

Global Research on *Tinospora cordifolia* (Medicinal Plant) with Special Reference to India: A Scientometric Assessment Publications Output during 2001-2016

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Abstract

The paper examines 865 global and 747 Indian publications on *Tinospora cordifolia* research, as indexed in international Scopus database during 2001-2016. Indian research output experienced an annual average growth rate of 11.85%, global publication share of 86.36%, international collaborative publication share of 7.50% and qualitative citation impact averaged to 15.15 citations per paper. Pharmacology, toxicology & pharmaceutics, among subjects, accounted for the highest publications share (57.30%) in Indian output, followed by medicine (33.60%), biochemistry, genetics & molecular biology (23.83%), agricultural & biological sciences (16.06%), chemistry (5.62%), immunology & microbiology (4.55%), environmental science (4.28%) and veterinary science (2.95%) during 2001-2016. The top 15 most productive Indian research organizations and the authors collectively contributed 24.23% and 14.73% respectively as their Indian publication share and 42.70% and 16.59% respectively as their Indian citation share during 2001-2016. Among the total Indian journal output with 98.39% Indian share, the top 20 journals contributed 31.32% share to the Indian journal output during 2001-2016. Of the total *Tinospora cordifolia* Indian research output, the top 18 highly cited publications registered citations from 104 to 1014 and they together received 4110 citations, with 228.33 citations per paper. These 18 highly cited papers involved the participation of 72 authors and 33 organizations and were published in 9 journals.

Keywords: *Tinospora cordifolia*; Medicinal plant; Global Output; Indian Output; Scientometrics; Bibliometrics

Abbreviations: NMPB: National Medicinal Plants Board.

Introduction

India is bestowed with enormous biodiversity of medicinal plants. Medicinal plants have been used as

natural medicines, since prehistoric times: (i) Used as crude extract directly in medicines, because of the presence of natural chemical constituents such as berberine, morphine, psilocin, vincristine etc. and (ii) Used as natural compounds for the synthesis of drugs such as tubocurarine, colchicine, nicotine, quinine etc. for therapeutic purpose by folk people. Many modern medicines had their origin from the natural compounds of medicinal plants. A large number of plants are being used in medicine for therapeutic or prophylactic purposes. The therapeutic properties of medicinal plants are attributed owing to the presence of active substances such as alkaloids, flavonoids, glycosides, vitamins, tannins, and coumarins [1].

Among various medicinal plants, *Tinospora cordifolia* (Family: Menispermaceae) is one of the most widely used shrub from the ancient medical system as a medicine. *Tinospora cordifolia* is commonly known as heart leaved Moonseed Plant (English), Amrita Guduchi (Sanskrit), Giloe (Hindi), Gulancha (Bengali), Giloya (Hindi), Galo (Gujrati) and Teppatige (Telugu), It is large deciduous climbing shrub found throughout India, and also in Sri Lanka, Bangladesh and China [1,2].

It has a wide array of bioactive principles as well as it has been proven medicinally important plant, have not received considerable scientific attention. However, keeping in view the above mentioned medicinal properties, this plant has been listed an important plant amongst the 32 prioritized plants by National Medicinal Plants Board (NMPB), New Delhi of Government of India [1].

Tinospora cordifolia has been used in Indigenous Systems of Medicine, as indicated in various classical texts of Ayurvedic System of Medicine, viz. Charak, Sushrut and Ashtang Hridaya and other ancient treaties. It also finds a special mention for its use in tribal or folk medicine in different parts of the country [3].

Tinospora cordifolia is known for its immense application in the treatment of various diseases in the traditional ayurvedic literature. Recently the discovery of active components from the plant and their biological function in disease control has led to active interest in the plant across the globe. A variety of active components derived from the plant like alkaloids, steroids, diterpenoid lactones, aliphatics, and glycosides have been isolated from the different parts of the plant body, including root, stem, and whole plant. Recently, the plant is of great interest to researchers across the globe because of its reported medicinal properties [4].

T. cordifolia medical applications include controlling various disorders and usages as anti-oxidant, anti-hyperglycemic, antihyperlipidemic, hepatoprotective, cardiovascular protective, neuroprotective, osteoprotective, radioprotective, anti-anxiety, adaptogenic agent, analgesic, anti-inflammatory, antipyretic, a thrombolytic agent, anti-diarrheal, anti-ulcer, anti-microbial and anti-cancer agent. The plant is also a source of micronutrients viz. copper, calcium, phosphorus, iron, zinc and manganese. A special focus has been made on its health benefits in treating endocrine and metabolic disorders and its potential as an immune booster. Several patents have been filed and granted to inventions encompassing *T. cordifolia* as a major component of therapeutics for ameliorating metabolic, endocrinal and several other ailments, aiding in the betterment of human life expectancy [5]. *Tinospora cordifolia* has an importance in traditional ayurvedic medicine used for ages in the treatment of fever, jaundice, chronic diarrhea, cancer, dysentery, bone fracture, pain, asthma, skin disease, poisonous insect, snake bite, eye disorders [4].

Literature Review

Only few scientometric studies are available in the past, which quantitatively analyze global and Indian literature on individual medicinal plants, such as Aloe Vera [6], Artemisinin [7], Glycyrrhiza glabra [8], Azadirachta indica [9] and Phoenix dactylifera [10,11].

Objectives

The main objectives of this study are to study the performance of *Tinospora cordifolia* research during 2001-2016, based on publications indexed in Scopus international and multidisciplinary database. The study focuses on analysis of the growth, contribution, citation impact and international collaborative papers share of world, top 10 most productive countries and India's international collaboration share, research output by broad subject areas and the dynamics of its growth and decline; the trends in Indian research by identifying significant keywords; publication productivity and citation impact of top 20 most productive organizations and authors; modes of communication in research and characteristics of top 18 highly cited Indian papers.

Methodology

The study retrieved and downloaded 16-year publication data of the world output in *Tinospora cordifolia* research from the Scopus database (<http://www.scopus.com>) covering the period 2001-2016.

Keywords, such as “Giloy or *Tinospora cordifolia*” was incorporated in the search string and qualified these keyword with “TITLE-ABS-Key” tag and in addition incorporated in this search string the period 2001-2016 within “date range tag”. This main search string was further restricted to individual country by name in “country tag” to ascertain publication output of top 10 most productive countries (including India) in *Tinospora cordifolia* research. The Indian search string was subsequently refined 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 24 January 2018.

TITLE-ABS-KEY (Giloy or *Tinospora cordifolia*) AND PUBYEAR > 2000 AND PUBYEAR < 2017

TITLE-ABS-KEY (Giloy or *Tinospora cordifolia*) AND PUBYEAR > 2000 AND PUBYEAR < 2017 AND (LIMIT-TO (AFFILCOUNTRY, "India"))

Analysis

The research output of the world and India in the field of *Tinospora cordifolia* cumulated to 865 and 747

publications in 16 years during 2001-2016. The annual output of the world and India in *Tinospora cordifolia* research increased from 14 and 13 in the year 2001 to 61 and 45 publications in the year 2016, registering 12.70% and 11.85% growth per annum. The cumulative world and Indian output in *Tinospora cordifolia* research in 8 years 2001-2008 increased from 220 and 185 to 645 and 562 publications during succeeding 8-year period 2009-2016, registering 193.18% and 203.78% growth. The global share of Indian publications of *Tinospora cordifolia* was 86.36% during 2001-2016, which increased from 84.09% to 87.13% from 2001-2008 to 2009-2016. The citation impact of global and Indian publications on *Tinospora cordifolia* research averaged to 15.94 and 15.15 citations per publication (CPP) during 2001-2016; eight-yearly impact averaged to 40.88 and 39.83 CPP for the period 2001-2008 which declined to 7.43 and 7.02 CPP in the succeeding eight-year 2009-2016. The international collaborative share of India in *Tinospora cordifolia* research was 7.50% during 2001-2016, which decreased from 10.81% to 6.41% from 2001-2008 to 2009-2016. Of the total Indian publications output, 84.87% (634) was published as articles, 11.24% (84) as reviews, 1.34% (10) as conference papers, and 1.07% (8) each as book chapters and letters and 0.40% (3) as short surveys during 2001-2016 (Table 1).

Period	World			India					
	TP	TC	CPP	TP	TC	CPP	ICP	%ICP	%TP
2001	14	445	31.79	13	440	33.85	2	15.38	92.86
2002	21	1490	70.95	15	1466	97.73	0	0.00	71.43
2003	27	1110	41.11	24	1019	42.46	1	4.17	88.89
2004	33	1149	34.82	29	898	30.97	5	17.24	87.88
2005	32	1509	47.16	26	1031	39.65	2	7.69	81.25
2006	28	1432	51.14	23	771	33.52	4	17.39	82.14
2007	27	1236	45.78	23	1188	51.65	1	4.35	85.19
2008	38	622	16.37	32	556	17.38	5	15.63	84.21
2009	50	943	18.86	39	730	18.72	9	23.08	78.00
2010	66	663	10.05	56	474	8.46	0	0.00	84.85
2011	92	937	10.18	85	909	10.69	5	5.88	92.39
2012	109	1086	9.96	95	801	8.43	3	3.16	87.16
2013	102	468	4.59	94	421	4.48	5	5.32	92.16
2014	91	365	4.01	80	320	4.00	5	6.25	87.91
2015	74	213	2.88	68	202	2.97	5	7.35	91.89
2016	61	117	1.92	45	89	1.98	4	8.89	73.77
2001-08	220	8993	40.88	185	7369	39.83	20	10.81	84.09
2009-16	645	4792	7.43	562	3946	7.02	36	6.41	87.13
2001-16	865	13785	15.94	747	11315	15.15	56	7.50	86.36

TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper; ICP=International Collaborative Papers

Table 1: World and Indian Research Output in *Tinospora cordifolia* during 2001-2016.

Top 10 Most Productive Countries in *Tinospora cordifolia* Research

The global research output in the field of *Tinospora cordifolia* research had originated from 45 countries during 2001-2016, of which 41 countries contributed 1-10 papers, 3 countries 11-50 papers and 1 country 747 papers. The top 10 most productive countries in *Tinospora cordifolia* research contributed 5 to 747 publications each during 2001-2016, and together accounted for more than 100% global publication and citation share during 2001-2016. Their eight-yearly output accounted for more than 100.0% global publication share during 2001-2008 which decreased to 99.53% during succeeding 8-year period 2009-2016. Each of top 10 countries accounted for 0.58% to 86.36% global publication share during 2001-2016, with India accounting for the highest publication share (86.36%), followed by USA (5.66% share), Bangladesh,

Pakistan, Malaysia and U.K. (from 1.04% to 1.97%) and Germany, Italy, Saudi Arabia and Nigeria (from 0.58% to 0.81%) during 2001-2016. The global publication share in eight years increased by 3.04% in India, followed by 1.42% in Bangladesh, 1.41% in Pakistan, 0.93% in Saudi Arabia, 0.33% each in Italy and Malaysia, as against decrease by 6.42% in USA, 2.87% in U.K., 1.05% in Nigeria and 0.74% in Nigeria from 2001-2008 to 2009-2016. Three of top 10 countries scored relative citation index above the world average *i.e.* 1.02: U.K. (4.56), USA (2.11) and Bangladesh (1.25) during 2001-2016. The international collaborative share of top 10 countries in *Tinospora cordifolia* research in their respective national output varied from 0.0% to 100.0%, with highest share coming from Saudi Arabia (100.0%), followed by U.K. (88.89%), Malaysia (60.0%), USA and Germany (57.14% each), Bangladesh (35.29%), Italy (33.33%), Pakistan (23.08%), India (7.50%) and Nigeria (0.0%) during 2001-2016 (Table 2).

S.No	Name of the Country	Number of Papers			Share of Papers			TC	CPP	HI	ICP	%ICP	RCI
		2001-08	2009-16	2001-16	2001-08	2009-16	2001-16						
1	India	185	562	747	84.09	87.13	86.36	11024	14.76	48	56	7.50	0.93
2	USA	23	26	49	10.45	4.03	5.66	1650	33.67	19	28	57.14	2.11
3	Bangladesh	2	15	17	0.91	2.33	1.97	338	19.88	7	6	35.29	1.25
4	Pakistan	1	12	13	0.45	1.86	1.50	147	11.31	7	3	23.08	0.71
5	Malaysia	2	8	10	0.91	1.24	1.16	79	7.90	3	6	60.00	0.50
6	U.K.	7	2	9	3.18	0.31	1.04	654	72.67	7	8	88.89	4.56
7	Germany	3	4	7	1.36	0.62	0.81	96	13.71	5	4	57.14	0.86
8	Italy	1	5	6	0.45	0.78	0.69	69	11.50	4	2	33.33	0.72
9	Saudi Arabia	0	6	6	0.00	0.93	0.69	25	4.17	3	6	100.00	0.26
10	Nigeria	3	2	5	1.36	0.31	0.58	38	7.60	4	0	0.00	0.48
	Total	227	642	869	103.18	99.53	100.46	14120	16.25	10.7	119	13.69	1.02
	World	220	645	865				13785	15.94				
	Share of 10 Countries in World Total	185	562	747									

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

Table 2: Global Publication Share of Top 10 Most Productive Countries in *Tinospora cordifolia* Research during 2001-2016.

Subject-Wise Distribution of Research Output

The Indian *Tinospora cordifolia* research output published during 2001-2016 is distributed across eight sub-fields (as identified in Scopus database classification), with pharmacology, toxicology & pharmaceuticals accounting for the highest publications share (57.30%), followed by medicine (33.60%), biochemistry, genetics & molecular biology (23.83%), agricultural & biological sciences (16.06%), chemistry (5.62%), immunology &

microbiology (4.55%), environmental science (4.28%) and veterinary science (2.95%) during 2001-2016. The activity index, which computes change in research activity in a discipline over time 2001-2008 to 2009-2016 (world average activity index of a given subject is taken as 100), witnessed increase in biochemistry, genetics & molecular biology (from 93.01 to 102.30), agricultural & biological sciences (from 67.30 to 110.77), chemistry (from 76.91 to 107.60) and veterinary science (from 91.77 to 102.71), as

against decline of research activity in pharmacology, toxicology & pharmaceuticals (from 107.55 to 97.51), medicine (from 102.96 to 99.03), immunology & microbiology (from 142.51 to 86.01) and environmental science (from 164.04 to 78.92) from 2001-2008 to 2009-2016. Environmental science, among various subjects registered the highest citations impact per paper of 18.97),

followed by immunology & microbiology (17.18), pharmacology, toxicology & pharmaceuticals (15.91), medicine (15.86), biochemistry, genetics & molecular biology (12.66), chemistry (11.12), agricultural & biological sciences (10.28) and veterinary science (1.77) during 2001-2016 (Table 3).

S.No	Subject*	Number of Papers (TP)			Activity Index		TC	CPP	%TP
		2001-08	2009-16	2001-16	2001-08	2009-16			
1	Pharmacology, Toxicology & Pharmaceuticals	114	314	428	107.55	97.51	6811	15.91	57.30
2	Medicine	64	187	251	102.96	99.03	3980	15.86	33.60
3	Biochemistry, Genetics & Molecular Biology	41	137	178	93.01	102.30	2254	12.66	23.83
4	Agricultural & Biological Sciences	20	100	120	67.30	110.77	1233	10.28	16.06
5	Chemistry	8	34	42	76.91	107.60	467	11.12	5.62
6	Immunology & Microbiology	12	22	34	142.51	86.01	584	17.18	4.55
7	Environmental Science	13	19	32	164.04	78.92	607	18.97	4.28
8	Veterinary Science	5	17	22	91.77	102.71	39	1.77	2.95
9	World Output	185	562	747					
<ul style="list-style-type: none"> • There is overlapping of literature covered under various subjects 									
<p>TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper</p>									

Table 3: Subject-Wise Breakup of Indian Publications in *Tinospora cordifolia* Research during 2001-2016.

Profile of Top 15 Most Productive Organizations

Two hundred eighty nine (289) organizations participated in Indian research on *Tinospora cordifolia* during 2001-2016, of which 248 organizations contributed 1-5 papers each, 22 organizations 6-10 papers each and 10 organizations 11-17 papers each. The productivity of 15 most productive Indian organizations in *Tinospora cordifolia* research varied from 9 to 17 publications and together they contributed 24.23% (181) publication share and 42.70% (4831) citation share to its cumulative publications output during 2001-2016. The scientometric profile of these 15 organizations is presented in Table 4.

- Seven of these organizations registered publications output greater than the group average of 12.07: Gujarat Ayurved University, Jamnagar (17 papers), Banaras Hindu University, Varanasi (15 papers), Maharishi Dayanand University, Rohtak, Indian Veterinary Research Institute and University of Rajasthan, Jaipur (14 papers each), University of Pune and Bhabha Atomic

Research Centre, Mumbai (13 papers each) during 2001-2016.

- Five organizations registered impact above the group average of 26.69: All India Institute of Medical Sciences, New Delhi (149.2), University of Pune (60.31), Kasturba Medical College, Manipal (47.27), Bhabha Atomic Research Centre, Mumbai (42.38) and Annamalai University (39.26) during 2001-2016.
- Six organizations contributed international collaborative publications share above the group average of 7.73%: Indian Veterinary Research Institute (21.43%), All India Institute of Medical Sciences, New Delhi (20.0%), University of Pune (15.38%), Gujarat Ayurved University, Jamnagar (11.76%), University of Mysore (11.11%) and Kasturba Medical College, Manipal (9.09%) during 2001-16
- Five organizations registered the relative citation index above the group average (1.76) of all organizations: All India Institute of Medical Sciences, New Delhi (9.85), University of Pune (3.98), Kasturba Medical College, Manipal (3.12), Bhabha Atomic Research Centre, Mumbai (2.80) and Annamalai University (2.60) during 2001-2016.

S.No	Name of the Organization	TP	TC	CPP	HI	ICP	%ICP	RCI
1	Gujarat Ayurved University, Jamnagar	17	87	5.12	5	2	11.76	0.34
2	Banaras Hindu University, Varanasi	15	149	9.93	5	1	6.67	0.66
3	Maharishi Dayanand University, Rohtak	14	83	5.93	5	1	7.14	0.39
4	Indian Veterinary Research Institute	14	154	11.00	5	3	21.43	0.73
5	University of Rajasthan, Jaipur	14	98	7.00	5	0	0.00	0.46
6	University of Pune	13	784	60.31	11	2	15.38	3.98
7	Bhabha Atomic Research Centre, Mumbai	13	551	42.38	10	1	7.69	2.80
8	Kasturba Medical College, Manipal	11	520	47.27	9	1	9.09	3.12
9	Annamalai University	11	433	39.36	8	0	0.00	2.60
10	Banasthali University	11	95	8.64	4	0	0.00	0.57
11	Guru Nanak Dev University, Amritsar	10	62	6.20	6	0	0.00	0.41
12	Central Food Technological Research Institute, Mysore	10	106	10.60	7	0	0.00	0.70
13	All India Institute of Medical Sciences, New Delhi	10	1492	149.20	9	2	20.00	9.85
14	Bharati Vidyapeeth University, Pune	9	100	11.11	5	0	0.00	0.73
15	University of Mysore	9	117	13.00	3	1	11.11	0.86
	Total of 15 organizations	181	4831	26.69	6.47	14	7.73	1.76
	Total of India	747	11315	15.15				
	Share of top 15 organizations in World total output	24.23	42.70					

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

Table 4: Scientometric Profile of Top 15 Most Productive Indian Organizations in *Tinospora cordifolia* Research during 2007-2016.

Profile of Top 15 Most Productive Authors

Three hundred twenty seven (327) authors participated in Indian research on *Tinospora cordifolia* during 2001-2016, of which 313 authors contributed 1-5 papers each, 13 authors 6-10 papers each and 1 author 12 papers. The research productivity in the field of *Tinospora cordifolia* research of top 15 most productive Indian authors varied from 6 to 13 publications. Together they contributed 14.73% (110) global publication share and 16.59% (1877) citation share during 2001-2016. The scientometric profile of these 15 authors is presented in Table 5.

- Three authors registered publications output above the group average of 7.33: B. Patwardhan (13 papers), G.C.

Jagetia (9 papers) and R. Dabur (8 papers) during 2001-2016;

- Three authors registered impact above the group average of 17.06: G. Kuttan (51.14), G.C. Jagetia (49.67) and B. Patwardhan (32.62) during 2001-2016.
- Four authors contributed international collaborative publications share above the group average of 4.55% of all authors: B. Patwardhan (15.38%), A. Kaur (14.29%), R. Dabur (12.50%) and G.C. Jagetia (11.11%) during 2001-2016.
- Three authors registered the relative citation index above the group average (1.13) of all authors: G. Kuttan (3.38), G.C. Jagetia (3.28) and B. Patwardhan (2.15) during 2001-2016.

S.No	Name of the Author	Affiliation of the Author	TP	TC	CPP	HI	ICP	%ICP	RCI
1	B. Patwardhan	University of Pune	13	424	32.62	10	2	15.38	2.15
2	G.C. Jagetia	Kasturba Medical College, Manipal	9	447	49.67	8	1	11.11	3.28
3	R. Dabur	Maharishi Dayanand University, Rohtak	8	27	3.38	4	1	12.50	0.22
4	P.K. Goyal	University of Rajasthan, Jaipur	7	45	6.43	3	0	0.00	0.42
5	A. Kaur	National Institute of Pharmaceutical Education & Research, Mohali	7	60	8.57	6	1	14.29	0.57
6	N. Kumar	Institute of Himalayan Bioresource Technology, Palampur	7	89	12.71	4	0	0.00	0.84

S.No	Name of the Author	Affiliation of the Author	TP	TC	CPP	HI	ICP	%ICP	RCI
7	G. Kuttan	Amala Cancer Research Centre, Trissur, Kerala	7	358	51.14	5	0	0.00	3.38
8	P.K. Prajapati	Gujarat Ayurveda University, Jamnagar	7	16	2.29	2	0	0.00	0.15
9	B. Ravishankar	Gujarat Ayurveda University, Jamnagar	7	53	7.57	3	0	0.00	0.50
10	V. Sharma	Banasthali University	7	80	11.43	4	0	0.00	0.75
11	B. Singh	Institute of Himalayan Bioresource Technology, Palampur	7	92	13.14	5	0	0.00	0.87
12	S.K. Agrawala	Indian Herbs Research and Supply Co. Ltd, Saharanpur	6	17	2.83	2	0	0.00	0.19
13	M. Bala	Institute of Himalayan Bioresource Technology, Palampur	6	77	12.83	4	0	0.00	0.85
14	P. Sharma	University of Rajasthan, Jaipur	6	28	4.67	2	0	0.00	0.31
15	R. Balaraman	M.S. University of Baroda	6	64	10.67	3	0	0.00	0.70
		Total of 15 authors	110	1877	17.06	4.33	5	4.55	1.13
		Total of India	747	11315	15.15				
		Share of top 15 authors in World total output	14.73	16.59					
TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper; HI=h-index; ICP=International Collaborative Papers; RCI=Relative Citation Index									

Table 5: Scientometric Profile of Top 15 Most Productive Indian Authors in *Tinospora cordifolia* Research during 2001-2016.

Medium of Communication

Of the total Indian output in *Tinospora cordifolia* research, 98.39% (735) appeared in journals, 1.07% (8) in books, 0.40% (3) as trade publications and 0.13% (1) as book series during 2001-2016. One hundred sixty four (164) journals participated in Indian research on *Tinospora cordifolia* during 2001-2016, of which 136 journals contributed 1-5 papers each, 15 journals 6-10 papers each, 9 journals 11-20 papers each and 4 journals 21-30 papers each. The top 20 most productive journals accounted for 7 to 30 papers each in *Tinospora cordifolia*

research and together accounted for 31.32% share (57 papers) of total journal publication output during 2001-2016. The publication share of these top 20 most productive journals increased from 31.32% to 41.59% between 2001-2008 and 2009-2016. The top most productive journal (with 30 papers) was *International Journal of Pharma & Bio Sciences*, followed by *Journal of Ethno-pharmacology* (29 papers), *International Journal of Pharmaceutical Science Review & Research* (26 papers), *Phytomedica* (21 papers), etc. during 2001-2016 (Table 6).

S.No	Name of the Journal	Number of Papers		
		2001-08	2009-16	2001-16
1	International Journal of Pharma& Bio Sciences	0	30	30
2	Journal of Ethno-pharmacology	16	13	29
3	International Journal of Pharmacy & Pharmaceutical Science	0	26	26
4	Phytomedica	0	21	21
5	Indian Journal of Pharmacology	6	10	16
6	Phytotherapy Research	12	4	16
7	Asian Journal of Pharmaceutical & Clinical Research	0	15	15
8	Pharmacologyonline	3	12	15
9	Indian Drugs	5	9	14
10	International Journal of Research in Ayurved& Pharmacy	0	14	14
11	Research Journal of Pharmaceutical Biological & Chemical Sciences	0	12	12
12	International Journal of Green Pharmacy	0	11	11
13	International Journal of Pharmaceutical Science Review & Research	0	11	11
14	Indian Journal of Experimental Biology	6	4	10

15	Asian Pacific Journal of Tropical Biomedicine	0	9	9
16	International Journal of Phytoedicine	0	8	8
17	Phytomedicine	4	4	8
18	Research Journal of Pharmacy & Technology	0	8	8
19	BMC Complementary & Alternative Medicine	3	4	7
20	Evidence based Complementary & Alternate Medicine	2	5	7
	Total of 20 journals	57	230	287
	Total Indian journal output	182	553	735
	Share of top 20 journals in global journal output	31.32	41.59	39.05

Table 6: Top 15 Most Productive Journals in *Tinospora cordifolia* Research during 2001-2016.

Significant Keywords

Around 134 significant keywords have been identified from the literature, which point to possible trends in Indian *Tinospora cordifolia* research including its pharmacological properties and medicinal uses. These keywords are listed in Table 7 in the decreasing order of the frequency of occurrence during 2007-2016.

S.No	Keyword	Frequency	S.No	Keyword	Frequency	S.No	Keyword	Frequency
1	<i>Tinospora cordifolia</i>	527	47	Barberine	33	93	Cancer Cell	6
2	Medicinal Plant	266	48	Liver	28	94	Ehrlich Ascites Tumor	6
3	<i>Tinospora</i>	224	49	Rattus	28	95	Genetic Diversity	6
4	Habaceous Agent	144	50	Sp		96	Hemorrhoid	6
5	Drug Efficacy	113	51	Skin Disease	28	97	Kidney Injury	6
6	Antioxidant Activity	104	52	Staphylococcus Aureus	28	98	Sarcoma	6
7	Ayurveda	95	53	Skin Diseases	28	99	Scabies	6
8	Drug Effect	90	54	Radiation Protection	27	100	Dementia	5
9	Diabetes Mellitus	87	55	Enzyme Inhibition	26	101	Diabetic Foot	5
10	Drug Screening	85	56	Jaundice	25	102	Edema	5
11	Drug Mechanism	81	57	Gamma Radiation	18	103	Fat	5
12	Phytochemistry	79	58	Malaria	18	104	Gastritis	5
13	In Vitro Study	76	59	Pain	17	105	Heart Infarction	5
14	Antioxidants	92	60	Radiation Exposure	16	106	Paw Edema	5
15	Glucose	69	61	Gastrointestinal Disease	16	107	Degenerative Disease	4
16	Phytotherapy	68	62	Acetone	14	108	Diabetes Mellitus, Type 2	4
17	Traditional Medicine	67	63	Diabetes	14	109	Gastric Hyperacidity	4
18	Herbal Medicine	62	64	Radiation Injury	14	110	Hair Loss	4
19	Immunomodulation	60	65	Scavenger	13	111	Knee Pain	4
20	Drug Isolation	59	66	KlebsiellaPneumoniae	13	112	Leukoderma	4
21	Alkaloids	56	67	Cancer	13	113	Paralysis	4
22	Ayurveda Drug	56	68	Neoplasm	13	114	Parkinson Disease	4
23	Drug Activity	56	69	Nausea	12	115	Dalton's Lymphoma	3
24	Lipid Peroxidation	53	70	Bacillus Subtilis	12	116	Fibroblast	3
25	Drug Formulation	52	71	Neuroprotection	11	117	Fibromyalgia	3
26	Flavonoids	51	72	Heart Disease	11	118	Fibrosis	3
27	Chemistry	49	73	Bacterial Strain	10	119	Hair Disease	3
28	Fruit	45	74	Kidney	10	120	Heart Muscle Ischemia	3
29	Oxidation Stress	44	75	Leukorrhea	10	121	Lactic Acidosis	3

30	Drug Safety	43	76	Depression	9	122	Pancreas	3
31	Antibacterial Activity	42	77	Leprosy	9	123	Dermatitis	2
32	Antidiabetic Activity	42	78	Eczema	8	124	Gestational Diabetes	2
33	Antineoplastic Activity	42	79	Calcium	8	125	HIV Infection	2
34	Histopathology	37	80	Bacteria (Microorganisms)	8	126	Pancreas Cancer	2
35	Clinical Trials	36	81	Fabaceae	8	127	Leg Injury	2
36	Liver Protection	36	82	Genotoxicity	8	128	Ear Disease	1
37	Anti-inflammatory Activity	35	83	Hepatitis	8	129	Genital Disease	1
38	Escherichia Coli	35	84	Obesity	8	130	Genital Ulcer	1
39	Fever	34	85	Cancer Chemotherapy	7	131	Genetic Urinary Disease	1
40	Insulin	34	86	Delayed Hypersensitivity		132	Glioblastoma	1
41	Diarrhea	33	87	Gene Expression	7	133	Visceral Leishmaniasis	1
42	Cholesterol	32	88	Genetics	7	134	Measles	1
43	Saponin	30	89	Helminthiasis	7			
44	Liver Toxicity	29	90	Knee Osteoarthritis	7			
45	Drug Synthesis	28	91	Leukemia	7			
46	Immunomodulation Agents	28	92	Osteoarthritis	7			

Table 7: List of Significant Keywords in Literature on *Tinospora cordifolia* during 2001-2016.

Highly Cited Papers

A total of 18 highly cited papers were identified which received citations from 104 to 1014 during 2001-2016. These 18 papers together received 4110 citations, which averaged to 228.33 citations per paper. Of the 18 highly cited papers, 9 resulted from the participation of single organization (non-collaborative) and 9 involved the participation of two or more organizations (all national collaborative). Among highly cited papers, the largest participation was from USA (2 papers), followed by China, Canada, Denmark and U.K. (1 papers each). 19 Indian organizations were involved in these 18 high cited papers, of which 3 papers are published from All India Institute of Medical Sciences, New Delhi, 2 papers each from University of Pune and Kasturba Medical College, Manipal and 1 paper each from 16 other Indian organizations. The 18 highly cited papers involved the participation of 72 authors and 33 organizations. Of the 18 highly cited papers, 10 were published as articles and 8 as review papers. These 18 highly cited papers were published in 9 journals, of which 8 papers were published in *Journal of Ethnopharmacology*, 2 papers each in *Journal of Clinical Biochemistry & Nutrition* and *Phytotherapy Research* and 1 paper each in *Cell*, *Indian Journal of Pharmacology*, *Immunology Letters*, *Journal of Alternate & Complementary Medicine*, *Journal of Medicinal Food*, etc.

Conclusion

The present study describes a quantitative and qualitative performance of the *Tinospora cordifolia* global research with a special focus on India over a period of 16 years using a Scopus international and multidisciplinary database.

The global research output in the field of *Tinospora cordifolia* research output originated from 45 countries during 2001-2016, with top 10 countries contribution varying from 5 to 747 publications and their cumulative contribution together accounted for 100% global publication and citation share. Among top 10 countries, India registered the highest publication share (86.36%), followed by USA (5.66% share), Bangladesh, Pakistan, Malaysia and U.K. (from 1.04% to 1.97%), etc. Only 3 out of 10 countries registered relative citation index above the world average i.e. 1.02: U.K. (4.56), USA (2.11) and Bangladesh (1.25) during 2001-2016. The share of *Tinospora cordifolia* international collaborative research varied from 0.0% to 100.0%, with highest share coming from Saudi Arabia (100.0%), followed by U.K. (88.89%), Malaysia (60.0%), USA and Germany (57.14% each), Bangladesh (35.29%), Italy (33.33%), Pakistan (23.08%), India (7.50%) and Nigeria (0.0%) during 2001-2016.

The Indian annual scientific output related to *Tinospora cordifolia* research during 2001-2016 registered a growth of 11.85% per annum. In terms of cumulative output, India's output increased from 185 to 562 from 2001-2008 to 2009-2016, registering 203.78% growth. However, qualitative performance of *Tinospora cordifolia* research literature measured in terms of citation impact is high. Compared to quantitative performance it averaged to 15.15 citations per paper in 16 years period, which decreased from 40.88 to 7.02 from 2001-2008 to 2009-2016. India is the top most productive country in the world in *Tinospora cordifolia* research with global share of 86.36%, which increased from 84.09% to 87.13% from 2001-2008 to 2009-2016. The share of India's international collaborative papers in *Tinospora cordifolia* research was 7.50% during 2001-2016, which decreased from 10.81% to 6.41% from 2001-2008 to 2009-2016.

Pharmacology, toxicology & pharmaceuticals, among subjects, accounted for the highest Indian publications share (57.30%), followed by followed by medicine (33.60%), biochemistry, genetics & molecular biology (23.83%), agricultural & biological sciences (16.06%), chemistry (5.62%), immunology & microbiology (4.55%), environmental science (4.28%) and veterinary science (2.95%) during 2001-2016. The research activity showed increase in biochemistry, genetics & molecular biology, agricultural & biological sciences, chemistry and veterinary science, as against decline in pharmacology, toxicology & pharmaceuticals, medicine, immunology & microbiology and environmental science from 2001-2008 to 2009-2016. Environmental science, among various subjects registered the highest citations impact per paper of 18.97), followed by immunology & microbiology, pharmacology, toxicology & pharmaceuticals, medicine, biochemistry, genetics & molecular biology, chemistry, agricultural & biological sciences and veterinary science during 2001-2016.

The top 15 most productive research organizations and the authors collectively contributed 24.23% and 14.73% respectively as their Indian publication share and 42.70% and 16.59% respectively as their Indian citation share during 2001-2016. The leading Indian organizations participating in *Tinospora cordifolia* were: Gujarat Ayurved University, Jamnagar (17 papers), Banaras Hindu University, Varanasi (15 papers), Maharishi Dayanand University, Rohtak, Indian Veterinary Research Institute and University of Rajasthan, Jaipur (14 papers each), University of Pune, Bhabha Atomic Research Centre, and Mumbai (13 papers each) etc. during 2001-16. The leading Indian organizations in terms of citation impact per paper were: All India Institute of Medical Sciences, New Delhi

(149.2), University of Pune (60.31), Kasturba Medical College, Manipal (47.27), Bhabha Atomic Research Centre, Mumbai (42.38), Annamalai University (39.26), etc. during 2001-16. The leading Indian authors participating in *Tinospora cordifolia* were: B. Patwardhan (13 papers), G.C. Jagetia (9 papers) and R. Dabur (8 papers) during 2001-16. The leading Indian organizations in terms of citation impact per paper were: G. Kuttan (51.14), G.C. Jagetia (49.67) and B. Patwardhan(32.62) during 2001-2016.

The journals medium has emerged as the most important mode of publishing Indian research in *Tinospora cordifolia* research accounting for 98.39% share. The top 20 most productive journals publishing research in *Tinospora cordifolia* research accounted for 31.32% share of total publications output in journals during 2001-2016. The top most productive journal (with 30 papers) was *International Journal of Pharma & Bio Sciences*, followed by *International Journal of Pharmacy & Pharmaceutical Science* (38 papers), followed by *Journal of Ethnopharmacology* (29 papers), *International Journal of Pharmaceutical Science Review & Research* (26 papers), *Phytomedica* (21 papers), etc. during 2001-2016

Of the total *Tinospora cordifolia* Indian research output, only 18 publications registered high citations, in the range of 104 to 1014 citations per paper, and collectively these highly cited papers received a total of 4110 citations, averaging to 228.33 citations per paper. These 18 highly cited papers involved the participation of 72 authors and 33 organizations and were published in 9 journals, of which 8 papers were published in *Journal of Ethnopharmacology*, 2 papers each in *Journal of Clinical Biochemistry & Nutrition* and *Phototherapy Research* and 1 paper each in other journals.

Conclude that a plant with as diverse a role as *Tinospora cordifolia* is a versatile resource for all forms of life. It is reported in literature that the plant extracts have active compounds in the form of alkaloids, glycosides, lactones and steroids. All these active compounds have immunomodulatory and physiological roles of different types, thereby demonstrating the diverse versatility of the plant. The therapeutic efficacy of *Tinospora cordifolia* extensively used in Indian System of Medicine (ISM) has been established through modern testing and evaluation (pre-clinical and clinical trials) in different disease conditions. Presence of chemical compounds indicates that the plant could serve as "lead" for development of novel agents for disorders in the coming years. In this regard, further studies need to be carried out to explore *Tinospora cordifolia* for its potential in preventing and treating diseases and indicate the need to carry out research on the

plant so that they could get some medicinally important drugs.

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