State of Panax ginseng Research: A Global Analysis

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Abstract: This article aims to understand the global and longitudinal trends of research on Panax ginseng. We used bibliometrics to analyze 3974 papers collected from the Web of Science TM Core Collection database during 1959–2016. The number of publications showed a steady growth before 2000 and exponentially increased in stage III (2000–2016, about 86% of the papers were published). Research on P. ginseng was conducted in 64 countries, mainly in Asia; in particular, 41% and 28% of the publications were from South Korea and China, respectively. The institutions from South Korea and China had high publication output and close cooperation and provided the majority of financial support. All top 10 authors and four of the top 20 journals in terms of number of publications originated from South Korea. The leading research subjects were pharmacology (39%), plant science (26%), and integrative complementary medicine (19%). The hotspot of P. ginseng research transformed from basic science to application, and multidisciplinary sciences will play a substantial role in the future. This study provides a comprehensive analysis to elucidate the global distribution, collaboration patterns, and research trends in the P. ginseng domain.

Keywords: Panax ginseng; bibliometrics; global cooperation; emerging trends

1. Introduction

Panax ginseng is a perennial herb that belongs to the Araliaceae family and is distributed in 35 countries, mainly in Asia, particularly South Korea and China [1]. Since ancient times, P. ginseng has been used as traditional medicine because of its heart-protective [2], anticancer [3], and neuroprotective properties [4]. Since the 21st century, the number of publications on P. ginseng has exponentially increased; more than 3400 articles, including 242 reviews, have focused on P. ginseng. However, few studies on P. ginseng employed bibliometrics analysis. In 2010, Kim [5] provided an overview of the trends in ginseng research. Therefore, understanding P. ginseng research from the global and longitudinal perspectives is crucial.

Bibliometrics analysis can be used to delineate development trend of an academic research domain, explore current research emphasis and hotspot, and predict future research focus and achievement [6,7]. This analytical method is especially suitable for P. ginseng research, which is a complex and multidisciplinary research field evolving rapidly since 2000.

In this study, we perform a bibliometric analysis of global research on P. ginseng between 1959 and 2016. This paper aims to reveal the intellectual landscape of P. ginseng and identify cooperation patterns, significant authors and papers, and emerging trends.

2. Data Collection and Methods

Data were retrieved from the Web of Science TM Core Collection database. “Panax ginseng” was chosen as the search topic, and the retrieval time span was set to 1900 to 2016. A total of 3974 records
were obtained between 1959 and 2016. Every bibliographic record in SCI contains the author, title, source, abstract, keywords, and cited references of a study.

A total of 64 countries, 9612 authors, 999 journals, 6609 keywords, and 13 languages were counted by HistCite software, a tool used for literature and statistical analyses. The original records were visually analyzed using the information visualization software CiteSpace V, which was invented by Dr. Chen Chaomei from the Drexel University. CiteSpace is the most advanced and distinctive information visualization tool that can reveal the intellectual landscape and detect recent emerging trends.

3. Results

Figure 1a shows the number of publications from 1959 to 2016. The number of published articles about *P. ginseng* generally increases annually. Since 1959, when German scientist PETKOV W [8,9] started to investigate the pharmacology and pharmacodynamics of *P. ginseng*, 3974 papers were published until 2016. Based on the number of publications, the past 60 years can be preliminarily divided into three stages, namely, stage I, 1959–1979; stage II, 1980–1999; and stage III, 2000–2016. Stage I (1959–1979) was considered the budding period, when less than 10 papers were published annually. Stage II (1980–1999), also known as the development period, began in 1980, when the number of annual publications reached 10. Stage III (2000–2016) or the boom period is the phase when an increased number of scholars began to focus on *P. ginseng* research.

![Figure 1a](image1.png)

**Figure 1a** shows the number of publications from 1959 to 2016. The number of published articles about *P. ginseng* generally increases annually.

![Figure 1b](image2.png)

**Figure 1b**: The status of publications. (a) Publication counts during 1959–2016 per year; (b) Types of publications.

According to publication category (Figure 1b), the 3974 publications obtained mainly included 3398 formal research articles (85.6%). A total of 262 review articles, 140 proceedings papers, and 103 meeting abstracts accounted for 6.6%, 3.5%, and 2.6% of the publications, respectively. Moreover, 33 notes, 13 letters, 7 corrections, 7 book chapters, 6 editorial materials, and 5 news items comprised less than 1.8% of all the publications.

Based on the heat map of the geographical distribution of research countries (Figure 2a), Asia, North America, and Europe produced the highest number of publications. *P. ginseng* research was conducted in 64 countries. In the first tier, South Korea ranked first in terms of research output by contributing 1632 articles (41.1%), and China ranked second with 1191 publications (27.5%). In the second tier, 396 papers originated from the USA and 381 papers from Japan. In the third tier, India, UK, Canada, and Russia published 127, 109, and 79 papers, respectively.
Figure 2. Global research status of Panax ginseng. (a) Geographical distribution of research countries; (b) 15 countries with burst detection among 64 countries; (c) Global cooperation.
Burst detection is a computational technique used to identify abrupt changes in events and other types of information [10]. A burst is detected through two attributes, namely, strength and duration [11]. The red line segment of the column indicates the time period of burst detections. Figure 2b shows 15 countries with burst detection during 1959–2016. Of these countries, Japan exhibited the highest strength of 77.84 from 1973 to 2001. Hence, Japan conducted substantial works on *P. ginseng* during these years. Scholars from Saudi Arabia started showing interest in ginseng research from 2013 and contributed 13 publications.

As shown in Figure 2c, the top four countries (South Korea, China, USA, and Japan) with the highest publication number worked in close cooperation with one another. These four countries also worked closely with Canada, Germany, Norway, UK, Australia, Egypt, France, Italy, and India.

Table 1 lists the top 10 organizations that conducted and provided funds for *P. ginseng* research. Of these organizations, eight originated from South Korea and two, namely, Chinese Academy of Sciences and Jilin University, were from China. Similarly, the top 10 sponsor organizations comprised 70% Korean institutions and 30% Chinese institutions (National Natural Science Foundation of China, Ministry of Science and Technology of China, Fundamental Research Funds for the Central Universities). The National Natural Science Foundation of China funded for 263 papers, accounting for almost half of the articles funded by the top 10 sponsor organizations.

| Rank | Research Institution                  | Publication Amount | Sponsor Institution                                      | Sponsoring Amount |
|------|--------------------------------------|--------------------|--------------------------------------------------------|-------------------|
| 1    | Kyung Hee University                 | 323                | National Natural Science Foundation of China            | 263               |
| 2    | Seoul Natl University                | 198                | Ministry of Education Science and Technology            | 73                |
| 3    | Konkuk University                    | 145                | Korean Society of Ginseng                               | 61                |
| 4    | Chungbuk National University         | 135                | Rural Development Administration Republic of Korea     | 37                |
| 5    | Chinese Academy of Sciences          | 124                | Korea ginseng corporation                               | 37                |
| 6    | Chungnam National University         | 108                | Ministry of Education Science and Technology Republic of Korea | 35               |
| 7    | Kangwon National University          | 84                 | National Research Foundation of Korea Nrf               | 32                |
| 8    | Jilin University                     | 82                 | National Research Foundation of Korea                   | 25                |
| 9    | Korea University                     | 75                 | Ministry of Science and Technology of China             | 22                |
| 10   | Chonnam National University          | 69                 | Fundamental Research Funds for the Central Universities | 22                |

Figure 3 shows the cooperation among global research institutions. The thick line indicates high collaboration frequency. A linear partnership was found among Chinese institutions such as Shenyang Pharmaceutical University, Hong Kong Baptist University, Chinese Academy of Medical Sciences, Chinese Academy of Sciences, Changchun University of Chinese Medicine, Jilin University, and Jilin Agricultural University. Numerous Korean institutions presented group cooperation relationship to Jilin Agricultural University from China. Kyung Hee University, Chungbuk National University, Seoul National University, and Konkuk University were in the center position. These Korean institutions cooperated with Zhejiang University and China Pharmaceutical University from China. In Japan, most research institutions exhibited strong cooperation with one another. Five organizations
(Russian Academy of Sciences, Toyama Medicinal and Pharmaceutical University, Chongqing Pharmaceutical University, Kyushu University, and Northumbria University) conducted *P. ginseng* research individually rather than cooperating with other institutions.

Figure 3. The collaboration patterns of global research institutions.

Figure 4a shows the publication outputs of top 10 authors and their total local citation scores. The top 10 authors originated from Korean institutions; in particular KIM DH and KIM SH contributed the highest number of publications and had the highest citation rate. Basing on the exponential increase in publication numbers during 2000–2016, we focused on the authors who started to burst from 2000 (Figure 4b). Twenty authors, including YANG DC, KIM YJ, KIM JH, and KIM SH, who also belong to the top 10 authors, had bursts from different years until 2016. Particularly, the articles of KIM SH showed high citation rate. In addition, Yuan CS, Wu JA, and Attele AS from University of Chicago had the highest citation rate and published 29, 7, and 3 articles, with TLCS of 1115, 765, and 684, respectively.
Each paper indexed by the Web of Science™ Core Collection was assigned with one or more subjects. A total of 120 unique subject categories were found (Figure 5a). The most common category (presented with the largest circle) is pharmacology and pharmacy, followed by plant science, chemistry, and integrative and complementary medicine. The nodes with thick purple ring have high betweenness centrality, which represents great transformation potential of a scientific contribution, and values tend to identify the boundary spanning potential that could lead to transformative discoveries [10,11]. Although engineering, biotechnology and applied microbiology, and toxicology and cell biology occupy a small space, their rings in purple indicate high betweenness centrality.
Figure 5. Major disciplines of *P. ginseng* and burst detection result. (a) Category co-occurrence network; (b) 16 subject categories have occurrence burst during 1959–2016.

The subject categories of the included papers were analyzed to determine their burstness (Figure 5b). Sixteen subject categories were detected with bursts. Multidisciplinary sciences, science and technology, and other topics showed burst from 2014 to 2016.

The major topics in *P. ginseng* research are shown in Figure 6. The visual representation, known as a form tree, was generated using clustering software Carrot based on the 38 clusters of the 3974 publications. The leading topics in *P. ginseng* research are cell activity, activity of the ginseng extract, study groups, use of ginseng root, cell investigation, induction of ginseng cells, and treatment of cells.

Figure 6. A visual survey of major topics on *P. ginseng* generated by the Carrot system.

Figure 7a shows the major keywords of *P. ginseng* research. The top 10 keywords in terms of the frequency of occurrence are: ginsenoside, saponin, ginseng, rat, cell, extract, mice, expression, in vitro, and apoptosis. The purple rings of ginsenoside, saponin, constituent, cell, red ginseng, rat, mice, apoptosis, cancer, and polysaccharide indicate their betweenness centrality, and the red ring indicates burst. This representation reveals the development of *P. ginseng* research focus (Figure 2b).

Figure 7. Cont.
Figure 7. Major keywords of P. ginseng research and burst detection result. (a) Major keywords on P. ginseng research; (b) Keywords with strongest frequency burst since 2000.

At a fine-grained level, keywords with burst reveal the new trend in P. ginseng research. Seventy-seven keywords showed burst. Considering that many articles were published after 2000, we focused on keywords with burst since 2000 (Figure 2b). The burst of keywords until 2016 are Korean red ginseng, nf kappa b, compound k, metabolite, methyl jasmonate, Alzheimer’s disease, biotransformation, ginsenoside rg1, differentiation, inflammation, and cancer. Inflammation, methyl jasmonate, compound k, metabolite, and Alzheimer’s disease had the strongest burst strengths of over 10.

A total of 3974 papers were found in 999 different journals. Table 2 shows that approximately all of the papers were written in English (98.0%), and the remaining papers were written in 12 different languages, such as Chinese (34), Japanese (16), and Russian (11). A few papers were written in Portuguese, German, Polish, French, Hungarian, Italian, Korean, Spanish, and Turkish.

Table 2. Languages of P. ginseng publication.

| Rank | Language | Number | Percentage |
|------|----------|--------|------------|
| 1    | English  | 3896   | 98.03      |
| 2    | Chinese  | 34     | 0.86       |
| 3    | Japanese | 16     | 0.40       |
| 4    | Russian  | 11     | 0.28       |
| 5    | Portuguese | 4      | 0.10     |
| 6    | German   | 3      | 0.08       |
| 7    | Polish   | 3      | 0.08       |
| 8    | French   | 2      | 0.05       |
| 9    | Hungarian| 1      | 0.03       |
| 10   | Italian  | 1      | 0.03       |
| 11   | Korean   | 1      | 0.03       |
| 12   | Spanish  | 1      | 0.03       |
| 13   | Turkish  | 1      | 0.03       |

Table 3 displays that most of the top 20 highest publishing journals originated from South Korea (4), Germany (3), England (3), the USA (3), and the Netherlands (3).

Table 4 lists the articles with the highest impact factor. The paper, “Herb-drug interactions,” published in The Lancet in 2000 had the highest impact factor of over 47. The article, “In vitro flowering of embryoids derived from mature root callus of ginseng (Panax-ginseng),” published in Nature on 1980 had an impact factor of over 40.
Table 3. The information about top 20 highest publishing journals.

| Rank | Journal                                      | Number | Percentage | IF    | Region         |
|------|----------------------------------------------|--------|------------|-------|----------------|
| 1    | Journal of Ginseng Research                  | 313    | 7.874      | 4.082 | South Korea    |
| 2    | Journal of Ethnopharmacology                 | 129    | 3.245      | 2.981 | Ireland        |
| 3    | Planta Medica                                | 124    | 3.119      | 2.342 | Germany        |
| 4    | Biological & Pharmaceutical Bulletin         | 95     | 2.390      | 1.683 | Japan          |
| 5    | Phytotherapy Research                         | 69     | 1.736      | 3.092 | England        |
| 6    | Food Science and Biotechnology               | 53     | 1.333      | 0.699 | South Korea    |
| 7    | American Journal of Chinese Medicine         | 53     | 1.333      | 3.222 | USA            |
| 8    | Archives of Pharmacal Research               | 52     | 1.308      | 2.324 | South Korea    |
| 9    | Chemical & Pharmaceutical Bulletin           | 51     | 1.283      | 1.133 | Japan          |
| 10   | Phytochemistry                               | 45     | 1.132      | 3.205 | England        |
| 11   | Journal of Agricultural and Food Chemistry   | 45     | 1.132      | 3.154 | USA            |
| 12   | Evidence-Based Complementary and Alternative Medicine | 43   | 1.082      | 1.740 | England        |
| 13   | Plant Cell Reports                           | 40     | 1.006      | 2.869 | Germany        |
| 14   | Journal of Pharmaceutical and Biomedical Analysis | 37 | 0.931      | 3.255 | Netherlands    |
| 15   | PLoS ONE                                     | 35     | 0.881      | 2.806 | USA            |
| 16   | Molecules                                    | 30     | 0.755      | 2.861 | Switzerland    |
| 17   | Plant Cell Tissue and Organ Culture          | 29     | 0.730      | 2.002 | Netherlands    |
| 18   | Phytomedicine                                | 28     | 0.704      | 3.526 | Germany        |
| 19   | Journal of Chromatography A                  | 26     | 0.654      | 3.981 | Netherlands    |
| 20   | Journal of Medicinal Food                    | 24     | 0.604      | 1.955 | South Korea    |

Table 4. Top 10 articles with the highest IF.

| Rank | Title                                                                 | Year | Journal                          | IF    | Reference |
|------|------------------------------------------------------------------------|------|----------------------------------|-------|-----------|
| 1    | Herb-drug interactions                                                 | 2000 | The Lancet                       | 47.831| [12]      |
| 2    | In vitro flowering of embryoids derived from mature root callus of ginseng (Panax ginseng) | 1980 | Nature                           | 40.137| [13]      |
| 3    | High-dose Asian ginseng (Panax ginseng) for cancer-related fatigue (CRF): A preliminary report | 2013 | Journal of Clinical Oncology     | 24.008| [14]      |
| 4    | Herbal remedies in the United States: Potential adverse interactions with anticancer agents | 2004 | Journal of Clinical Oncology     | 24.008| [15]      |
| 5    | Electrophysiological and blood pressure effects of energy drinks and Panax ginseng in healthy volunteers: A randomized clinical trial | 2016 | Circulation                      | 19.309| [16]      |
| 6    | Progesterone regulates cardiac repolarization through a nongenomic pathway—An in vitro patch-clamp and computational modeling study | 2007 | Circulation                      | 19.309| [17]      |
| 7    | Modulating angiogenesis: the yin and the yang in ginseng               | 2004 | Circulation                      | 19.309| [18]      |
| 8    | Production of bioactive ginsenoside compound K in metabolically engineered yeast | 2014 | Cell Research                    | 15.606| [19]      |
| 9    | Traditional Chinese medicine: an approach to scientific proof and clinical validation | 2000 | Pharmacology & Therapeutics      | 11.127| [20]      |
| 10   | Enantioselective prophenol-catalyzed addition of 1,3-diynes to aldehydes to generate synthetically versatile building blocks and diyne natural products | 2010 | Journal of the American Chemical Society | 13.858| [21]      |

Table 5 lists the top 10 references with the most citations from 1959 to 2016. Most of the top 10 cited references are reviews, and half of them were published before 2000.
Table 5. Top-10 most cited references.

| Rank | Title                                                                 | TLCS | Year | Journal                      | Reference |
|------|------------------------------------------------------------------------|------|------|------------------------------|-----------|
| 1    | *Ginseng* pharmacology—Multiple constituents and multiple actions      | 512  | 1999 | Biochemical Pharmacology     | [22]      |
| 2    | *Panax ginseng* pharmacology: A nitric oxide link?                     | 232  | 1997 | Biochemical Pharmacology     | [23]      |
| 3    | Antidiabetic effects of *Panax ginseng* berry extract and the          | 137  | 2002 | Diabetes                     | [24]      |
|      | identification of an effective component                               |      |      |                              |           |
| 4    | Botanical characteristics, pharmacological effects and medicinal       | 134  | 2008 | Acta Pharmacologica Sinica   | [25]      |
|      | components of Korean *Panax ginseng* C. At Meyer                      |      |      |                              |           |
| 5    | Inhibitory effect of tumor-metastasis in mice by saponins,             | 133  | 1995 | Biological & Pharmaceutical Bulletin | [26] |
|      | ginsenoside-rb2, 20(r)-ginsenoside-rg3 and                           |      |      |                              |           |
|      | 20(s)-ginsenoside-rg3, of red-ginseng                                 |      |      |                              |           |
| 6    | Recent advances on *ginseng* research in China                        | 131  | 1992 | Journal of Ethnopharmacology | [27]      |
| 7    | Antioxidant and anti-tumor promoting activities of the                | 116  | 2000 | Cancer Letters               | [28]      |
|      | methanol extract of heat-processed *ginseng*                          |      |      |                              |           |
| 8    | *Panax ginseng*                                                       | 115  | 2003 | American Family Physician    | [29]      |
| 9    | Inhibition of tumor angiogenesis and metastasis by a                   | 105  | 1994 | Biological & Pharmaceutical Bulletin | [30] |
|      | saponin of *Panax-ginseng*, ginsenoside-rb2                            |      |      |                              |           |
| 10   | Chemistry and cancer preventing activities of *ginseng* saponins and   | 101  | 2001 | Journal of Korean Medical Science | [31]   |
|      | some related triterpenoid compounds                                    |      |      |                              |           |

4. Discussion

The number of research on *P. ginseng* worldwide showed a high growth between 1959 and 2016 and surged since 2000. Asia, especially South Korea and China, are the most active countries on *P. ginseng* research because this herb is mainly distributed in these countries (South Korea, 57.4%; and China, 31.1%). The amounts of *P. ginseng* produced in China and South Korea account for more than 55% and 34% of the total world output [1]. The top 10 organizations funding *P. ginseng* research all originate from South Korea and China. Hence, these two countries provide stronger financial support for *P. ginseng* research than the other countries. However, Japan greatly contributed to study of *P. ginseng* during 1973–2001. Saudi Arabia showed great interest in *P. ginseng* research since 2013, and most of the publications from this country are related to ginseng extracts.

The global cooperation pattern of different institutions is as important as the research output. Generally, institutions in South Korea and China have the highest number of publications and closest cooperation worldwide. Institutions from Japan, Russia, and UK exhibit less cooperation with the other countries. The USA belongs to the top publishing country but does not appear in the cooperation network (Figure 3). This finding suggests that research organizations in the USA are scattered.

Korean scholars conducted numerous studies on *P. ginseng* and published 41% of the total articles obtained. Korean authors, namely, KIM DH and KIM SH, submitted many publications and had high citations. In particular, KIM SH had burst during 2009–2016 and will become an important scholar in the *P. ginseng* domain in the near future.

China ranks second in terms of the quantity of publications. However, no institution on China belonged to the top 10 highest publishing journals. China still needs to improve the quality of *P. ginseng* research. China has abundant resources, a large number of research funding support, and high cooperativeness with other countries and thus exhibits high potential on *P. ginseng* research.

Figure 5a displays the main disciplines which are involved in *P. ginseng* research. Pharmacology, pharmacy, plant sciences, chemistry, integrative & complementary, biochemistry and molecular biology are the leading disciplines. Chemistry is the core discipline, which connects many other disciplines. Plant sciences are closely linked to integrative & complementary medicine, which have close cooperation with chemistry and medicine. Interestingly, chemistry is a bridge between these important subjects, like pharmacology & pharmacy, chemistry and medicinal. Figure 5b shows that the
interest of scholars gradually changed from basic science to applied science during 1959–2016. Studies on neuroscience and neurology showed strong burst and have been the hotspots since 2000. At the bottom of Figure 5b, the subject categories of multidisciplinary sciences and science and technology exhibited a period of burst between 2014 and 2016, with burst strengths of over 7.6. This finding reveals a new trend of multidisciplinary disciplines in P. ginseng research. According to the clustering results of topics, numerous scientists focused on ginseng root, extracts, and cells that including cell activity, induction of ginseng cells and treatment of cells. At a fine-grained level, keywords with high frequency of occurrence indicate hotspots, such as ginsenoside, rat, cell, extract, expression, in vitro, and apoptosis. Inflammation, Alzheimer’s disease, compound k, and metabolite have the strongest burst since 2000. Therefore, these keywords will be the central concern of P. ginseng research in the near future. By analyzing disciplines, topics and key words, it’s not difficult to find that the future study of P. ginseng may be biased towards clinical research and application, such as clinical neurology, toxicology and polymer science. Ginseng root, extracts (especially ginsenoside) and treatment of inflammation, Alzheimer’s disease would continue to be the research hotspots.

5. Conclusions

We utilized the visualization software CiteSpace to analyze the bibliographic data collected from the Web of ScienceTM Core Collection database of P. ginseng research during 1959–2016. The research output showed a steady growth, and Asia, especially South Korea and China, was the most active area. A close collaboration was found between these countries. Our study reveals the intellectual landscape and detects emerging topics and trends. This study can help people who are unfamiliar with the active area of P. ginseng research to elucidate the global situation and overall structure of this domain. This paper also provides research hotspots, structured knowledge, and emerging trends with regard to P. ginseng research.

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**Sample Availability:** Data are available from the Web of ScienceTM Core Collection database.