

Glycyrrhiza glabra (Medicinal Plant) Research: A Scientometric Assessment of Global Publications Output during 1997-2016

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ABSTRACT

The present study examined 3428 global publications in *Glycyrrhiza glabra*, as covered in multidisciplinary Scopus bibliographical database during 1997-2016, with a view to understand their growth rate, global share, citation impact, international collaborative papers share, distribution of publications by broad subjects, productivity and citation profile of top organizations and authors, preferred media of communication and bibliographic characteristics of high cited papers. The global publications registered an annual average growth rate of 10.87% and its citation impact averaged to 19.09 citations per paper. Among the top 12 most productive countries, the global share ranged from 1.87% to 19.81%, with China contributing the largest share of 19.81%, followed by India (13.71%), USA (11.84%), etc. More than 79.0% of the cumulative global publication share comes from top 12 countries during 1997-2016, showing decrease from 100.0% to 77.80% from 1997-2006 to 2007-16. Seven countries registered relative citation index above the world average of 1.10: U.K. (2.39), USA (1.87), Canada (1.71), Italy (1.51), Japan (1.49), Turkey (1.24) and Taiwan (1.18) during 1997-2016. Medicine, among seven broad subjects, contributed the largest publications share of 44.41%, followed by pharmacology, toxicology and pharmaceuticals (35.04%), biochemistry, genetics and molecular biology (26.84%), agricultural and biological sciences (16.89%), chemistry (14.59%), etc. during 1997-16. Among various organizations and authors contributing to global *Glycyrrhiza glabra* research, the 20 most productive global organizations and authors together contributed 15.08% and 9.16% global publication share respectively and 14.57% and 16.62% global citation share respectively during 1997-16. Amongst 3322 journal papers (in 1153 journals) in global *Glycyrrhiza glabra* research, the top 20 most productive journals contributed 16.80% share of total journal publication output during 1997-2016. One hundred thirteen (113) publications were found to be high cited, as they registered citations from 100 to 852 during 1997-2016 and they together received 22234 citations, which averaged to 196.76 citations per paper.

Key words: *Glycyrrhiza glabra*, Medicinal plant, Global research output, Scientometrics, Bibliometrics.

INTRODUCTION

Medicinal plants are of great importance to the health of individuals and communities. The medicinal value of these plants lies in some chemical substances that produce a definite physiological action on the human body. The most important of these bioactive constituents of plants are triterpenoid saponin, flavonoids, tannins, alkaloids and phenolic compounds. Many of these indigenous medicinal plants are used as a spices and food plant. They are also sometimes added to foods meant for pregnant and nursing mothers for medicinal purposes.¹

Glycyrrhiza is a genus of about 20 species and a member of the pea and bean family (Leguminosae/Fabaceae), with a sub-cosmopolitan distribution in Asia, Australia, Europe, and the Americas. Its scientific name is taken from the Greek for sweet root (glykys,

meaning sweet, and rhiza, meaning root).^{2,3} *Glycyrrhiza glabra* (known as Liquorice in English, Mulethi in Hindi and also called Yashtimadhu in Ayurveda), is an important herb used in Indian medicines, home remedies, folk medicines and Ayurveda.

Liquorice (British English) or licorice (American English) is the root of *Glycyrrhiza glabra* from which a sweet flavour can be extracted. It is cultivated for its rhizomes that contain the compound glycyrrhizin, which is 50 times sweeter than sugar.²⁻³ Phytochemical analysis of *Glycyrrhiza glabra* root extract showed that it contains saponin triterpenes (glycyrrhizin, glycyrrhetic acid and liquiritic acid), flavonoids (liquirtin, isoflavonoids and formononetin) and other constituents such as coumarins, sugars, amino acids, tannins, starch, choline, phytosterols and bitter principles.⁴

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Glycyrrhiza glabra is a plant used in in herbalism and traditional medicine across the world for its ethnopharmacological value. It is found to contain important phytoconstituents, which are effectively used as anti-inflammatory, anti-bacterial, anti-fungal, anti-diabetic, antiviral, anti-ulcer, antitussive, anti-oxidant, skin whitening, anti-diuretic agent. Its roots were also demonstrated to have antidepressant, hypotensive hepatoprotective, spasmolytic, memory strengthening activity. Licorice roots are used for its demulcent property.⁵⁻⁶

This plant species is reported in the literature for its biological activities such as: anti-inflammatory and expectorant, controls coughing and has hormonal effects. It detoxifies and protects the liver. Medicinally, it is used internally for Addison's disease asthma, bronchitis, peptic ulcer, arthritis, allergic complaints and steroid therapy. Externally, liquorices are used for eczema, herpes and shingles. Since, liquorice extract is used in auto-immune conditions and has therapeutic benefit in immunodeficiency conditions like AIDS. Components of licorice root have both estrogenic and anti-estrogenic activity. It is thus, an important herb for treating hormone-related female problems. It is used as an energy tonic, particularly for the spleen and stomach, and the root is added to many formulae. Roots of *Glycyrrhiza glabra* being tonic, demulcent laxative emollient are used in genito-urinary diseases. It is also useful in gout, asthma, sore throat, tonsillitis, flatulence, sexual debility, epilepsy, hyperdypsia, fever, coughs, skin diseases, swellings, acidity, leucorrhoea, bleeding, jaundice, hiccough, hoarseness, and vitiated conditions of vata dosha, gastralgia, cephalgia, ophthalmopathy and pharyngodnia. Licorice is an important ingredient in medicinal oils for epilepsy, paralysis, rheumatism, haemorrhagic diseases. It is also used in the treatment of diarrhoea, fevers, fever with delirium and anuria.⁷

Historically, the dried rhizome and root of this plant were employed medicinally by the Egyptian, Chinese, Greek, Indian, and Roman civilizations as an expectorant and carminative. In modern medicine, licorice extracts are often used as a flavoring agent to mask bitter taste in preparations, and as an expectorant in cough and cold preparations. Licorice extracts have been used for more than 60 years in Japan to treat chronic hepatitis, and also have therapeutic benefit against other viruses, including human immunodeficiency virus (HIV), cytomegalovirus (CMV), and Herpes simplex.⁴

Literature Review

Only one scientometric study had been published so far on *Glycyrrhiza glabra* by Shri Ram,⁸ which assessed the research output of liquorice, indexed in Scopus database during 1993-2013. It assessed the characteristics of liquorice publications including publication distribution by countries, journals and authors. It also identified the distribution of publications by subject categories and analysed the keywords associated with liquorice research. There are only few other scientometric studies available in the past, which quantitatively analyze global and Indian literature on individual medicinal plants, such as Aloe Vera,⁹ Artemisinin,¹⁰ *Azadirachta indica*¹¹ and Phlox dactylifera.¹²⁻¹³

OBJECTIVES

The main objectives of this study are to study the performance of *Glycyrrhiza glabra* research during 1997-16, based on publications output covered in Scopus database. In particular, the study focuses on the following objectives: (i) To study the growth of world and top 12 most productive countries research output in *Glycyrrhiza glabra* research, its citation impact and international collaborative publication share; (ii) To study the global research output by broad subject areas and the dynamics of its growth and decline; (iv) To study the trends in *Glycyrrhiza glabra* research by identifying significant keywords; (v) To study the publication productivity and citation impact of top 20 most productive organi-

zations and authors; (vi) To study the leading modes of communication in research and (vii) to study the characteristics of top 113 highly cited papers.

METHODOLOGY

The study retrieved and downloaded 20-year publication data in *Glycyrrhiza glabra* research from the Scopus database (<http://www.scopus.com>) covering the period 1997-2016. Keywords, such as "Glycyrrhiza glabra or liquorice or licorice or glycyrrhizic acid" was incorporated in the search string and qualified these keywords with "TITLE-ABS-KEY" tag and in addition incorporated in this search string the period '1997-16' within "date range tag". Finally, this search string was applied first for searching global publication data on *Glycyrrhiza glabra* and then further restricted to individual country by name in "country tag" to ascertain publication output of top 12 most productive countries (including India) in *Glycyrrhiza glabra* research. The search string was subsequently refined, using analytical functions and tags in Scopus database, by "subject area tag", "country tag", "source title tag", "journal title name" and "affiliation tag", to get data/information on the distribution of publications output by subject, collaborating countries, author-wise, organization-wise and journal-wise, etc. For citation data, citations to publications were also collected from date of publication till 19 January 2018.

(TITLE-ABS-KEY(liquorice) OR TITLE-ABS-KEY(glycyrrhiza glabra) OR TITLE-ABS-KEY(licorice) OR TITLE-ABS-KEY(glycyrrhizic acid)) AND PUBYEAR > 1996 AND PUBYEAR < 2017

ANALYSIS

The total research output of the world in field of *Glycyrrhiza glabra* cumulated to 3428 publications in 20 years during 1997-2016. The annual output of the world in *Glycyrrhiza glabra* research increased from 53 in the year 1997 to 329 publications in the year 2016, registering 10.87% growth per annum. The cumulative world output in *Glycyrrhiza glabra* research in 10 years 1997-2006 increased from 901 to 2527 publications during succeeding 10-year period 2007-16, registering 180.47% growth. Of the total global publications output, 81.80% (2804) appeared as articles, 11.35% (389) as reviews, 2.51% (86) as conference papers, 1.28% (44) as letters, 1.14% (39) as book chapters, 0.55% (19) as short surveys, 0.53% (18) as notes, 0.32% (11) as editorials, 0.26% (9) as erratum, 0.09% (3) each as books, conference reviews and articles in press. The citation impact of global publications on *Glycyrrhiza glabra* research in 20 years averaged to 19.09 citations per publication (CPP) during 1997-2016; ten-yearly impact averaged to 38.67 CPP for the period 1997-2006, which sharply declined to 12.10 CPP in the succeeding ten-year 2007-2016 (Table 1).

TOP 12 MOST PRODUCTIVE COUNTRIES IN GLYCYRRHIZA GLABRA RESEARCH

The global research output in the field of *Glycyrrhiza glabra* research had originated from 94 countries during 1997-2016, of which, 60 published 1-10 papers each in 20 years, 20 countries 11-50 papers each, 6 countries 51-100 papers each and 8 countries 132 to 679 papers each. The top 12 most productive countries in *Glycyrrhiza glabra* research contributed 64 to 679 publications each during 1997-2016 (Table 2). The top 12 most productive countries in *Glycyrrhiza glabra* research accounted for 79.18% global publications share and 84.94% citation share during 1997-2016. Their ten-yearly output accounted for 100.0% global publication share during 1997-2006 which decreased to 77.80% during succeeding ten-year period 2007-16. Country-wise, the global publication shares of top 12 countries varied widely 1.87% to 19.81% during 1997-16, with China accounting for the highest publication share (19.81%), followed

Table 1: World Output in *Glycyrrhiza glabra* Research, 2007-16.

Publication Period	TP	World	
		TC	CPP
1997	53	2478	46.75
1998	58	2752	47.45
1999	57	2200	38.60
2000	76	4892	64.37
2001	74	2871	38.80
2002	76	3145	41.38
2003	112	3822	34.13
2004	126	4241	33.66
2005	122	4776	39.15
2006	147	3663	24.92
2007	151	3985	26.39
2008	188	4458	23.71
2009	204	3789	18.57
2010	249	4149	16.66
2011	262	3591	13.71
2012	279	3276	11.74
2013	282	3092	10.96
2014	305	2089	6.85
2015	278	1357	4.88
2016	329	801	2.43
1997-2006	901	34840	38.67
2007-2016	2527	30587	12.10
1997-2016	3428	65427	19.09

TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper

by India (13.71%), USA (10.72% share), Japan (8.66%), South Korea (6.59%), Iran (5.72%) and Germany (4.38%). The other 8 countries contributed their global publication share between 1.87% to 3.85 in 20 years during 1997-16. The global publication share registered a decreasing publication share varying from 0.83% to 4.76% in 11 countries, except for increase in Iran in ten years period (1997-2006 and 2007-16). Seven of top 12 countries scored relative citation index above the world average of 1.10: U.K. (2.39), USA (1.87), Canada (1.71), Italy (1.51), Japan (1.49), Turkey (1.24) and Taiwan (1.18) during 1997-2016. India has though emerged as one of the world leaders in *Glycyrrhiza glabra* research, its performance in terms of relative citation index has below the world average (0.68).

INTERNATIONAL COLLABORATION

The international collaborative output of top 12 most productive countries in *Glycyrrhiza glabra* research as a national share in the country-wise output varied widely from 6.12% to 42.55%, with highest share coming from U.K. (42.55%), followed by Canada (42.19%), USA (35.96%), Germany (29.33%), Italy (21.97%), Japan (19.19%), South Korea (19.03%), Turkey (17.24%), China (13.84%), Taiwan, India and Iran (from 6.12% to 9.09%) during 1997-16. Most surprisingly, India's international collaborative share in its national output in *Glycyrrhiza glabra* research has been comparatively small and marginal, 8.09

SUBJECT-WISE DISTRIBUTION OF RESEARCH OUTPUT

The global *Glycyrrhiza glabra* research output published during 1997-16 is distributed across twelve sub-fields (as identified in Scopus database classification), with medicine accounting for the highest publications share (44.41%), followed by pharmacology, toxicology and pharmaceuticals (35.04%), biochemistry, genetics and molecular biology (26.84%), agricultural and biological sciences (16.89%), chemistry (14.59%), and other 7 sub-fields contribution varying from 0.90% to 4.99% during

Table 2: Global Publication Share of Top 12 Most Productive Countries in *Glycyrrhiza glabra* during 1997-2016.

S.No	Name of the Country	Number of Papers			Share of Papers			TC	CPP	HI	ICP	%ICP	RCI
		1997-2006	2007-2016	1997-2016	1997-2006	2007-2016	1997-2016						
1	China	187	492	679	20.75	19.47	19.81	7922	11.67	42	94	13.84	0.61
2	India	153	317	470	16.98	12.54	13.71	6119	13.02	37	38	8.09	0.68
3	USA	135	271	406	14.98	10.72	11.84	14460	35.62	59	146	35.96	1.87
4	Japan	82	215	297	9.10	8.51	8.66	8475	28.54	49	57	19.19	1.49
5	South Korea	91	135	226	10.10	5.34	6.59	4096	18.12	35	43	19.03	0.95
6	Iran	50	146	196	5.55	5.78	5.72	2880	14.69	24	12	6.12	0.77
7	Germany	45	105	150	4.99	4.16	4.38	3159	21.06	31	44	29.33	1.10
8	Italy	41	91	132	4.55	3.60	3.85	3811	28.87	33	29	21.97	1.51
9	U.K.	31	63	94	3.44	2.49	2.74	4286	45.60	34	40	42.55	2.39
10	Turkey	38	49	87	4.22	1.94	2.54	2064	23.72	24	15	17.24	1.24
11	Taiwan	24	42	66	2.66	1.66	1.93	1488	22.55	25	6	9.09	1.18
12	Canada	24	40	64	2.66	1.58	1.87	2092	32.69	21	27	42.19	1.71
	Total	901	1966	2867	100.00	77.80	83.63	60852	21.22	34.5	551	19.22	1.11
	World	901	2527	3428				65427	19.09				
	Share of 12 Countries in World Total	100.0	77.80	83.63				93.01					

TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper; HI=h-index; ICP=International Collaborative Papers; RCI=Relative Citation Index

Table 3: Subject-Wise Breakup of Global Publications in *Glycyrrhiza glabra* Research during 1997-2016.

S.No	Subject*	Number of Papers (TP)			Activity Index		TC	CPP	%TP
		1997-2006	2007-16	1997-16	1997-2006	2007-16			
1	Medicine	417	1102	1519	104.45	98.41	29008	19.10	44.31
2	Pharmacology, Toxicology and Pharmaceutics	282	919	1201	89.34	103.80	23972	19.96	35.04
3	Biochemistry, Genetics and Molecular Biology	264	656	920	109.18	96.73	23022	25.02	26.84
4	Agricultural and Biological Sciences	130	449	579	85.42	105.20	10456	18.06	16.89
5	Chemistry	125	375	500	95.12	101.74	11459	22.92	14.59
6	Immunology and Microbiology	36	135	171	80.10	107.10	3804	22.25	4.99
7	Chemical Engineering	21	119	140	57.07	115.31	2343	16.74	4.08
8	Environmental Science	22	93	115	72.78	109.70	2510	21.83	3.35
9	Engineering	10	82	92	41.36	120.91	723	7.86	2.68
10	Neurosciences	10	45	55	69.18	110.99	1209	21.98	1.60
11	Dentistry	3	29	32	35.67	122.94	323	10.09	0.93
12	Veterinary Science	4	27	31	49.09	118.15	137	4.42	0.90
	World Output	901	2527	3428			65427	19.09	

• There is overlapping of literature covered under various subjects
TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper

1997-16. Its activity index, which computes change in research activity in the discipline over time 1997-2006 to 2007-16 (world average activity index of a given subject is taken as 100), witnessed increase in pharmacology, toxicology and pharmaceutics (from 89.34 to 103.80), agricultural and biological sciences (from 85.42 to 105.20), chemistry (from 95.12 to 101.74), immunology and microbiology (from 80.10 to 107.10), chemical engineering (from 57.07 to 115.31), environmental science (from 72.78 to 109.70), engineering (from 41.36 to 120.91), neurosciences (from 69.18 to 110.99), dentistry (from 35.67 to 122.94) and veterinary science (from 49.09 to 118.15), as against decline of research activity in medicine (from 104.45 to 98.41) and biochemistry, genetics and molecular biology (from 109.18 to 96.73) from 1997-2006 to 2007-16. Biochemistry, genetics and molecular biology, among various subjects registered the highest citations impact per paper of 25.02 CPP, followed by chemistry (22.92), immunology and microbiology (22.25), neurosciences (21.98), environmental science (21.83), pharmacology, toxicology and pharmaceutics (19.96), medicine (19.10), agricultural and biological sciences (18.06), chemical engineering (16.74), dentistry (10.09), engineering (7.86) and veterinary science (4.42) during 1997-16 (Table 3).

PROFILE OF TOP 20 MOST PRODUCTIVE GLOBAL ORGANIZATIONS

Six Hundred Ninety-eight (698) organizations participated in global research on *Glycyrrhiza glabra* during 1997-16, of which 487 organizations contributed 1-5 papers each, 151 organizations 6-10 papers each, 45 organizations 11-20 papers each, 11 organizations 21-30 papers each and 4 organizations 31-46 papers each. The productivity of top 20 most productive global organizations in *Glycyrrhiza glabra* research varied from 18 to 46 publications and together they contributed 15.08% (517) publication share and 14.57% (9530) citation share during 1997-2016.

The scientometric profile of these top 20 organizations is presented in Table 4.

Seven of these organizations registered publications output greater than the group average of 25.85: Beijing University of Chinese Medicine, China (46 papers), Hallym University, South Korea (39 papers), Seoul National University, South Korea (37 papers), Tehran University of Medical Sciences, Iran (34 papers), China Pharmaceutical University, China (29 papers), Peking University, China (28 papers) and, University of Illinois at Chicago, USA (26 papers) during 1997-2016;

Ten organizations registered citation impact above the group average of 18.43 citations per publication during 1997-16: University of Padua, Italy (38.57), Gifu Pharmaceutical University, Japan (37.55), University of Illinois at Chicago, USA (34.08), Hallym University, South Korea (29.08), Kaneka Corporation, Osaka, Japan (26.70), Tehran University of Medical Sciences, Iran (25.53), Seoul National University, South Korea (22.0), Korea Food Research Institute, South Korea (20.19), China Pharmaceutical University, China (19.69) and China Medical University Taichung, Taiwan (18.52);

Nine organizations contributed international collaborative publications share above the group average of 10.64%: Seoul National University, South Korea (24.32%), Korea Food Research Institute, South Korea (23.81%), Gifu Pharmaceutical University, Japan (20.0%), China Pharmaceutical University, China (17.24%), Kyungpook National University, South Korea (16.67%), China Agricultural University, Beijing, China (16.0%), University of Padua, Italy (14.29%), University of Illinois at Chicago, USA (11.54%) and Zhejiang University, China (11.11%) during 1997-2016;

Nine organizations registered the relative citation index above the group average (0.97) of all organizations: University of Padua, Italy (2.02), Gifu Pharmaceutical University, Japan (1.97), University of Illinois at Chi-

Table 4: Scientometric Profile of Top 20 Most Productive Global Organizations in *Glycyrrhiza glabra* Research during 1997-2016.

S.No	Name of the Organization	TP	TC	CPP	HI	ICP	%ICP	RCI
1	Beijing University of Chinese Medicine, China	46	219	4.76	8	0	0.00	0.25
2	Hallym University, South Korea	39	1134	29.08	20	4	10.26	1.52
3	Seoul National University, South Korea	37	814	22.00	15	9	24.32	1.15
4	Tehran University of Medical Sciences, Iran	34	868	25.53	8	3	8.82	1.34
5	China Pharmaceutical University, China	29	571	19.69	12	5	17.24	1.03
6	Peking University, China	28	387	13.82	12	2	7.14	0.72
7	University of Illinois at Chicago, USA	26	886	34.08	13	3	11.54	1.79
8	China Agricultural University, Beijing, China	25	223	8.92	7	4	16.00	0.47
9	China Academy Chinese Medical Science, Beijing, China	25	125	5.00	6	0	0.00	0.26
10	Nanjing University of Traditional Chinese Medicine, China	23	204	8.87	9	1	4.35	0.46
11	China Medical University Taichung, Taiwan	23	426	18.52	13	2	8.70	0.97
12	Central Institute of Medicinal and Aromatic Plants, Lucknow, India	23	374	16.26	11	2	8.70	0.85
13	Chinese Academy of Medical Sciences, China	23	138	6.00	7	2	8.70	0.31
14	University of Padua, Italy	21	810	38.57	14	3	14.29	2.02
15	Korea Food Research Institute, South Korea	21	424	20.19	11	5	23.81	1.06
16	Kaneka Corporation, Osaka, Japan	20	534	26.70	13	0	0.00	1.40
17	Gifu Pharmaceutical University, Japan	20	751	37.55	12	4	20.00	1.97
18	Zhejiang University, China	18	296	16.44	10	2	11.11	0.86
19	Peking Union Medical College, China	18	102	5.67	7	1	5.56	0.30
20	Kyungpook National University, South Korea	18	244	13.56	11	3	16.67	0.71
	Total of 20 organizations	517	9530	18.43	10.95	55	10.64	0.97
	Total of World	3428	65427	19.09				
	Share of top 20 organizations in World total output	15.08	14.57					

TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper; HI=h-index; ICP=International Collaborative Papers; RCI=Relative Citation Index

cago, USA (1.79), Hallym University, South Korea (1.52), Kaneka Corporation, Osaka, Japan (1.40), Tehran University of Medical Sciences, Iran (1.34), Seoul National University, South Korea (1.15), Korea Food Research Institute, South Korea (1.06) and China Pharmaceutical University, China (1.03) during 1997-2016.

PROFILE OF TOP 20 MOST PRODUCTIVE AUTHORS

One thousand and sixtyeight (1068) authors participated in global research on *Glycyrrhiza glabra* during 1997-16, of which 967 authors contributed 1-5 papers each, 81 authors 6-10 papers each, 16 authors 11-20 papers each and 4 authors 21-26 papers each. The research productivity in the field of *Glycyrrhiza glabra* research of top 20 most productive authors varied from 11 to 26 publications. Together they contributed 9.16% (314) global publication share and 16.62% (10876) citation share during 1997-16. The scientometric profile of these 20 authors is presented in Table 5.

Nine authors registered publications output above the group average of 15.7: S.S. Lim (26 papers), J.H.Y. Park (23 papers), D.A. Armanini and M. Ye (21 papers each), H. Hayashi (20 papers), E. Yarnell (18 papers), J. Bielenberg and C. Fiore (16 papers each) during 1997-2016;

Seven authors registered impact above the group average of 34.64 citations per publication: M. Aviram (120.58), J. Vaya (92.5), I.C. Haznedaroglu (61.62), S. Tamir (55.0), C. Fiore (48.75), R.B. Breemen (43.92) and D.A. Armanini (41.33) during 1997-2016;

Nine authors contributed international collaborative publications share above the group average of 10.19% of all authors: W. Li (27.27%), H. Hayashi (20.0%), J. Vaya (18.75%), C. Fiore and J. Bielenberg (18.75% each), S. Tamir (18.18%), D.A. Armanini, J.H.Y. Park (13.04%) and S.S. Lim (11.54%) during 1997-2016;

Seven authors registered the relative citation index above the group average (1.81) of all authors: M. Aviram (6.32), J. Vaya (4.85), I.C. Haznedaroglu (3.23), S. Tamir (2.88), C. Fiore (2.55), R.B. Breemen (2.30) and D.A. Armanini (2.17) during 1997-2016.

MEDIUM OF RESEARCH COMMUNICATION

Of the total world output on *Glycyrrhiza glabra* research, 96.91% (3322) appeared in journals, 1.20% (41) in books, 0.90% (31) in book series, 0.70% (24) in conference proceedings, 0.26% (9) as trade publications and 0.03% (1) as unidentified during 1997-16. 3322 journal papers appeared in 1153 journals, of which 1110 journals published 1-10 papers each, 30 journals 11-20 papers each and 13 journals 21-64 papers each during 1997-2016. The top 20 most productive journals reported 16 to 64 papers each on *Glycyrrhiza glabra* research; together they accounted for 16.80% (558 papers) of total *Glycyrrhiza glabra* output published in journals during 1997-16. *Glycyrrhiza glabra* research being reported increasingly in journals is gradually becoming a trend; for example, the top 20 most productive journals in ten years has shown decline in their *Glycyrrhiza glabra* output from 18.74% to 16.09% share between 1997-2006 and 2007-16. The top ranking journal is *Journal of Ethnopharmacology* (with 64 papers), followed by *Phototherapy Research* (50 papers), *Jour-*

Table 5: Scientometric Profile of Top 20 Most Productive Authors in *Glycyrrhiza glabra* Research during 1997-16.

S.No	Name of the Author	Affiliation of the Author	TP	TC	CPP	HI	ICP	%ICP	RCI
1	S.S. Lim	Hallym University, South Korea	26	704	27.08	16	3	11.54	1.42
2	J.H.Y. Park	Hallym University, South Korea	23	753	32.74	16	3	13.04	1.71
3	D.A. Armanini	University of Padua, Italy	21	868	41.33	14	3	14.29	2.17
4	M. Ye	Peking University, Health Science Centre, China	21	583	27.76	12	1	4.76	1.45
5	H. Hayashi	Gifu Pharmaceutical University, Japan	20	546	27.30	13	4	20.00	1.43
6	E. Yarnell	Botanical Medicine Academy, WA, USA	18	34	1.89	4	0	0.00	0.10
7	J. Bielenberg	Raphael-Apotheke Westerhorn, Germany	16	331	20.69	4	3	18.75	1.08
8	C. Fiore	University of Padua, Italy	16	780	48.75	13	3	18.75	2.55
9	J. Vaya	Migal, Galilar Technology Centre, Israel	16	1480	92.50	14	3	18.75	4.85
10	K. Abascal	Botanical Medicine Academy, WA, USA	15	30	2.00	3	0	0.00	0.10
11	K. Nakagawa	Kaneka Corporation, Osaka, Japan	14	422	30.14	10	0	0.00	1.58
12	X. Qiao	Peking University, China	14	261	18.64	9	0	0.00	0.98
13	I.C. Haznedaroglu	Hacettepe University Medical School, Turkey	13	801	61.62	13	1	7.69	3.23
14	M. Aviram	Migal, Galilar Technology Centre, Israel	12	1447	120.58	12	1	8.33	6.32
15	M. Shibano	Osaka University of Pharmaceutical Science, Japan	12	135	11.25	7	1	8.33	0.59
16	R.B. Breemen	University of Illinois at Chicago, USA	12	527	43.92	10	1	8.33	2.30
17	W.Q. Wang	Beijing University of Chinese Medicine, China 12	12	90	7.50	5	0	0.00	0.39
18	S. Ji	Peking University, China	11	136	12.36	7	0	0.00	0.65
19	W. Li	Kitasato University, Tokyo, Japan	11	343	31.18	9	3	27.27	1.63
20	S. Tamir	Migal, Galilar Technology Centre, Israel	11	605	55.00	8	2	18.18	2.88
		Total of 20 authors	314	10876	34.64	9.95	32	10.19	1.81
		Total of World	3428	65427	19.09				
		Share of top 20 authors in World total output	9.16	16.62					

TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper; HI=h-index; ICP=International Collaborative Papers; RCI=Relative Citation Index

nal of Agricultural and Food Chemistry and Zhongguo Zhongyao Zachi (43 papers each), Biological and Pharmaceutical Bulletin (37 papers), etc. during 1997-16 (Table 6).

SIGNIFICANT KEYWORDS

Around 133 significant keywords have been identified from the literature which through light on the research trends in *Glycyrrhiza glabra* research including its pharmacological properties and medicinal uses. These keywords are listed in Table 8 in the decreasing order of the frequency of their occurrence in the literature during 1997-2016.

HIGHLY CITED PAPERS

A total of 113 highly cited papers were identified each having 100 to 852 citations (82 papers each in citation range 100-200, 17 papers each in 201-300 citations range, 5 papers each in 301-400 citations range, 3 papers each in 401-500 citations range, 2 papers each in 501-600 citations range, 3 papers each in 601-700 citations range and 1 paper 852 citations) in 20 years during 1997-2016. Together these 113 papers cumulated a total of 22234 citations, averaging 196.76 citations per paper. Of the 113 highly cited papers, 49 resulted from the participation of research organizations in their roles stand-alone (non-collaborating) institutional authors and remaining 64 from two or more research organizations working in their role as collaborating partners per paper (42 national collaborative and 22 international collaborative). Among 113 highly cited papers, the largest participation was seen from USA (29 papers), followed by the U.K. (13 papers), Japan (11 papers), Israel (10 papers), India and Italy (9 papers

each), China (8 papers), Germany (7 papers), South Korea and Canada (4 papers each), Iran, Turkey, Netherlands, Australia, Spain and Switzerland (2 papers each), etc. These 113 highly cited papers involved the participation of 444 personal authors and 236 research organizations in total across globe. Of the 113 highly cited papers, 62 were published as articles, 42 as reviews papers, 5 as conference papers and 4 as short surveys. These 113 highly cited papers were published in 80 journals, with 10 papers in *Journal of Ethnopharmacology*, 6 papers in *Journal of Agricultural and Food Chemistry*, 4 papers in *Phytotherapy Research*, 3 papers in *Phytomedicine*, 2 papers each in *American Journal of Health-System Pharmacy*, *Applied Microbiology and Biotechnology*, *Archives of Internal Medicine*, *Atherosclerosis*, *Food Chemistry*, *Free Radical Biology and Medicine*, *Journal of Chromatography A*, *Journal of Steroid Biochemistry and Molecular Biology*, *Lancet*, *Life Sciences*, *Menopause* and *Phytochemistry* and 1 paper each in 64 other journals.

CONCLUSION

Research publications data sourced from the Scopus database was analysed in this study to provide a quantitative and qualitative description of global *Glycyrrhiza glabra* research covering 20 years period, 1997-2016. The study showed that annual and ten-year cumulative global output of *Glycyrrhiza glabra* research registered 10.87% and 180.47% growth. Its global citation impact averaged to 19.09 citations per paper in 20 years, which decreased from 38.67 to 12.10 from 1997-2006 to 2007-16.

More than 40% of global *Glycyrrhiza glabra* research output share was mainly from China, India and USA, whereas other 9 top ranking coun-

Table 6: Top 20 Most Productive Journals in *Glycyrrhiza glabra* Research during 1997-16

S.No	Name of the Journal	Number of Papers		
		2007-11	2012-16	2007-16
1	Journal of Ethnopharmacology	21	43	64
2	Phototherapy Research	10	40	50
3	Journal of Agricultural and Food Chemistry	16	27	43
4	Zhongguo Zhongyao Zachi	9	34	43
5	Biological and Pharmaceutical Bulletin	22	15	37
6	Phytomedicine	17	13	30
7	Chinese Journal of Clinical Rehabilitation	28	0	28
8	Planta Medica	6	20	26
9	Evidence-based Complementary and Alternative Medicine	1	24	25
10	Chinese Traditional and Herbal Drugs	1	22	23
11	International Journal of Pharma and Bio Sciences	0	22	22
12	International Journal of Pharmacy and Pharmaceutical Sciences	0	21	21
13	PLOS One	0	21	21
14	Food Chemistry	2	18	20
15	Alternate and Complementary Therapies	3	16	19
16	Journal of Separation Science	2	17	19
17	International Immunopharmacology	5	12	17
18	Journal of Chromatography A	4	13	17
19	Photochemistry	14	3	17
20	Fitoterapia	5	11	16
	Total of 20 journals	166	392	558
	Total global journal output	886	2436	3322
	Share of top 20 journals in global journal output	18.74	16.09	16.80

tries accounted each for global share between 1.87% and 8.66% during 1997-2006. The top 12 most productive countries in *Glycyrrhiza glabra* research together accounted for a high of 79.18% global share during 1997-2016, which decreased from 100.0% to 77.80% from 1997-2006 to 2007-16. Top ranking Asian countries in *Glycyrrhiza glabra* research dominate in quantity of research whereas American and western countries in the ranking list dominate more in quality of research. For example, China, India, Japan, South Korea, Iran and Taiwan from Asia together accounted for 56.42% global share and citation impact (averaging 18.46 citations per paper) and comparatively the USA, Germany, Italy, the U.K., Turkey and Canada account for 25.22% global share and citation impact (averaging 31.28 citations per paper) during 1997-2016. The global publication share registered a decreasing publication share in 11 countries (except for Iran) varying from 0.83% to 4.76% in 11 out of 12 countries from 1997-2006 to 2007-17. Of the top 12 countries,

seven registered relative citation index above the world average of 1.10: U.K. (2.39), USA (1.87), Canada (1.71), Italy (1.51), Japan (1.49), Turkey (1.24) and Taiwan (1.18) during 1997-2018. The international collaborative publications share of American and western countries in *Glycyrrhiza glabra* was greater (21.77% to 42.55% share) compared to that of Asian countries (6.12% to 19.19% share).

Medicine was the most sought after subject area of *Glycyrrhiza glabra* research, accounting for (44.41%) the highest publications share, followed by pharmacology, toxicology and pharmaceuticals (35.04%), biochemistry, genetics and molecular biology (26.84%), agricultural and biological sciences (16.89%), chemistry (14.59%), etc. during 1997-16. Among broad subjects, the research activities registered increase in pharmacology, toxicology and pharmaceuticals, agricultural and biological sciences, chemistry, immunology and microbiology, chemical engineering, environmental science, engineering, neurosciences, dentistry and veterinary science, as against decline in medicine and biochemistry, genetics and molecular biology from 1997-2006 to 2007-16. Biochemistry, genetics and molecular biology, among various subjects registered the highest citations impact per paper, followed by chemistry, immunology and microbiology, neurosciences, environmental science, pharmacology, toxicology and pharmaceuticals, medicine, agricultural and biological sciences, chemical engineering, dentistry, engineering and veterinary science during 1997-16.

The top 20 most productive research organizations and the authors on *Glycyrrhiza glabra* research collectively contributed 15.08% and 9.16% global publication share and 14.57% and 16.62% global citation share respectively during 1997-16. The leading organizations in terms of publication productivity were: Beijing University of Chinese Medicine, China (46 papers), Hallym University, South Korea (39 papers), Seoul National University, South Korea (37 papers), Tehran University of Medical Sciences, Iran (34 papers), China Pharmaceutical University, China (29 papers), Peking University, China (28 papers), University of Illinois at Chicago, USA (26 papers), etc. during 1997-2016. The leading organizations in terms of citation impact per paper were: University of Padua, Italy (38.57), Gifu Pharmaceutical University, Japan (37.55), University of Illinois at Chicago, USA (34.08), Hallym University, South Korea (29.08), Kaneka Corporation, Osaka, Japan (26.70), Tehran University of Medical Sciences, Iran (25.53), Seoul National University, South Korea (22.0), Korea Food Research Institute, South Korea (20.19), China Pharmaceutical University, China (19.69), China Medical University Taichung, Taiwan (18.52), etc. during 1997-2016.

The journals medium accounted for 96.91% global share in *Glycyrrhiza glabra* research with top 20 most productive journals accounting for 16.80% of total publications output in journals during 1997-2016. Journal of Ethnopharmacology contributed the largest number of papers (64), Phototherapy Research (50 papers), Journal of Agricultural and Food Chemistry and Zhongguo Zhongyao Zachi (43 papers each), Biological and Pharmaceutical Bulletin (37 papers), etc. during 1997-2016

Conclusively, this research study reveals that Asian countries dominate in *Glycyrrhiza glabra* research more in terms of quantity of research, whereas American and western countries dominate instead more in terms of quality of research. For enabling Asian countries to perform better in terms of citation impact, it is suggested that the participating Asian countries should give higher priority to *Glycyrrhiza glabra* research and encourage its leading academic and research organizations to participate in international collaboration with counterparts from western countries. Licorice (*Glycyrrhiza glabra*) root and its extract such as glycyrrhizin have a long history of use in traditional medicines, folk remedies, and as a sweetening and flavoring agent. The present study analyzed chemical, traditional use, bioactive constituents and pharmacologic activities and medicinal aspects of *Glycyrrhiza glabra*. Such an analysis will help

Table 8: List of Significant Keywords in Literature on Global Aloe Vera Research during 2007-16.

S.No	Keyword	Frequency	S.No	Keyword	Frequency	S.No	Keyword	Frequency
1	Glycyrrhiza	1616	41	Liquiritin	122	81	Jaundice	16
2	<i>Glycyrrhiza glabra</i>	932	42	Liquorice	122	82	Weight Gain	16
3	Plant Extract	696	43	Genetics	109	83	Radiation Exposure	15
4	Glycyrrhizic Acid	590	44	Anti-Bacterial Activity	104	84	Immune System	14
5	<i>Glycyrrhiza glabra</i> Extract	562	45			85	Radiation Injury	14
6	Herbaceous Agent	463	46	Ginger	104	86	Tacrolimus	14
7	Medicinal Plant	555	47	Ginseng	103	87	Fatty Liver	13
8	Plant Root	430	48	Liver	99	88	Ulcer Healing	13
9	Licorice	424	49	Cell Line, Tumor	98	89	Radiation Doss	11
10	Drug Effect	383	50	Randomised Control Trials	96	90	Ultrasound	11
11	Glycyrrhiza Extract	361	51	Gene EXpression	94	91	Hair Loss	9
12	Metabolism	323	52	Pathology	94	92	Hair Growth	8
13	Glycyrrhetic Acid	322	53	Cytotoxicity	93	93	Vasomotor Disorder	8
14	Drug Efficacy	292	54	Anti-Viral Activity	81	94	Vancomycin	8
15	<i>Glycyrrhiza Uralensis</i>	286	55	Fabacea	97	95	Female Infertility	7
16	Phototherapy	277	56	Macrophage	65	96	Occupational	7
17	Drug Mechanism	262	57	Obesity	47	97	Ultrasonic	7
18	Flavonoid	256	58	Kidney	46	98	Vaginitis	7
19	Anti-Oxidant Activity	254	59	Fatigue	43	99	Vascular Disease	7
20	Hypertension	254	60	Kidney Disease	39	100	Kidney Cancer	6
21	Herbal Medicine	250	61	Pain	39	101	Olfaction Disorders	6
22	High Performance Liquid Chromatography	250	62	Quercetin	38	102	Palliative Therapy	6
23	Anti-Inflammatory Activity	214	63	Immune Response	30	103	Radiation Dermatitis	6
24	Protein Expression	207	64	Ulcer	26	104	Radioimmunoassay	6
25	Enzyme Activity	201	65	Ultraviolet Radiation	26	105	Vascular Endothelium	6
26	Glycyrrhizin	195	66	Echinacea	25	106	Fat	5
27	Drug Structure	191	67	Abdominal Pain	24	107	Gall Bladder Disease	5
28	Drug Effects	189	68	Dandelion	24	108	HIV	5
29	Apoptosis	155	69	Magnesium	24	109	Hair Follicle	5
30	Chinese Medicine	155	70	Ochratoxin	24	110	Rabdosia	5
31	Antioxidants	154	71	Quality of Llife	24	111	Ear Infection	4
32	Glabridin	153	72	Odor	23	112	Femur	4
33	Anti-Neoplastic Activity	150	73	Techycardia	23	113	Nail Disease	4
34	Clinical Trial	147	74	Daidzein	22	114	Upper Gastrointestinal Bleeding	4
35	Drug Screening	141	75	Oat	20	115	Ear Diseases	3
36	Oxidation Stress	140	76	Vasculotropin	20	116	Facial Dermatosi	3
37	Drug Safety	136	77	Fatty Acids	19	117	Kidney Failure, Chronic	3
38	Phytochemistry	127	78	Weight Gain	19	118	KidneyFibrosis	3
39	Inflammation	125	79	Tamoxifen	19	119	Facial Nerve Paralysis	2
40	Traditional Medicine	124	80	Immune Deficiency	16			

in undertaking further studies on *Glycyrrhiza glabra* for exploring its potential in preventing and treating diseases. It will also give direction for future investigators to carry out research in discovering potential therapeutic effects and developing new formulations.

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