14	Zhejiang University	China	137	1.8
15	Changchun University of Chinese Medicine	China	130	1.8
16	Chung Ang University	Korea	125	1.7
17	Sungkyunkwan University	Korea	123	1.7
18	Korea Food Research Institute	Korea	119	1.6
19	Kyungpook National University	Korea	117	1.6
20	Shenyang Pharmaceutical University	China	114	1.5
21	Korea University	Korea	112	1.5
22	Peking University	China	110	1.5
23	Jeonbuk National University	Korea	104	1.4
24	University of Chicago	USA	101	1.4
25	Korea Advanced Institute of Science Technology	Korea	100	1.3
26	Chonma National University	Korea	94	1.3
27	Yonsei University	Korea	94	1.3
28	Korea Institute of Science Technology	Korea	93	1.3
29	Institute of Medicinal Plant Development	China	90	1.2
30	Korea Research Institute of Bioscience & Biotechnology	Korea	89	1.2

number of publications of Korea and China, in general, has increased during the most recent period.

### THE JOURNAL OF GINSENG RESEARCH HAS BEEN THE MOST PROLIFIC JOURNAL ON GINSENG RESEARCH

The top 30 journals that published ginseng papers occupied 36.7% of the total publications in the observed period (1996 - 2019) (Table 6).

The journal publishing with the most significant number of ginseng papers (582 papers, 7.9%) was the *Journal of Ginseng Research* (impact factor, IF 2018 = 4.029), which is the official journal of The Korean Society of Ginseng.

The other leading journals include the *Journal of Ethnopharmacology* (179, 2.4%), *Biological Pharmaceutical Bulletin* (133, 1.8%), *Molecules* (130, 1.8%), and *International Journal of Systematic and Evolutionary Microbiology* (115, 1.6%). The research fields covered by the top 30 journals were diverse, and the *Journal of Ginseng Research* is the only international source that has released scholarly reports on ginseng research only since 1976.

### CONCLUSION

In the modern era, ginseng has proven its importance; it is one of best-selling medicinal plants. It is also the most intensively studied herbal medicine in the world. Korea and China have shown great interest in ginseng

<sup>10)</sup> Grouped by the corresponding author's institution

**Table 6.** Top 30 most active journals and their impact factor (2018 IF) in recent years (1996 to 2019).

No.	Journal	Records	%	Impact factor (2018)
1	Journal of Ginseng Research	582	7.9	4.029
2	Journal of Ethnopharmacology	179	2.4	3.414
3	Biological & Pharmaceutical Bulletin	133	1.8	1.540
4	Molecules	130	1.8	3.060
5	International Journal of Systematic and Evolutionary Microbiology	115	1.6	2.166
6	Journal of Agricultural and Food Chemistry	109	1.5	3.571
7	Planta Medica	109	1.5	2.746
8	Food Science and Biotechnology	104	1.4	0.888
9	American Journal of Chinese Medicine	98	1.3	3.510
10	Evidence-Based Complementary and Alternative Medicine	92	1.2	1.984
11	Phytotherapy Research	90	1.2	3.766
12	Archives of Pharmacal Research	79	1.1	2.458
13	Journal of Pharmaceutical and Biomedical Analysis	69	0.9	2.983
14	Plos One	68	0.9	2.776
15	European Journal of Pharmacology	67	0.9	3.170
16	Acta Pharmacologica Sinica	66	0.9	4.010
17	Phytomedicine	52	0.7	4.180
18	Molecular Medicine Reports	51	0.7	1.851
19	Scientific Reports	50	0.7	4.011
20	International Journal of Molecular Sciences	48	0.6	4.183
21	Journal of medicinal Food	47	0.6	2.020
22	Life Sciences	46	0.6	3.448
23	Food Chemistry	45	0.6	5.399
24	Journal of Microbiology and Biotechnology	45	0.6	1.975
25	Chemical & Pharmaceutical Bulletin	44	0.6	1.405
26	Journal of Chromatography B	44	0.6	2.813
27	Biomedicine & Pharmacotherapy	43	0.6	3.743
28	Food and Chemical Toxicology	42	0.6	3.775
29	International Immunopharmacology	40	0.5	3.361
30	Plant Cell Tissue and Organ Culture	37	0.5	2.200

research. Moreover, publications related to *Panax* species have increased in quantity and have extended to various subjects. However, ginseng research is currently localized to a small number of countries, which may limit the opportunity for the development of further ginseng research. International cooperation is indeed necessary to guarantee its future.

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