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Review Article

Global Research on *Terminalia arjuna*: A Quantitative and Qualitative Assessment of Publications during 2004-18

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ABSTRACT

683 global research publications on *Terminalia arjuna* were derived from the Scopus database during the last 22 years (1997-18) with a view to study its quantitative and qualitative aspects. The global publication data showed that the average annual and eleven-year cumulative global output of *Terminalia arjuna* research registered 8.33% and 169.19% growth. The plant global citation impact averaged to 16.92 citations per paper (CPP) in twenty-two years, which decreased from 36.02 CPP to 9.82 CPP from 1997-07 to 2008-18. The top 10 most productive countries together accounted for more than 100.0% global publication share and 99.13% global citation share during 1997-18. India, alone accounting for the highest and largest publication share of 82.43% and other 9 countries from 1.02% to 5.27% during 1997-18. Five out of top 10 countries, namely Iran (2.85), U.K. (1.94), Japan (1.22), USA (1.16) and Pakistan (1.09) registered relative citation index above the global average of 0.97. Pharmacology, toxicology and pharmaceutics, among seven broad subjects, contributed the largest publications share of 50.51%, followed by medicine (30.31%), biochemistry, genetics and molecular biology (26.52%), agricultural and biological sciences (21.52%) and other 3 sub-fields contribution varying from 4.54% to 10.83% during 1997-18. 239 global organizations and 309 global authors in global *Terminalia arjuna* research during 1997-18, of which the 15 most productive global organizations and authors together contributed 30.16% and 15.37% global publication share and 36.87% and 20.68% global citation share respectively during 1997-18. Hamdard University, Delhi, India (with 30 papers), Banaras Hindu University, Varanasi, India (22 papers) and All India Institute of Medical Sciences, New Delhi, India (19 papers), S. Dwivedi (with 11 papers), S.K. Maulik (10 papers) and P.C. Sil (8 papers) and Journal of Ethnopharmacology (with 26 papers), International Journal of Pharmacy and Pharmaceutical Sciences (15 papers), Asian Journal of Pharmaceutical and Clinical Research (14 papers) were the three leading organizations, authors and journals reporting global research in *Terminalia arjuna* during 1997-18.

Key words: *Terminalia arjuna*, Medicinal plant, Global publications, Scientometrics, Bibliometric.

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INTRODUCTION

Medicinal plants have been a major source of therapeutic agents to treat various diseases, since ancient time. The medicinal plants are being studied in order to develop new molecules for use in pharmacology, neutraceuticals, food supplements, folk medicines etc. However, comparatively fewer plant products are nowadays utilized in the modern medical system to treat most of the diseases, particularly; cardiovascular diseases (CVD), ulcers, diabetes, cough, excessive perspiration, asthma, tumor, inflammation and skin disorders.[1,2]

Terminalia arjuna plant (with family name of Combretaceae, rangoon creeper family), mainly a native of Indian sub-continent, is also found eastward in Myanmar and Southwest in Sri Lanka. It is one kind of widely used medicinal plant used in various indigenous system of medicine like Ayurveda, Siddha and Unani and Yunnan system of medicine, besides being used as a source of timber, fuel, tannin and sericulture. The tree attracts lot of attention because of its association with Hindu mythology and astrology. The name "Arjuna" occurs few time in the Rig Veda and Artharva Veda. The use of Arjuna bark powder as an astringent and diuretic finds mention in Charka Sambita. Vagbhata, a disciple of Charka, was the first to recognize the cardioprptective properties of the bark in his treatise Ashtanga Hridayam some 1200 years ago.[1,2]

According to Ayurveda it is alexiteric, styptic, tonic, anthelmintic and useful in fractures, ulcers, heart diseases, biliousness, urinary discharges, asthma, tumors, leucoderma, anemia, excessive perspiration etc. According to Yunnan system of medicine, it is used both externally and internally in gleet and urinary discharges.[3]

Arjuna is a large, deciduous/evergreen tree up to 6-15 (-25) m tall, often having buttressed trunk and with a spreading crown and drooping branches. The bark

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is thin, smooth, shining and greenish-grey and peels of regularly. The leaves are sub-opposite, 5-14 × 2-4.5 cm in size, oblong or elliptic oblong. Flowers are greenish white or creamy and have a sweet scent. Fruit is 2.3-3.5 cm long, fibrous woody, glabrous and has five hard wings, striated with numerous curved veins. Flowering time of the tree is April-July, in Indian conditions.[1,2]

Several chemical compounds have been isolated from its root bark, stem bark, leaves, seeds and fruits. Root contains triterpenoids and glycosides, fruit contains triterpenoids and flavonoids, Leaves and seeds contain flavonoid and glycosides. But bark is considered most important constituent from medicinal point because it contains flavonoids, glycosides, polyphenols, tannins, triterpenoids, sapiens, sterols and minerals such as calcium, magnesium, zinc, copper, amino acids also. These phytochemical constituents have been reported to exhibit various pharmacological activities like antimicrobial, anticancer, cardio protective, antifungal, antidiabetic, antioxidant, anti-inflammatory, hypolipidemic, anthelmintic, insecticidal, wound healing, anticancer, gastroprotective etc.[4]

Traditionally, its bark is highly valued in Ayurveda as a cure for number of ailments including heart associated problems. Its dried stem bark has been used widely used as a cardio tonic in heart failure, ischemic, cardiomyopathy, atherosclerosis, myocardium necrosis and has been used for the treatment of different human diseases like blood diseases, anemia, venereal and viral disease; and to continue excellent healthiness. It is used in the treatment of fractures, ulcers, hepatic and showed hypocholesterolemic, antibacterial, antimicrobial, antitumor, antioxidant, antiallergic and antifeedant, antifertility and anti-HIV activities.[1,2]

Terminalia arjuna has been clinically researched for a number of cardiovascular conditions including ischemic heart disease, hypertension, mitral regurgitation, endothelial dysfunction and heart failure.[5] Various clinical and pharmacological studies have indicated and validated the cardio protection role of Arjuna bark in cardiac ailments and received and attracted considerable attention in recent years. The efficacy of *Terminalia arjuna* as a cardio protective agent, a potential anti-inflammatory and antioxidant preventing LDL cholesterol oxidization and its potential to reduce atherogenic lipid levels have been amply demonstrated in various experimental studies. Its molecular actions in different cells of cardiovascular systems are also reported. Its role in improving the autonomic control plays an important part in improving cardiovascular functions.[6]

Literature Review

No scientometric study had been carried out in the past on *Terminalia arjuna* plant. However, few other similar studies are available, which quantitatively and qualitatively analyze global and Indian literature on individual medicinal plants, including on *Aegle marmelos*,[7] *Aloe vera*,[8] *Andrographis paniculate*,[9] *Azadrachta indica*,[10] *Curcuma longa*,[11] *Glycyrrhiza glabra*,[12] *Nigella sativa*,[13] *Ocimum sanctum*,[14] *Phyllanthis emblica*,[15] *Rhodiola rosea*,[16] *Tinospora cordifolia*[17] and *Withania somnifera*.[18]

Objectives

The present study makes a modest attempt to analyze the performance of *Terminalia arjuna* global research output, as indexed in Scopus database during 1997-18. Specifically, it studied the plant global publication output and of its 10 most productive participating countries, by document type, format and source, its annual and eleven year output growth rate, its international collaborative publications, its subject-wise scatter across sub-fields and by identification of significant keywords, its publication by top 15 global organizations, authors and journals and characteristics of its high cited publications. The study main aim is to analyze the research contribution and its usefulness to pharmacological and medical research.

Methodology

Terminalia arjuna global publications and of top 10 leading countries data was derived from indexed publications in the Scopus database (http://www.scopus.com) during 1997-2018. Keywords, such as "*Terminalia arjuna*" or "Arjuna Tree" were searched in "KEY" (Keyword) or "TITLE" (Title of the papers) tags during 1997-18 to get publication data on global output (683 records). The search string was subsequently refined, using analytical 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 20 August 2019.

KEY ("*Terminalia arjuna*" or "Arjuna Tree") OR TITLE ("*Terminalia arjuna*" or "Arjuna Tree") AND PUBYEAR > 1996 AND PUBYEAR < 2019.

Analysis

The global research output of the world in field of *Terminalia arjuna* cumulated to 683 publications in 22 years during 1997-18 [Table 1]. The *Terminalia arjuna* global annual research output increased from 12

Table 1: *Terminalia arjuna* Plant Annual Publications during 1997-18.

Publication Period	World		
	TP	TC	CPP
1997	12	280	23.33
1998	8	419	52.38
1999	8	75	9.38
2000	10	116	11.60
2001	17	1339	78.76
2002	14	350	25.00
2003	19	531	27.95
2004	22	499	22.68
2005	24	1152	48.00
2006	24	680	28.33
2007	27	1223	45.30
2008	29	519	17.90
2009	33	791	23.97
2010	48	605	12.60
2011	63	648	10.29
2012	50	593	11.86
2013	49	437	8.92
2014	41	361	8.80
2015	46	340	7.39
2016	50	289	5.78
2017	50	216	4.32
2018	39	92	2.36
1997-07	185	6664	36.02
2008-18	498	4891	9.82
1997-18	683	11555	16.92

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

in the year 1997 to 39 publications in the year 2018, registering 8.33% growth per annum. The research output was maximum (63) in the year 2011 and minimum (8) in the year 1998. The cumulative world output in *Terminalia arjuna* research in 11 years; 1997-07 increased from 185 to 498 publications during succeeding eleven-year period 2008-18, registering 169.19% growth. Of the total global publications output, 84.77% (579) appeared as articles, 12.15% (83) as reviews, 0.73% (5) as letters, 0.44% (3) each as book chapters, conference papers, editorials and short surveys, 0.29% (2) as notes and 0.15% (1) each as erratum and unidentified. The citation impact of global publications on *Terminalia arjuna* research in 22 years averaged to 16.92 citations per publication (CPP) during 1997-18; its eleven-yearly impact averaged to 36.02 CPP for the period 1997-07, which sharply declined to 9.82 CPP for the period 2008-18.

Top 10 Most Productive Countries in *Terminalia arjuna* research

Terminalia arjuna global research output had originated from 39 countries during 1997-18, of which 29 published 1-5 papers each, 5 countries 6-10 papers each, 2 countries each 11-20 and 21-50 papers and 1 country 563 papers.

The top 10 most productive countries in *Terminalia arjuna* have contributed 7 to 563 papers during 1997-18 [Table 2]. The 10 leading countries on *Terminalia arjuna* together accounted for more than 100.0% global publication share and 99.13% global citation share during 1997-18; it however accounted for 99.46% global publication share during 1997-2007 which increased to more than 100.0% during succeeding eleven-year period 2008-18. Country-wise, the global publication share of 10 leading countries varied widely 1.02% to 82.43% during 1997-18, with India alone accounting for the highest and largest publication share of 82.43% and other 9 countries from 1.02% to 5.27% during 1997-18. The global publication share registered an increasing publication share in Pakistan, Bangladesh, Saudi Arabia, USA, Egypt and Iran (from 0.66% to 3.34%), as against decrease in India, Japan, U.K and Italy (from 0.42% to 5.57%) in eleven years period (1997-07 and 2008-18). Five of the 10 leading countries scored relative citation index above the world average of 0.97: Iran (2.85), U.K. (1.94), Japan (1.22), USA (1.16) and Pakistan (1.09) during 1997. India has though emerged as one of the world leader in *Terminalia arjuna* research, its performance in terms of relative citation index has below the world average (0.94).

International Collaboration

The international collaborative output of top 10 most productive countries in *Terminalia arjuna* research as a national share in the country-wise output varied widely from 7.28% (India) to 100.0% (Saudi Arabia), with average share of 14.94% during 1997-18. Most surprisingly, India's international collaborative share in its national output in *Terminalia arjuna* research has been comparatively small and lowest during this period.

Subject-Wise Distribution of Research Output

According to the Scopus classification, the global *Terminalia arjuna* research output published during 1997-18 is distributed across seven sub-fields, with pharmacology, toxicology and pharmaceutics accounting for the highest publications share (50.51%), followed by medicine (30.31%), biochemistry, genetics and molecular biology (26.52%), agricultural and biological sciences (21.52%) and other 3 sub-fields contribution varying from 4.54% to 10.83% during 1997-18. Its activity index, which computes change in research activity in the discipline over time 1997-07 to 2008-18 (world average activity index of a given subject is taken as 100), witnessed increase in pharmacology, toxicology and pharmaceutics (from 96.31 to 101.37), medicine (from 99.88 to 100.05), biochemistry, genetics and molecular biology (from 97.04 to 101.10), as against decline in agricultural and biological sciences (from100.46 to 99.83), chemistry (from immunology and microbiology (from 119.82 to 85.07) and environmental science (from 129.72 to 88.96) from 1997-07 to 2008-18.

Chemistry, among various subjects registered the highest citations impact per paper of 24.03 CPP, immunology and microbiology (22.71), medicine (16.87), environmental science (16.27), pharmacology, toxicology and pharmaceutics (15.89), biochemistry, genetics and molecular biology (15.40) and agricultural and biological sciences (12.84) during 1997-18 (Table 3).

Profile of Top 15 Most Productive Global Organizations

Two hundred Thirty Nine (239) organizations participated in global *Terminalia arjuna* research during 1997-18, of which 206 organizations

Table 2: Top 10 Most Productive Countries Global Publication Share on *Terminalia arjuna* during 1997-18.

S.No	Name of the Country	Number of Papers			Share of Papers			TC	CPP	ICP	%ICP	RCI
		1997-07	2008-18	1997-18	1997-07	2008-18	2004-18					
1	India	160	403	563	86.49	80.92	82.43	8951	15.90	41	7.28	0.94
2	USA	8	28	36	4.32	5.62	5.27	706	19.61	15	41.67	1.16
3	Pakistan	2	22	24	1.08	4.42	3.51	443	18.46	8	33.33	1.09
4	Bangladesh	1	19	20	0.54	3.82	2.93	274	13.70	7	35.00	0.81
5	Egypt	2	9	11	1.08	1.81	1.61	141	12.82	6	54.55	0.76
6	Saudi Arabia	0	10	10	0.00	2.01	1.46	39	3.90	10	100.00	0.23
7	Italy	3	6	9	1.62	1.20	1.32	135	15.00	5	55.56	0.89
8	Japan	4	4	8	2.16	0.80	1.17	165	20.63	5	62.50	1.22
9	U.K.	3	5	8	1.62	1.00	1.17	263	32.88	5	62.50	1.94
10	Iran	1	6	7	0.54	1.20	1.02	337	48.14	2	28.57	2.85
	Total	184	512	696	99.46	102.81	101.90	11454	16.46	104	14.94	0.97
	World	185	498	683				11555	16.92			
	Share of 10 Countries in World Total	99.46	102.81	101.9				99.13				

contributed 1-5 papers each, 22 organizations 6-10 papers each, 9 organizations 11-20 papers each and 2 organizations 21-30 papers each.

The productivity of top 15 most productive global organizations in *Terminalia arjuna* research varied from 8 to 30 publications and together they contributed 30.16% (206) global publication share and 36.87% (4260) global citation share during 1997-18. The scientometric profile of these top 15 organizations is presented in Table 4.

- **Five of these organizations** registered publications output greater than the group average of 13.73: Hamdard University, Delhi, India (30 papers), Banaras Hindu University, Varanasi, India (22 papers), All India Institute of Medical Sciences, New Delhi, India (19 papers), University of Delhi, India (18 papers) and National Botanical Research Institute, Lucknow, India (17 papers) during 1997-18.
- **Eight organizations** registered citation impact above the group average of 20.68 citations per publication and relative citation index of 1.22 during 1997-18: Bose Institute, Kolkata, India (58.25 and 3.44), University of Agriculture, Faisalabad, Pakistan (31.55 and 1.86), University of Madras, India (31.08 and 1.84), National Botanical Research Institute, Lucknow, India (30.41 and 1.80), University College of Medical Sciences, Delhi, India (29.82 and 1.76), Panjab University, Chandigarh, India (26.40 and 1.56), Guru Nanak Dev University, Amritsar, India (25.33 and 1.50) and University of Mysore, India (21.11 and 1.25).
- **Six organizations** contributed international collaborative publications share above the group average of 6.80%: University of Agriculture, Faisalabad, Pakistan (36.36%), Guru Nanak Dev University, Amritsar, India (33.33%), Postgraduate Institute of

Table 3: Subject-Wise Breakup of *Terminalia arjuna* Global Publications during 1997-18.

S.No	Subject*	Number of Papers (TP)			Activity Index		TC	CPP	%TP
		1997-07	2008-18	1997-18	1997-07	2008-18		1997-18	
1	Pharmacology, Toxicology and Pharmaceutics	90	255	345	96.31	101.37	5481	15.89	50.51
2	Medicine	56	151	207	99.88	100.05	3493	16.87	30.31
3	Biochemistry, Genetics and Molecular Biology	46	129	175	97.04	101.10	2695	15.40	25.62
4	Agricultural and Biological Sciences	40	107	147	100.46	99.83	1888	12.84	21.52
5	Chemistry	26	48	74	129.72	88.96	1778	24.03	10.83
6	Environment Science	18	44	62	107.18	97.33	1009	16.27	9.08
7	Immunology and Microbiology	10	21	31	119.09	92.91	704	22.71	4.54
	World Output	185	498	683			11555		

There is overlapping of literature covered under various subjects

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

Table 4: Scientometric Profile of Top 15 Most Productive Global Organizations on *Terminalia arjuna* Research during 1997-18.

S.No	Name of the Organization	TP	TC	CPP	ICP	%ICP	RCI
1	Hamdard University, Delhi, India	30	267	8.9	2	6.67	0.53
2	Banaras Hindu University, Varanasi, India	22	369	16.77	0	0.00	0.99
3	All India Institute of Medical Sciences, New Delhi, India	19	320	16.84	2	10.53	1.00
4	University of Delhi, India	18	346	19.22	0	0.00	1.14
5	National Botanical Research Institute, Lucknow, India	17	517	30.41	0	0.00	1.80
6	University of Madras, India	13	404	31.08	1	7.69	1.84
7	University College of Medical Sciences, Delhi, India	11	328	29.82	0	0.00	1.76
8	Jadavpur University, Kolkata, India	11	111	10.09	0	0.00	0.60
9	University of Agriculture, Faisalabad, Pakistan	11	347	31.55	4	36.36	1.86
10	Panjab University, Chandigarh, India	10	264	26.40	0	0.00	1.56
11	Amity University, Noida, India	10	49	4.90	0	0.00	0.29
12	University of Mysore, India	9	190	21.11	0	0.00	1.25
13	Guru Nanak Dev University, Amritsar, India	9	228	25.33	3	33.33	1.50
14	Postgraduate Institute of Medical Education and Research, Chandigarh, India	8	54	6.75	1	12.50	0.40
15	Bose Institute, Kolkata, India	8	466	58.25	1	12.50	3.44
	Total of 15 organizations	206	4260	20.68	14	6.80	1.22
	Total of World	683	11555	16.92			
	Share of top 15 organizations in World total output	30.16	36.87				

Medical Education and Research, Chandigarh, India and Bose Institute, Kolkata, India (12.50% each), All India Institute of Medical Sciences, New Delhi, India (10.53%) and University of Madras, India (7.69%) during 1997-18.

Profile of Top 15 Most Productive Authors

Three Hundred Nine (309) authors participated in global *Terminalia arjuna* research during 1997-18, of which 286 authors contributed 1-5 papers each, 22 authors 6-10 papers each and 1 author 11 papers. The research productivity in the field of *Terminalia arjuna* research of top 15 most productive authors varied from 6 to 11 publications.

Together they contributed 15.37% (105) global publication share and 20.68% (2389) global citation share during 1997-18. The scientometric profile of these 15 authors is presented in Table 5.

- **Three authors** registered publications output above the group average of 7.0: S. Dwivedi (11 papers), S.K. Maulik (10 papers) and P.C. Sil (8 papers);
- **Six authors r**egistered citation impact above the group average of 22.75 citations per publication and relative citation index of 1.34: P. Manna (59.29 and 3.50), P.C. Sil (58.25 and 3.44), I.S. Grover (30.50 and 1.80), S. Kumar (30.14 and 1.78), S. Dwivedi (28.55 and 1.69) and S.K. Maulik (24.90 and 1.47);
- **Five authors** contributed international collaborative publications share above the group average of 8.57% of all authors: I.S. Grover (50.0%), S. Kumar (28.57%), S.K. Maulik (20.0%), K. Balakrishna (16.67%) and P.C. Sil (12.50%).

Medium of Research Communication

Of the total world output on *Terminalia arjuna* research, 98.68% (674) appeared in journals, 0.73% (5) in trade publications, 0.29% (2) each as books and book series during 1997-18.

674 journal papers appeared in 343 journals, of which 325 journals published 1-5 papers each, 13 journals 6-10 papers each, 4 journals 11-20 papers each and 1 journal 21-26 papers each during 1997-18.

The top 15 most productive journals reported 7 to 26 papers each on *Terminalia arjuna* research; together they accounted for 24.18% (163 papers) of total *Terminalia arjuna* output published in journals during 1997-18, shown increase from 22.10% to 24.95% share between 1997-07 and 2008-18. The top ranking journal is Journal of Ethnopharmacology (with 26 papers), followed by International Journal of Pharmacy and Pharmaceutical Sciences (15 papers), Asian Journal of Pharmaceutical and Clinical Research, International Journal of Pharmaceutical Science Review and Research (14 papers each), Pharmaceutical Biology (12 papers), etc. during 1997-18 (Table 6).

Significant Keywords

Around 59 significant keywords have been identified from the literature which through light on the research trends in *Terminalia arjuna* including chemical constituents, biological and pharmacological properties and medicinal applications. These keywords are listed in Table 7 in the decreasing order of the frequency of their occurrence in the literature during 1997-18.

Highly Cited Papers

A total of 16 highly cited papers were identified each having 101 to 667 citations (9 papers each in citation range 101-200, 6 papers each in 201-300 citations range each and 1 paper with 667 citations) in 22 years during 1997-18. Together these 16 papers cumulated a total of 3159 citations, averaging 197.44 citations per paper. Of the 16 highly cited papers, 10 resulted from the participation of research organizations in their role as stand-alone (non-collaborating) institutional authors and remaining 6 from two or more research organizations working in their

Table 5: Scientometric Profile of Top 15 Most Productive Authors on *Terminalia arjuna* Research during 1997-18.

S.No	Name of the Author	Affiliation of the Author	TP	TC	CPP	HI	ICP	%ICP	RCI
1	S. Dwivedi	University College of Medical Sciences, Delhi, India	11	314	28.55	7	0	0.00	1.69
2	S.K. Maulik	All India Institute of Medical Sciences, New Delhi, India	10	249	24.90	6	2	20.00	1.47
3	P.C. Sil	Bose Institute, Kolkata, India	8	466	58.25	8	1	12.50	3.44
4	S. Kumar	Guru Nanak Dev University, Amritsar, India	7	211	30.14	7	2	28.57	1.78
5	P. Manna	Bose Institute, Kolkata, India	7	415	59.29	7	0	0.00	3.50
6	S.K. Singla	Panjab University, Chandigarh, India	7	43	6.14	3	0	0.00	0.36
7	C. Tandon	Panjab University, Chandigarh, India	7	43	6.14	3	0	0.00	0.36
8	K. Balakrishna	Central Research Institute for Siddha, India	6	127	21.17	3	1	16.67	1.25
9	S. Bhattacharya	Bengal Institute of Pharmaceutical Sciences, India	6	45	7.50	3	0	0.00	0.44
10	M. Biswas	Jadavpur University, Kolkata, India	6	49	8.17	3	0	0.00	0.48
11	A.K. Ghosh	Jadavpur University, Kolkata, India	6	49	8.17	3	0	0.00	0.48
12	I.S. Grover	Guru Nanak Dev University, Amritsar	6	183	30.50	6	3	50.00	1.80
13	M.M. Gupta	Central Institute of Aromatic and Medicinal Plants, Lucknow, India	6	111	18.50	6	0	0.00	1.09
14	P.K. Haldar	Jadavpur University, Kolkata, India	6	49	8.17	3	0	0.00	0.48
15	N. Jahan	University of Agricultural Sciences, Faisalabad, Pakistan	6	35	5.83	4	0	0.00	0.34
		Total of 15 authors	105	2389	22.75	4.8	9	8.57	1.34
		Total of World	683	11555	16.92				
		Share of top 15 authors in World total output	15.37	20.68					

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

Table 6: Top 15 Most Productive Journals on *Terminalia arjuna* Research during 1997-18.

S.No	Name of the Journal	Number of Papers		
		1997-07	2008-18	1997-18
1	Journal of Ethnopharmacology	12	14	26
2	International Journal of Pharmacy and Pharmaceutical Sciences	0	15	15
3	Asian Journal of Pharmaceutical and Clinical Research	0	14	14
4	International Journal of Pharmaceutical Science Review and Research	0	14	14
5	Pharmaceutical Biology	3	9	12
6	Indian Drugs	7	3	10
7	Pharmacologyonline	1	9	10
8	Phytotherapy Research	8	2	10
9	Phytomedicine	3	6	9
10	International Journal of Pharmatech Research	0	8	8
11	Indian Journal of Experimental Biology	3	4	7
12	International Journal of Research in Ayurveda and Pharmacy	0	7	7
13	Pharmacognosy Journal	0	7	7
14	Planta Medica	3	4	7
15	Research Journal of Pharmaceutical Biology and Chemical Sciences	0	7	7
	Total of 15 journals	40	123	163
	Total global journal output	181	493	674
	Share of top 15 journals in global journal output	22.10	24.95	24.18

role as collaborating partners per paper (4 national collaborative and 2 international collaborative). Among 16 highly cited papers, the largest participation was seen from India (12 papers), followed by the Canada, Iran, Pakistan, Singapore, Taiwan and USA (1 paper each) during 1997-18. These 16 highly cited papers involved the participation of 57 personal authors and 24 research organizations in total across globe. Of the 16 highly cited papers, 14 were published as articles and 1 each as review and editorial. These 16 highly cited papers were published in 12 journals, with 5 papers in *Journal of Ethnopharmacology,* 1 paper each in *Antiviral Research, BMC Complementary and Alternative Medicine, Chemical Engineering Science, Food Chemistry, Hepatology, International Journal of Food Sciences and Nutrition, Journal of Cleaner Production, Life Sciences, Molecular and Cellular Biochemistry, Phytotherapy Research* and *World Journal of Gastroenterology.*

CONCLUSION

683 global research publications on *Terminalia arjuna* were derived during the last 22 years (1997-18) from the Scopus database with a view to study its quantitative and qualitative aspects. The publication data showed that the average annual and eleven-year cumulative global output of *Terminalia arjuna* research registered 8.33% and 169.19% growth. The plant global citation impact averaged to 16.92 citations per paper (CPP) in twenty two years, which decreased from 36.02 CPP to 9.82 CPP from 1997-07 to 2008-18.

Of the 39 participating countries, more than 82% of global *Terminalia arjuna* research output share was from India alone, whereas other 9 top ranking countries accounted each for global share from 1.02% to 5.27% during 1997-18. The top 10 most productive countries together accounted for more than 100.0% global publication share and 99.13% global citation share in *Terminalia arjuna* research during 1997-18. The plant global publication share, however, increased from 99.46% to more than 100.0% from 1997-07 to 2008-18. Five countries, among top 10, scored relative citation index above the world average of 0.97: Iran (2.85), U.K. (1.94), Japan (1.22), USA (1.16) and Pakistan (1.09) during 1997.

Pharmacology, toxicology and pharmaceutics was the most sought after subject area of *Terminalia arjuna* research, accounting for (50.51%) the highest publications share, followed by medicine (30.31%), biochemistry, genetics and molecular biology (26.52%), agricultural and biological sciences (21.52%) and other 3 sub-fields contribution varying from 4.54% to 10.83% during 1997-18. Among broad subjects, the research activities registered increase in pharmacology, toxicology and pharmaceutics, medicine, biochemistry, genetics and molecular biology, as against decline in agricultural and biological sciences, chemistry, immunology and microbiology and environmental science from 1997-07 to 2008-18.

The top 15 most productive research organizations and the authors, amongst 239 and 309 participating organizations and authors, collectively contributed 30.16% and 15.37% global publication share and 36.87% and 20.68% global citation share respectively on *Terminalia arjuna* research during 1997-18. The leading organizations in terms of publication productivity were: Hamdard University, Delhi, India (30 papers), Banaras Hindu University, Varanasi, India (22 papers), All India Institute of Medical Sciences, New Delhi, India (19 papers), University of Delhi, India (18 papers) and National Botanical Research Institute, Lucknow, India (17 papers) during 1997-18. The leading organizations in terms of citation impact per paper and relative citation index were: Bose Institute, Kolkata, India (58.25 and 3.44), University of Agriculture, Faisalabad, Pakistan (31.55 and 1.86), University of Madras, India (31.08 and 1.84), National Botanical Research Institute, Lucknow, India (30.41 and 1.80), University College of Medical Sciences, Delhi, India (29.82 and 1.76), Panjab University, Chandigarh, India (26.40 and 1.56), Guru Nanak Dev University, Amritsar, India (25.33 and 1.50), etc.

The journals medium accounted for 98.68% global share in *Terminalia arjuna* research with top 15 most productive journals accounting for 24.18% of total publications output in journals during 1997-18. *Journal of Ethnopharmacology* contributed the largest number of papers (26),

Table 7: List of Significant Keywords in Literature on Global *Terminalia arjuna* Research during 1997-18.

S.No	Keyword	Frequency	S.No	Keyword	Frequency
1	*Terminalia arjuna*	650	31	Hyperlipidemia	38
2	Plant Extracts	410	32	Drug Formulation	37
3	Terminalia	235	33	Antibacterial Activity	36
4	Medicinal Plants	235	34	Tanin Derivatives	36
5	Bark	178	35	Arjunolic Acid	34
6	Antioxidant Activity	115	36	Antimicrobial Activity	33
7	Herbaceous Agents	102	37	Antineoplastic Activity	33
8	Plant Leaf	89	38	Hypertension	30
9	Phytotherapy	84	39	Drug Structure	29
10	Oxidation Stress	77	40	*In vivo* Study	29
11	Drug Effects	76	41	Plant Seed	29
12	Phytochemistry	73	42	Atherosclerosis	28
13	Drug Efficacy	69	43	Drug Safety	28
14	*In vitro* Study	66	44	Anti-inflammatory Activity	27
15	Traditional Medicine	64	45	Clinical Trials	27
16	Chemistry	61	46	Diarrhea	27
17	Drug Mechanisms	61	47	Anti-infective Agents	25
18	Drug Isolation	58	48	Ethnobotany	25
19	Flavonoids	53	49	Lipids	25
20	Fruit	50	50	Sapanins	25
21	Diabetes Mellitus	54	51	Antidiabetic Activities	24
22	Drug Screening	49	52	Body Weight	24
23	Glutathione	49	53	Flower	23
24	Heart Protection	49	54	Cassia Fistula	23
25	Plant Stem	46	55	Inflammation	23
26	Ascorbic Acid	45	56	Liver Protection	23
27	Ayurveda	44	57	Gallic Acid	22
28	Enzyme Activity	44	58	Abdominal Pain	6
29	Cardiovascular Disease	44	59	Depression	6
30	Plant Root	41			

followed *International Journal of Pharmacy and Pharmaceutical Sciences* (15 papers), *Asian Journal of Pharmaceutical and Clinical Research, International Journal of Pharmaceutical Science Review and Research* (14 papers each), *Pharmaceutical Biology* (12 papers), etc. during 1997-18 (Table 6).

Of the total *Terminalia arjuna* global research output, only 16 publications registered high citations, in the range of 101-667 citations per paper and collectively these highly cited papers received a total of 3159 citations, averaging to 197.44 citations per paper. These 16 highly cited papers involved the participation of 57 authors and 24 organizations and were published in 12 journals, of which 5 papers in *Journal of Ethnopharmacology* and 1 paper each in 11 other journals.

Concludes that the above analysis have given the idea about existing status of research including the present trends, most active countries, prominent scientific sub-fields and identification of core organizations, authors and journals involved in research and possible collaboration opportunities.

The above study will encourage policy makers to undertake more extensive R&D work on *Terminalia arjuna* with an objective of exploring its full potential in treating various diseases and in discovering potential therapeutic effects and developing new formulations.

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