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Summer 7-2021

Mapping the research output of Medicinal Mushroom: A Scientometric Study

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Kumari, Prasanna; Srinivasaragavan, Subburaj; and Muthuraj, Surulinathi, "Mapping the research output of Medicinal Mushroom: A Scientometric Study" (2021). *Library Philosophy and Practice (e-journal)*. 5897. <https://digitalcommons.unl.edu/libphilprac/5897>

Mapping the research output of Medicinal Mushroom: A Scientometric Study

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Abstract

This paper attempts to show up the growth trends on Medicinal Mushroom literature and make the quantitative and qualitative assessment by analyzing various features of research output and Citations impact based on the Scopus database. A total of 3513 publications were published on Medicinal Mushroom during 1990-2020. Year 2019 has highest publication of 363 whereas the year 2015 scores the highest citation impact of 5612. The People's Republic of China has the highest share 1125 of publications and received 19435 Citations followed by Taiwan with 5311 Citation for 288 publications, India with 3087 Citations for 275 publications. It's noteworthy that USA moves the Taiwan to third place through citations wise analysis with less number of publications compared to Taiwan and India. The highly productive Institutions were: Chinese Academy of Science with 152 publications having citation of 2921 followed by University Malaya with 1849 citations having 110 records and National Chung Hsing University with 83 publications. The highly productive journals are INTERNATIONAL JOURNAL OF MEDICINAL MUSHROOMS with 1004 Publications and having citation of 7798, followed by JOURNAL OF ETHNOPHARMACOLOGY and MOLECULES with 65 publications having citation of 2035 and 912 respectively. There were 126 single Author publications by the scientists and remaining were multi-Author collaborative publications. The Collaboration Index is 3.30. The average citation per document is 17.7 and an average citation per year per document is 2.06.

Keywords Scientometric, h-index, Citation Impact, Medicinal Mushroom, Impact Factor

Introduction

The title may seem eccentric, but for most species of mushrooms, there is a question as to whether the mushroom is able to treat the diseases/symptoms that have been attributed to it. Unlike microscopic fungi that have yielded some compounds of significance such as penicillin and cephalosporins, many medicinal mushrooms have been utilized as traditional medicine. It is also referred to as Herbalism, Botanical medicine or Herbology and is defined by UK-Skeptics

(2004) as the use of plants, in a wide variety of forms, for their therapeutic value. Herb plants produce and contain a variety of chemical compounds that act upon the body and are used to prevent or treat disease or promote health and well-being. However, as in the case of medicinal mushrooms, several well known herbals have recently been critically studied, resulting in conflicting conclusions. Mushrooms have been utilized in folk medicine since ancient time (Wasson and Wasson, 1957; Wasson, 1968; Hobbs, 1995). The species of mushrooms used varied in different cultures, i.e. more species have been used in China and Japan than in Western Cultures. Scientometrics study is one of the truly interdisciplinary research fields extended to almost all scientific fields. Scientometrics applications are used to measure scientific activities, mainly by producing statistics on scientific publications indexed in databases. The field of library and information science (LIS) has developed several quantitative methods to study the various aspects of subjects. The metrics of LIS are continuously increasing, starting from librametrics, bibliometrics, scientometrics, informatics, webometrics, netometrics to cybernetics. The study be going to explore the scholarly communication of Indian chemical science for the period 1990 to 2020 and determine to exposure the quality of contributions

Review of Literature

Chan, X.H., Sabaratnam, V., Abdullah, N., Phan, C.W. (2020) The research field of culinary and medicinal mushrooms has been well developed since the first relevant publication in 1966. there has been no bibliometric analysis published specifically for this field. This study aimed to assess the most influential publications as well as the research trends and important drivers in the field of culinary and medicinal mushrooms. Scopus was used to identify relevant publications and the 1000 most-cited publications were identified and analyzed. Bradford's law of scattering shows one-third of the papers were published in 14 core journals, with a total of 102 papers published in International Journal of Medicinal Mushrooms. There is an insignificant negative correlation (Pearson's correlation coefficient, $r = -0.355$) between the journal impact factor and publication count. VOS viewer was used to generate a country network. China represents Asia's research center in this field, having contributed 20% of the 1000 most-cited publications. A term map was also created to visualize the co-occurrence of key terms in the domain. Different biological activities such as antioxidant and antitumor properties of mushrooms appeared to be a recurring topic in this field. Wasser (2003) showed the highest citation count ($n = 1282$), which is almost double the second most-cited publication ($n = 611$). There is a weak positive correlation ($r = +0.237$) between the years since publication and total citation count. In conclusion, this bibliometric study will assist researchers to comprehend the

current status of the research on culinary and medicinal mushrooms, and to visualize the future impact of such an important field.

Wasser, S. (2002) mushrooms on Earth is estimated at 140,000, yet maybe only 10% (approximately 14,000 named species) are known. Mushrooms comprise a vast and yet largely untapped source of powerful new pharmaceutical products. In particular, and most importantly for modern medicine, they represent an unlimited source of polysaccharides with antitumor and immuno-stimulating properties. Most of the clinical evidence for antitumor activity comes from the commercial polysaccharides lentinan, PSK (krestin), and schizophyllan, but polysaccharides of some other promising medicinal mushroom species also show good results. Their activity is especially beneficial in clinics when used in conjunction with chemotherapy. Mushroom polysaccharides prevent oncogenesis, show direct antitumor activity against various allogeneic and syngeneic tumors, and prevent tumor metastasis. Polysaccharides from mushrooms do not attack cancer cells directly, but produce their antitumor effects by activating different immune responses in the host. Practical application is dependent not only on biological properties, but also on biotechnological availability. The present review analyzes the peculiarities of polysaccharides derived from fruiting bodies and cultured mycelium (the two main methods of biotechnological production today) in selected examples of medicinal mushrooms.

Objectives of the Study

- To examine the growth of literature on Medicinal Mushroom during the period 1990–2020;
- To identify the country-wise research contribution and international collaboration in Medicinal Mushroom research;
- To identify the worldwide Medicinal Mushroom research in context of different subjects;
- To identify the highly productive institutions in this field of research;
- To identify the most productive authors in Medicinal Mushroom research; and
- To identify the most productive journals, and frequently cited research papers in this field of research.

Methodology

The data for this study has been obtained from Scopus multidisciplinary database by using suitable search syntax available at <http://www.scopus.com> during 1990-2020. A total of 3513 publications were transferred to spread sheet application. The bibliographic fields were analyzed by normal count procedure for various facets using bilioshiny software. Country wise collaboration, subject domains, authorships, journals, Institutes, most cited source and highly cited papers.

Analysis and Interpretation

Growth Trend

A total 3513 publications were made during 1990–2021, which have received 62172 citations. Table 1 show that the highest numbers of publication (363) were published in 2019, which have received (1861). The second highest publications (359) occurred in the year 2020, followed by (315) publications in the year 2018. The highest numbers of citations 5621 were received in the year 2015, followed by (5480) in the year 2012. Overall, growth of the literature for the study period was calculated and presented in Table 1. The global research output in Medicinal Mushroom has increased from 1 in 1993 to 363 in 2019. World's publications had increased from 118 publications during 2008-2020 In the same manner, the Indian research output in Medicinal Mushroom stands third place.

Table 1 Year wise Distribution of Publications

Sl. No.	Publication Impact			Citation Impact		
	Year	Records	Citations	Year	Records	Citations
1	2019	363	1861	2015	300	5612
2	2020	359	518	2012	202	5480
3	2018	315	2393	2013	209	4792
4	2015	300	5612	2010	148	4197
5	2016	296	3220	2011	175	4186
6	2017	282	3394	2014	233	4000
7	2014	233	4000	2009	135	3746
8	2013	209	4792	2017	282	3394
9	2012	202	5480	2008	118	3308
10	2011	175	4186	2016	296	3220
11	2010	148	4197	2006	52	2926
12	2009	135	3746	2007	70	2469
13	2008	118	3308	2018	315	2393
14	2021	94	36	2002	14	2356
15	2007	70	2469	2019	363	1861
16	2006	52	2926	2005	34	1781
17	2004	34	1669	2004	34	1669
18	2005	34	1781	2003	27	1357
19	2003	27	1357	1999	6	1062
20	2002	14	2356	2020	359	518
21	2001	9	336	2001	9	336
22	1995	8	243	2000	2	293
23	1999	6	1062	1992	3	290
24	1997	4	87	1995	8	243
25	1992	3	290	1990	2	241
26	1998	3	67	1996	2	154
27	1990	2	241	1993	1	98

28	1996	2	154	1997	4	87
29	2000	2	293	1998	3	67
30	1993	1	98	2021	94	36

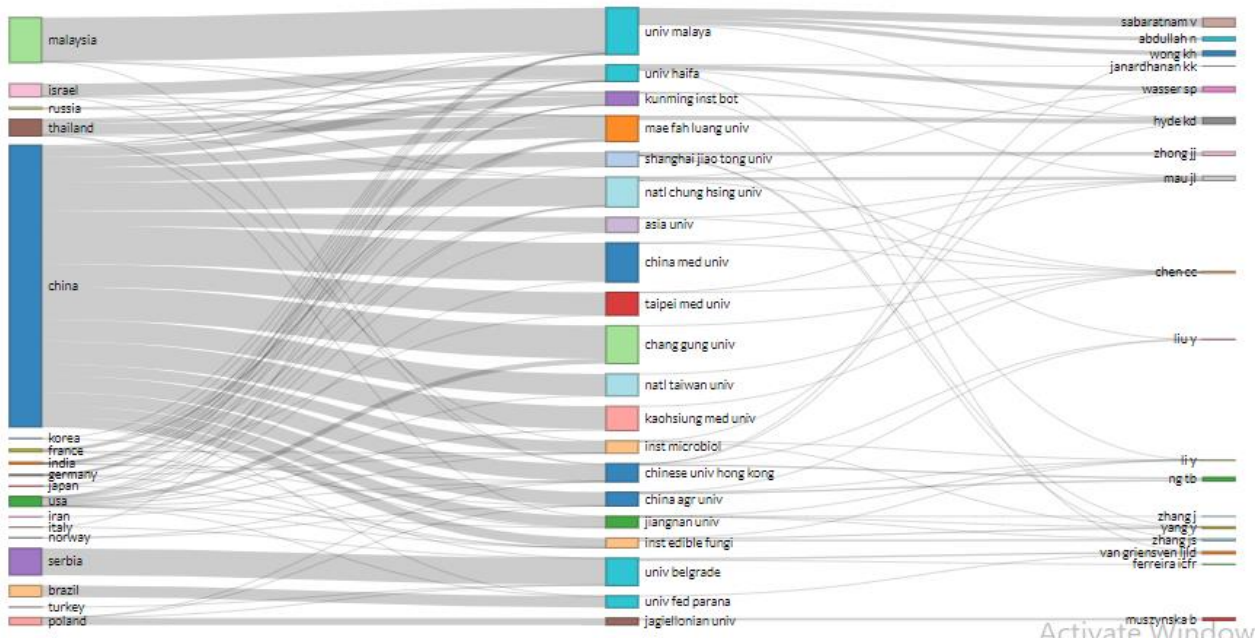
Most Productive Countries

On the basis of literature analysis around the world, it is found that the 3513 publications came from 110 countries. Table 2 illustrates that Peoples R China is the most productive country with 1125 publications and received 19435 citations, followed by Taiwan with 288 publications 5311 Citations, India with 275 publications 3087 Citations and USA with 244 having 6524 Citations. It is noted that, 9 countries with more than 100 Publications, 18 countries with more than 50 publications, 52 countries with more than 10 Publications. It also noted that, 20 countries with more than 1000 citations and 54 countries with more than 100 Citations.

Table 2: Most Productive Countries (Top 20)

Publication Impact					Citation Impact		
Sl. No	Country	Records	%	Citations	Country	Records	Citations
1	Peoples R China	1125	32.0	19435	Peoples R China	1125	19435
2	Taiwan	288	8.2	5311	USA	244	6524
3	India	275	7.8	3087	Taiwan	288	5311
4	USA	244	6.9	6524	South Korea	241	5305
5	South Korea	241	6.9	5305	Israel	71	4578
6	Japan	174	5.0	2556	Ukraine	41	3644
7	Brazil	158	4.5	2400	India	275	3087
8	Malaysia	157	4.5	2389	Japan	174	2556
9	Poland	112	3.2	1266	Brazil	158	2400
10	Serbia	88	2.5	1717	Malaysia	157	2389
11	Turkey	86	2.4	835	Serbia	88	1717
12	Thailand	79	2.2	1413	Germany	67	1653
13	Italy	73	2.1	987	Netherlands	46	1518
14	Israel	71	2.0	4578	Thailand	79	1413
15	Germany	67	1.9	1653	France	55	1366
16	Mexico	65	1.9	808	Canada	40	1344
17	Iran	59	1.7	888	Portugal	39	1329
18	France	55	1.6	1366	Poland	112	1266

19	Russia	47	1.3	460	UK	43	1244
20	Netherlands	46	1.3	1518	Spain	44	1125



Country Collaboration Map

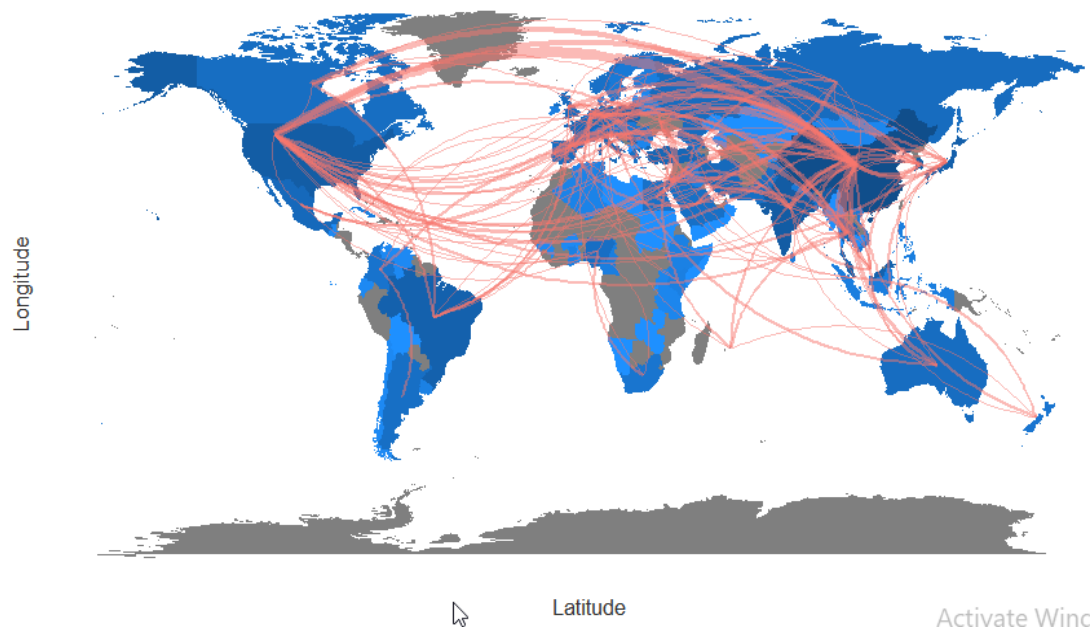


Figure 1 Country wise distribution

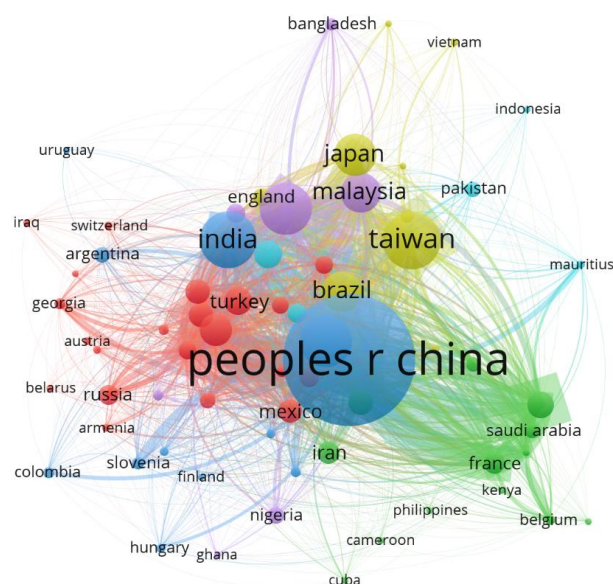


Figure 2 Citation Network of Countries

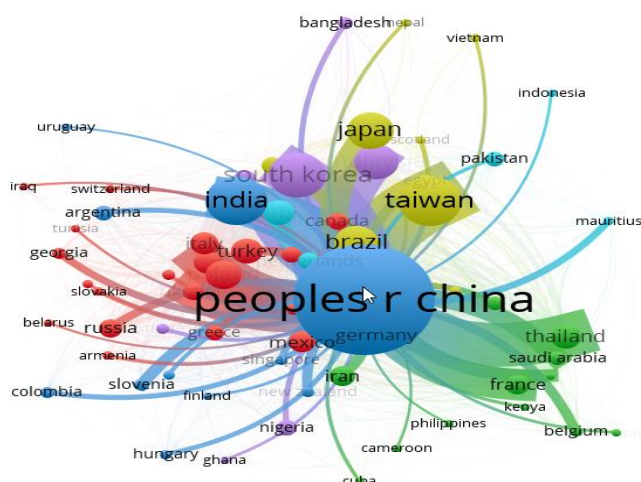


Figure 3 Citation Network (China)

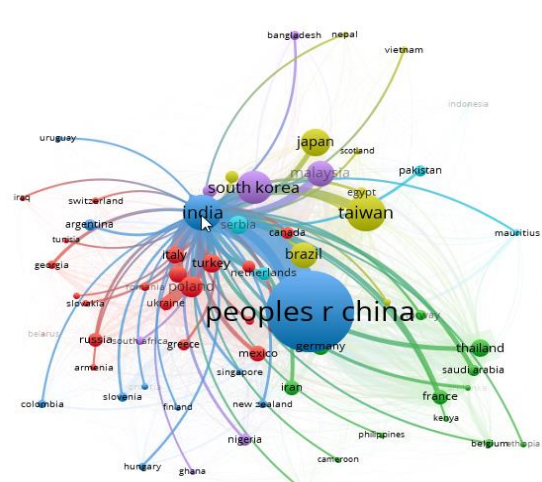


Figure 4 Citation Network (India)

Most Productive Institutions

Among the highly productive institutions, top twenty most productive institutions contributed on Medicinal Mushroom research and published 3513 share received 44460 citations. Table 3 illustrate that highest numbers of publications were contributed by Chinese Academy of Science with 152 publications; and received 2921 citations, and this institution is ranked number one in productivity. The highest impact of citations was registered by University of Haifa, with only 55 records. Asian institutions dominate in the Medicinal Mushroom research and none of Indian institution is found in the top fifteen institution list.

Table 3: Most Productive Institutions

Publication Impact				Citation Impact		
Sl. No	Institution	Records	Citations	Institution	Records	Citations
1	Chinese Academy of Science	152	2921	University of Haifa	55	4109
2	University Malaya	110	1849	National Academy of Science Ukraine	32	3489
3	National Chung Hsing University	83	1609	Chinese University of Hong Kong	73	3128
4	University Belgrade	76	1506	Chinese Academy of Sciences	152	2921
5	Chinese University Hong Kong	73	3128	Shanghai Jiao Tong University	60	1858
6	National Taiwan University	64	1169	University of Malaya	110	1849
7	Shanghai Jiao Tong University	60	1858	National Chung Hsing University	83	1609
8	Shanghai Academy of Agricultural Sciences	58	486	University of Belgrade	76	1506
9	University Haifa	55	4109	Mae Fah Luang University	53	1180
10	Mae Fah Luang University	53	1180	National Taiwan University	64	1169
11	China Medical University	50	673	E China University of Science & Technology	23	1052
12	China Agricultural University	42	1023	China Agricultural University	42	1023
13	Jiangnan University	41	524	Indiana University	15	866
14	Asia University	40	407	Fu Jen Catholic University	28	852
15	University Chinese Academy of Sciences	38	455	Konkuk University	20	806
16	Tokyo University of Pharmacy and Life Sciences	34	289	University of Wageningen & Research Centre	18	783
17	Natonal Academy of Sciences Ukraine	32	3489	University of Fed Parana	32	739
18	Federal University of Parana	32	739	Agriculture & Agricultural Food Canada	5	721
19	Amala Cancer Research Centre	31	640	Hong Kong Polytech University	19	701
20	Yunnan Academy of Agricultural Sciences	31	417	Academia Sinica	23	697



Figure 5 Institution wise Collaboration

Most Preferred Journals

Among 730 sources, it is noted that 53 Journals with more than 10 publications, 2 Journals with more than 50 Publications and only one with more than 1000 Publications. 7 journals with more than 1000 Citations, 24 Journals with more than 500 citations and 113 Journals with more than 100 citations.

In this study, ten highly productive journals publishing Medicinal Mushroom research papers were identified, and it was found that these journals collectively contributed immensely. A total of 3513 papers in Medicinal Mushroom research were published in 730 journals. Table 4 indicated below shows the impact of the most productive journals. “International Journal of Medicinal Mushrooms” is the highly productive journal with 1004 publications, followed by “Journal of Ethnopharmacology” and “Molecules” with 65. “Applied Microbiology and Biotechnology” has 3447 citations with 43 publications. It was found that Journal “Carbohydrate Polymers” has the highest impact factor (9.15) followed by Food Chemistry (7.27), International Journal of Biological Macromolecules (6.78), Journal of Agricultural and Food Chemistry (5.04), Journal of Ethnopharmacology (4.27).

Table 4: Most Preferred Journals

Sl. No	Journal	Country	Impact Factor	Records	Citations
1	International Journal of Medicinal Mushrooms	USA	1.52	1004	7798
2	Journal of Ethnopharmacology	Ireland	4.27	65	2035
3	Molecules	Switzerland.	3.26	65	912
4	Carbohydrate Polymers	United Kingdom	9.15	45	1437
5	Plos One	USA	2.74	45	637
6	International Journal of Biological Macromolecules	Netherlands	6.78	44	676
7	Applied Microbiology and Biotechnology	Germany	4.70	43	3441
8	Food Chemistry	United Kingdom	7.27	42	1765
9	Journal of Agricultural and Food Chemistry	USA	5.04	35	1485
10	Scientific Reports	United Kingdom	3.99	32	465

Most cited Journals

Table 5 depicts the Most Cited Journals; “International Journal of Medicinal Mushrooms” is leading with 7798 Citations followed by “Applied Microbiology and Biotechnology” with 3441 Citations, “Journal of Ethnopharmacology” with 2035 Citations, “Food Chemistry” with 1765 Citations, “Journal of Agricultural and Food Chemistry” with 1485, “Carbohydrate Polymers” with 1437 and “Fungal Diversity” with 1000 Citations.

Table 5: Most cited Journals

Sl. No	Journal	Records	Citations
1	International Journal of Medicinal Mushrooms	1004	7798
2	Applied Microbiology and Biotechnology	43	3441
3	Journal of Ethnopharmacology	65	2035
4	Food Chemistry	42	1765
5	Journal of Agricultural And Food Chemistry	35	1485
6	Carbohydrate Polymers	45	1437
7	Fungal Diversity	15	1000
8	International Immunopharmacology	15	998
9	Food and Chemical Toxicology	16	916
10	Molecules	65	912

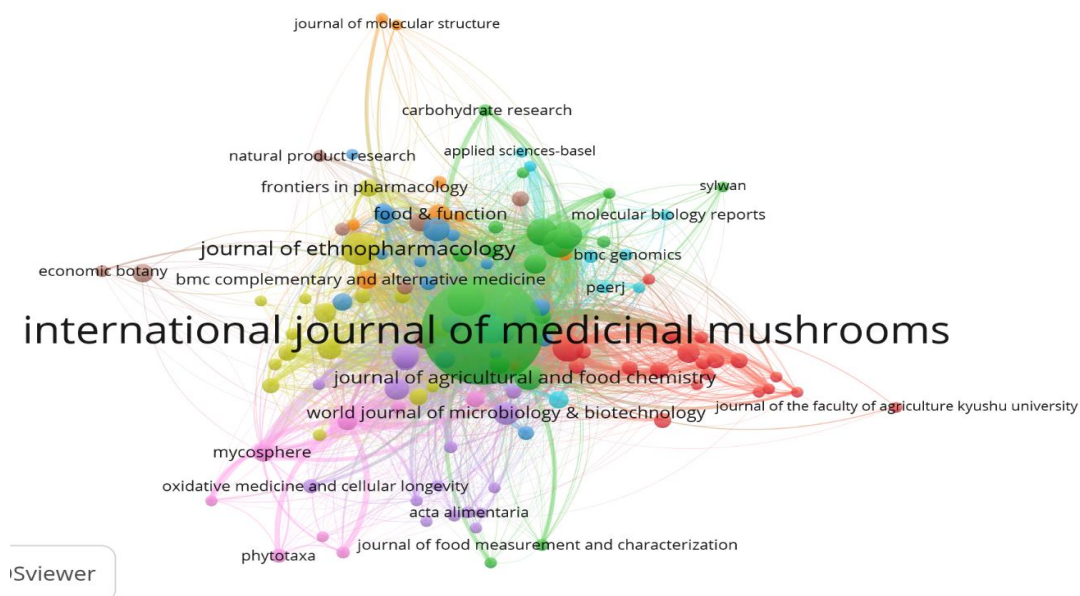


Figure 6 Most Cited Journals

Journal Impact

The below table show that “International Journal of Medicinal Mushrooms” started in the year 2007 has h-index 28, g-index 53, m-index 1.86 with total citation of 7798 having 1004 publications. Followed by “Journal of Ethnopharmacology” started in the year 2004 has h-index 27, g-index 44, m-index 1.5 with citation of 2035 having 65 publications.

Table 6 Source Impact

Sl. No.	Source	h_index	g_index	m_index	TC	NP	PY_start
1	International Journal of Medicinal Mushrooms	28	53	1.866666667	7798	1004	2007
2	Journal of Ethnopharmacology	27	44	1.5	2035	65	2004

3	Molecules	17	28	1.416666667	912	65	2010
4	Carbohydrate Polymers	24	37	1.5	1437	45	2006
5	PLOS One	15	23	1.5	637	45	2012
6	International Journal of Biological Macromolecules	17	24	1.7	676	44	2012
7	Applied Microbiology and Biotechnology	23	43	1.15	3441	43	2002
8	Food Chemistry	23	42	1.095238095	1765	42	2001
9	Journal Of Agricultural and Food Chemistry	19	35	0.863636364	1485	35	2000
10	Scientific Reports	13	21	1.3	465	32	2012

Most Productive Authors

It is noted that 189 authors with more than 10 Publications, and only three authors with more than 50 Publications. 6 authors with more than 1000 citations, 44 authors with more than 500 citations and 688 authors with more than 100 citations. Table 7 shows that top 20 authors have collectively contributed 703 papers during 1990–2020. It was identified that three authors have published higher number of papers (ie above 50 publications). Author “Sabaratnam V” 54 articles; followed by Wasser SP with 52 articles; and Zhong JJ with 51 articles. The twenty most productive authors have received a total of 17682 citations for 703 papers. Among the twenty authors Wasser SP has highest citation score of 4051 with 52 publications followed by Zhong JJ having citation score of 1795 with 51 records.

Table 7: Most Productive and Cited Authors (Top 20)

Publication Impact				Citation Impact		
Sl. No	Author	Records	Citations	Author	Records	Citations
1	Sabaratnam V	54	847	Wasser SP	52	4051
2	Wasser SP	52	4051	Zhong JJ	51	1795
3	Zhong JJ	51	1795	Ferreira ICFR	27	1324
4	Hyde KD	49	1107	Cheung PCK	20	1162
5	Mau JL	40	789	Hyde KD	49	1107
6	Yang Y	39	376	van Griensven LJLD	29	1006
7	Li Y	36	729	Sliva D	20	992
8	Abdullah N	34	587	Ng TB	28	952
9	Zhang JS	33	273	Barros L	19	883
10	Ohno N	32	282	Sabaratnam V	54	847
11	Wong KH	32	758	Wang HX	25	804
12	Janardhanan KK	30	639	Mau JL	40	789
13	Zhang J	30	646	Dai YC	19	780
14	van Griensven LJLD	29	1006	Wong KH	32	758

15	Chen CC	28	558	Wang Q	13	737
16	Ng TB	28	952	Zhang M	10	735
17	Ferreira ICFR	27	1324	Li Y	36	729
18	Muszynska B	27	349	Niksic M	20	669
19	Wang YZ	27	306	Zhang J	30	646
20	Liu Y	25	308	Cui SW	2	645

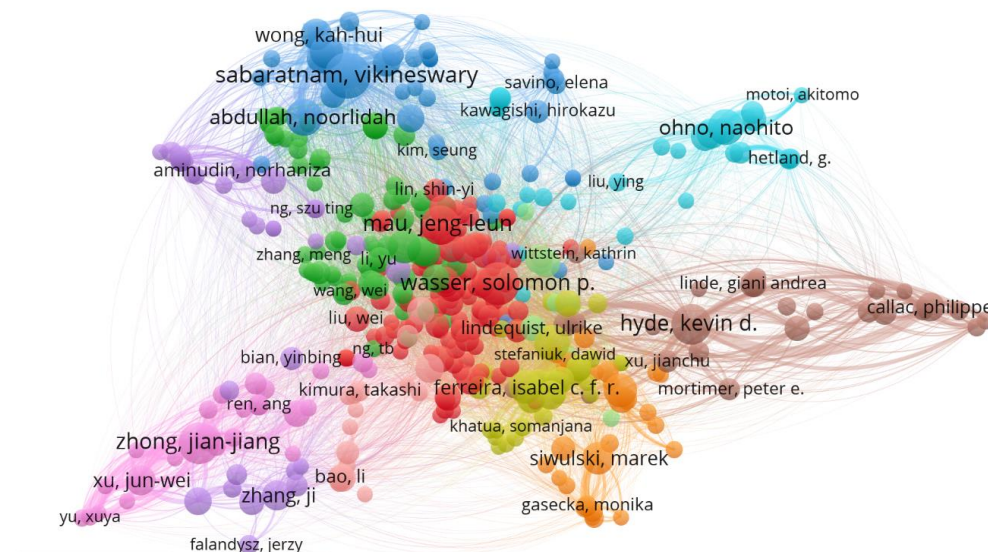


Figure 7 Most Productive Authors

Most Cited References

It is noted that 12 papers with more than 100 referred, 80 papers with more than 80 times referred, 1932 papers with 10 times referred and the study found totally 87796 cited references.

Table 8: Most Cited References

Sl. No	Author / Year / Journal	Records
1	Wasser SP, 2010, INT J MED MUSHROOMS, V12, P1, DOI 10.1615/IntJMedMushr.v12.i1.10	433
2	Wasser SP, 2002, APPL MICROBIOL BIOT, V60, P258, DOI 10.1007/s00253-002-1076-7	351
3	Chang ST, 2012, INT J MED MUSHROOMS, V14, P95, DOI 10.1615/IntJMedMushr.v14.i2.10	263
4	DUBOIS M, 1956, ANAL CHEM, V28, P350, DOI 10.1021/ac60111a017	263
5	Russell R, 2006, PHYTOCHEMISTRY, V67, P1985, DOI	180

	10.1016/j.phytochem.2006.07.004	
6	Lindequist U, 2005, EVID-BASED COMPL ALT, V2, P285, DOI 10.1093/ecam/neh107	160
7	Zhang M, 2006, TRENDS FOOD SCI TECH, V18, P4, DOI 10.1016/j.tifs.2006.07.013	148
8	BRADFORD MM, 1976, ANAL BIOCHEM, V72, P248, DOI 10.1016/0003-2697(76)90527-3	138
9	WASSER SP, 1999, INT J MED MUSHROOMS, V1, P31	138
10	Wasser SP, 1999, CRIT REV IMMUNOL, V19, P65	117

Highly Cited Papers

It is noted that 4 papers with more than 500 citations, 87 papers with more than 100 citations, 273 papers with more than 50 citations and only one papers with more than 1000 Citations.

Table 9: Highly Cited Papers

Sl. No	Date / Author / Journal	LCS	GCS	LCR	CR
1	64 Wasser SP Medicinal mushrooms as a source of antitumor and immunomodulating polysaccharides APPLIED MICROBIOLOGY AND BIOTECHNOLOGY. 2002 NOV; 60 (3): 258-274	351	1336	1	138
2	165 Zhang M, Cui SW, Cheung PCK, Wang Q Polysaccharides from mushrooms: a review on their isolation process, structural characteristics and antitumor activity TRENDS IN FOOD SCIENCE & TECHNOLOGY. 2006; 18 (1): 4-19	148	623	2	134
3	37 Wasser SP, Weis AL Therapeutic effects of substances occurring in higher basidiomycetes mushrooms: A modern perspective CRITICAL REVIEWS IN IMMUNOLOGY. 1999; 19 (1): 65-96	117	547	4	220
4	540 Wasser SP Medicinal Mushroom Science: History, Current Status, Future Trends, and Unsolved Problems INTERNATIONAL JOURNAL OF MEDICINAL MUSHROOMS. 2010; 12 (1): 1-16	433	505	13	85
5	1708 Chang CJ, Lin CS, Lu CC, Martel J, Ko YF, et al. Ganoderma lucidum reduces obesity in mice by modulating the composition of the gut microbiota NATURE COMMUNICATIONS. 2015 JUN; 6: Art. No. 7489	0	392	2	70
6	41 Borchers AT, Stern JS, Hackman RM, Keen CL, Gershwin ME Mushrooms, tumors, and immunity	56	350	5	119

	PROCEEDINGS OF THE SOCIETY FOR EXPERIMENTAL BIOLOGY AND MEDICINE. 1999 SEP; 221 (4): 281-293				
7	258 Moradali MF, Mostafavi H, Ghods S, Hedjaroude GA Immunomodulating and anticancer agents in the realm of macromycetes fungi (macrofungi) INTERNATIONAL IMMUNOPHARMACOLOGY. 2007 JUN; 7 (6): 701-724	79	322	7	132
8	882 Chang ST, Wasser SP The Role of Culinary-Medicinal Mushrooms on Human Welfare with a Pyramid Model for Human Health INTERNATIONAL JOURNAL OF MEDICINAL MUSHROOMS. 2012; 14 (2): 95-134	263	307	9	97
9	142 Zaidman BZ, Yassin M, Mahajna J, Wasser SP Medicinal mushroom modulators of molecular targets as cancer therapeutics APPLIED MICROBIOLOGY AND BIOTECHNOLOGY. 2005 JUN; 67 (4): 453-468	112	288	5	179
10	43 Broadhurst CL, Polansky MM, Anderson RA Insulin-like biological activity of culinary and medicinal plant aqueous extracts in vitro JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY. 2000 MAR; 48 (3): 849-852	0	276	0	30

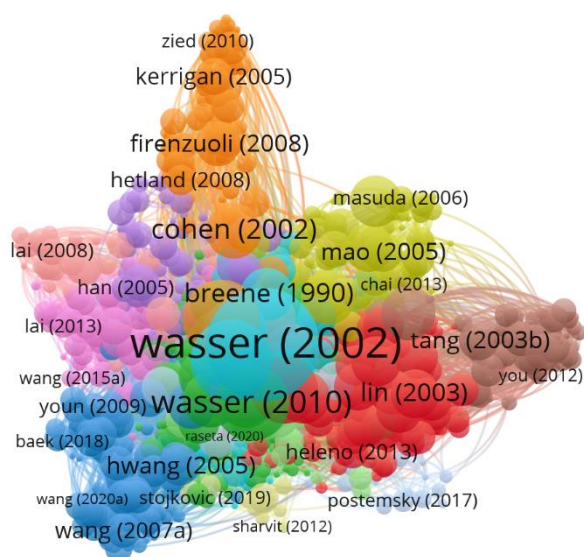


Figure 8 Highly Cited Papers

Findings and Conclusion

As per the Socpus database, a total of 3513 publications were published on Medicinal Mushroom, which received 44460 citations during 1990-2020. The average number of citations per publication was 17.7. The research was peaked in 2019 with 363 Publications. The Collaboration Index is 3.03 and Citing Articles (References) 87796. Among 3513 documents only 126 documents were singled authored remaining 3387 were Multi-Author. This study reveals that the collaborative publications were predominant in the field of Medicinal

Mushroom. The most frequently cited document was “Wasser SP, Medicinal mushrooms as a source of antitumor and immunomodulating polysaccharides, *Applied Microbiology and Biotechnology*. 2002 NOV; 60 (3): 258-274 with 1336 citations. Republic R China ranks first in the field of Medicinal Mushroom research. “Wasser SP” having 52 records with citations 4051. Research productivity of 1004 articles covered in “*International Journal of Medicinal Mushrooms*” with citation of 7798 h-index 28, g-index 53 & m – index 1.8. The investigations of such nature may be found useful in understanding the research and communication patterns in the field of Medicinal Mushroom. This study will be helpful in planning more effective research and communication systems in future.

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