

Moringa oleifera: A Bibliometric Analysis of International Publications during 1935-2019

BM Gupta^{1,*} and K.K. Ahmed²

ABSTRACT

The paper examines quantitative and qualitative aspects of research on *Moringa oleifera*, based on global publications output (3187 publications), as covered in Scopus database during 1935-2019. The publications on *Moringa oleifera* registered annual average growth of 16.18% and cumulative growth of 3594.0% and averaged to 17.69 citations per paper. Bulk of global publications output (76.72%) and the global citations (68.06%) in the field emanates from top 10 countries. The paper further provides an insight into qualitative performance of research on *Moringa oleifera* in terms of relative citation index, citations per paper, highly cited papers, besides analyzing the top 25 global organizations and authors in the field, the distribution of publications by broad subjects, the identification of the most significance keywords, the most productive journals and the analysis of higher-cited papers in the field. The study found that Universidade Estadual de Maringá, Brazil (72 papers), National Research Centre, Giza, Egypt (66 papers) and University of Agriculture, Faisalabad, Pakistan (65 papers) were the most productive organizations and University of Agriculture, Faisalaba, Pakistan (38.35 and 2.17), University of Karachi, Pakistan (35.23 and 1.99) and Mahidol University, Thailand (27.35 and 1.55) were the most significant organizations in terms of citation per paper and relative citation index. Similarly, R. Bergamasco. (65 papers), P.M.G. Paiva. (36 papers) and L.C.B.B Coelho (34 papers) were the most productive authors and F. Anwar. (124.21 and 7.02), J. Beltrán-Heredia (36.07 and 2.04) and J. Sánchez-Martín (34.69 and 1.96) were the leading authors in terms of citation per paper and relative citation index. South African Journal of Botany (62 papers), *Journal of Ethnopharmacology* (61 papers) and Desalination and Water Treatment (44 papers) were the leading journals contributing to the field.

Key words: *Moringa oleifera*, Medicinal plant, Global publications, Scientometrics, Bibliometrics.

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INTRODUCTION

Moringa oleifera Lam (Moringaceae) is a valued plant, distributed in many countries of the tropics and subtropics.^[1] Its common names include moringa, drumstick tree (from the long, slender, triangular seed-pods), horseradish tree (from the taste of the roots, which resembles horseradish) and ben oil tree or benzolive tree (from the oil which is derived from the seeds).^[2]

Moringa oleifera is a fast-growing, drought-resistant tree of the family Moringaceae, native to the Indian subcontinent.^[3] It is now widely introduced and naturalized across the tropics and subtropics. It is also widely cultivated for a range of purposes including for human consumption, as livestock feed and for use in cosmetics. Its increasing commercialisation and international trade are likely to result in further spread of this species, though its sensitivity to low temperatures may restrict its distribution to tropical and subtropical regions.^[3]

In terms of economic value, most of the production and international trade of *M. oleifera* comes from India, in canned produce, fresh fruits, oil, seeds and

leaf powder. India has an annual production of 1.1-1.3 million tons of tender pods.^[4]

It has an impressive range of medicinal uses with high nutritional value. As reported by researchers in different countries, all parts of *Moringa oleifera* (leaves, fruits, immature pods and flowers) are combined into the traditional food for human consumption. Different parts of this plant contain a profile of important minerals and are a good source of protein, vitamins, beta-carotene, amino acids and various phenolics. The Moringa plant provides a rich and rare combination of zeatin, quercetin, beta-sitosterol, caffeoylquinic acid and kaempferol. In addition to its compelling water purifying powers and high nutritional value, *Moringa oleifera* is very important for its medicinal value.^[1]

Various parts of this plant such as the leaves, roots, seed, bark, fruit, flowers and immature pods act as cardiac and circulatory stimulants, possess antitumor, antipyretic, antiepileptic, anti-inflammatory, antiulcer, antispasmodic, diuretic, antihypertensive, cholesterol lowering, antioxidant, anti-diabetic,

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hepato-protective, antibacterial and antifungal activities and are being employed for the treatment of different ailments in the indigenous system of medicine, particularly in South Asia.^[1]

Moringa oleifera has wide range of uses. Among those, water purification, human consumption, medicine, fuel wood, dye, soil and water conservation, livestock forage and green manure. The seed of *Moringa oleifera* is also used for water treatment as water purification and remove bacteria from water. There are many uses of *Moringa* tree and these will all be: medicines, Human food, Water purification, Animal fodder, Alley cropping, Fertilizer, Living fence, Living fence, Domestic cleaning agent, Fuel wood and other uses. Different studies reveal that, *Moringa* has a direct effect on agriculture, nutrition, health, water, environment, biodiversity and sanitation. The capacity of the *Moringa* tree is inspiring in mitigating the adverse effects of climate change. There is great potential for the *Moringa* tree to not only store carbon, but also to improve the livelihoods of many smallholder farmers. By planting of this tree in different parts of the country, it will help to mitigate the impacts of climate change.^[5]

The global *Moringa oleifera* plant products market size was valued at USD 5.5 billion in 2018 and is anticipated to expand at a healthy CAGR over the forecast period. The plant can be used in various forms such as raw moringa, moringa powder used in food supplements, tea and oil. The market is driven by several factors such as growing need for nutritional supplements, improving health awareness among people and shifting focus towards organic medication. By product, the market is divided into leaf powder, tea, oil and seeds. Leaf powder accounted for the largest market share of more than 30.0% in the year 2018. Growing demand for nutritional supplements as a part of daily diet is one of the major factors for the segment growth. Leaf powder is used in making useful medicines that help in treating a wide variety of skin problems. Leaf extracts might help treat some stomach disorders, such as constipation, gastritis and ulcerative colitis. The antibiotic and antibacterial properties of moringa may help inhibit the growth of various pathogens and its high vitamin B content helps with digestion. Moringa powder can last for a longer time and can also be transported easily and hence it is more preferred in this form as compared to the other forms.^[6] In addition, moringa is marketed for various other uses. These include weight management, improving digestion and helping to support normal sugar levels in the body.

Literature Review

Only three bibliometric studies have been published on *Moringa oleifera*. Mainenti^[7] analyzed *Moringa oleifera* global research output, by deriving publications data from three bibliographical databases during 1935-2018: the publications distribution and type and source of publications, keyword frequency, country, subjects, organizations, authors and journals. Dou and Kister^[8] studied both publications (314 records) and patent records (356 patents from 171 families) on *Moringa oleifera* during 2000-14, using PubMed and EPO (European Patent Office) databases. The study examined literature growth, leading countries, authors, journals and keywords and also collaborative linkages among countries, authors and keywords. The patents records were studied by filing country distribution, patent assignees (applicants) applications and important properties. The names of important organizations, researchers and companies were also identified. Gupta and Mueen Ahmed^[9] analysed Indian *Moringa oleifera* 819 research publications during 1980-19, using bibliometric methods. It studied their growth characteristics, research quality and impact, extent of international collaborative papers, distribution by broad subjects and significant keywords, leading organizations, authors and journals and features of its high-cited papers

Similar bibliometric studies have been carried out on other medicinal plants such as including on *Aloe vera*,^[10] *Andrographis paniculata*,^[11] *Azadirachta indica*,^[12] *Curcuma longa*,^[13] *Glycyrrhiza glabra*,^[14] *Nigella sativa*,^[15] *Ocimum Sanctum*,^[16] *Phyllanthis emblica*,^[17] *Rhodiola rosea*,^[18] *Tinospora cordifolia*^[19] and *Withania somnifera*.^[20]

Objectives

The objective of the present study is to evaluate global performance in *Moringa oleifera* field during the period 1935-2019. The specific objectives of the study are: (i) To study the research world output and of top 10 most productive countries output in *Moringa oleifera* research; (ii) To study the annual growth rate, citation impact and collaboration profile of top 10 countries in *Moringa oleifera* research; (iii) To study the distribution of global publications output by broad subject areas and by keyword frequency; (iv) To study the publication productivity and citation impact of top 25 global organizations and 25 global authors in the subject; (iv) To study the distribution of papers by source journals and identify the leading productive journals; and (v) To study the bibliographic characteristics of highly cited papers

Methodology

The publications data on *Moringa oleifera* plant species was retrieved and downloaded from the Scopus database (<http://www.scopus.com>) covering the period 1935-2019 for the present study. Keyword for search was *Moringa oleifera*, which was suffixed to “keyword tag” and “Article Title tag” and the search output refined by period ‘1935-2019’ using “date range tag”.

This main search strategy was further refined by country to identify top 10 most productive countries on *Moringa oleifera* research. For citation data, citations to publications were counted from date of their publication till 11 January 2020. The study analyzed the publications data across a series of raw and relative bibliometric indicators with a view to understand the dynamics of *Moringa oleifera* research.

(KEY("Moringa oleifera") OR TITLE("Moringa oleifera")) AND (EXCLUDE (PUBYEAR,2020))

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ANALYSIS AND RESULTS

The global research output on *Moringa oleifera* research resulted in 3187 publications during 1935-19. The annual number of publications remained low till 1993, starting increasing and decreasing slowly up to 2004 and then showed fast growth from 33 in 2005 to 474 in 2019. The annual publications witnessed 16.18 % average growth, up from 1 publication in 1935 to 474 publications in 2019. The global cumulative

publications increased from 84 during 1935-1997 to 3103 during 1998-2019, registering 3594.0% absolute growth. The total publications on *Moringa oleifera* registered citation impact per paper (CPP) of 17.69 during 1935-2019, which decreased from 51.70 CPP (1935-1997 to 16.77 (1998-2019) (Table 1). Of the total publications, 85.79% (2734) appeared as articles, 6.06% (193) as reviews, 5.59% (178) as conference papers and other categories contributed less than 1.0%: book chapters (0.72%), letters (0.35%), notes (0.28% each), editorials and erratum (0.22% each), short surveys (0.14%), data papers (0.09%), book and retracted (0.03% each) and undefined (0.50%).

English language contribution constituted the largest output and share (96.80% and 3085), followed by Spanish publications (1.26% and 40), Portuguese publications (1.26% and 40), Chinese publications (0.72% and 23), French publications (0.38% and 12) and 7 other language publications contributed between 0.03% to 0.19% publication share.

Country-wise distribution

121 countries unevenly participated in global *Moringa oleifera* research during 1935-2019: 56 published 1-5 papers each, 14 countries 6-10 papers each, 34 countries each 11-50 papers each, 7 each published 51-100 and 101-200 papers, 2 countries 01-300 papers each and 1 country 820 papers.

The contribution of top 10 most productive countries varied from 112 to 820 papers in *Moringa oleifera* and together accounted for more than 76.72% global publication share and 68.06% global citation share during 1935-19. These countries, however accounted for 52.38% global publication share during 1935-1997 which increased to more than 77.38% during 1998-2019. Country-wise, the global publication share of 10 leading countries varied widely 3.51% to 25.73% during 1935-2019, with India alone accounting for the highest publication share of 25.73%, followed distinctly by Nigeria and Brazil (8.38% and 8.25%), Pakistan, Malaysia, Egypt, South Africa and USA (from 5.05% to 5.40%), China and Indonesia (4.83% and 3.51%) during 1935-2019. The global publication share registered an increasing publication share in Brazil, Malaysia, Egypt, China, South Africa, USA, Indonesia and Nigeria (from 1.27% to 8.48%), as against decrease in Pakistan and India (from 3.02% to 9.03%) during 1935-1997 to 1998-2019. Four of the 10 leading countries scored relative citation index above the world average of 0.89: Pakistan (1.48), USA (1.44), Malaysia (1.16) and India (1.08) during 1935-2019. India has though emerged as one of the world leader in *Moringa oleifera* research, it ranked at 4th position in terms of relative citation index (Table 2).

Country Collaboration among Top 10 Most productive Countries

Amongst top 10 most productive countries, the USA leads in research collaboration with its highest 55 linkages with 9 other countries, followed by China (41 linkages with 8 countries), India and Pakistan (38 linkages with 7 and 8 countries), Nigeria (37 linkages with 8 countries), Malaysia (28 linkages with 8 countries), etc. The number of collaborative linkages between two countries was the largest (17) between India-USA, followed by USA-China (9), Pakistan-US (9), Pakistan-USA (9), etc. (Table 3).

Subject-Wise Distribution of Research Output

Agricultural and biological sciences is the major subject contributing to global research on *Moringa oleifera* (36.99%), followed by pharmacology, toxicology and pharmaceuticals (22.18%), biochemistry, genetics and molecular biology (19.96%), medicine (17.01%), environmental science (16.79%), chemistry (12.21), chemical engineering (8.32%) and immunology and microbiology (4.71%) during 1935-2019. As seen through activity index, the research activity have decreased in

pharmacology, toxicology and pharmaceuticals (from 166.36 to 98.20), biochemistry, genetics and molecular biology (from 119.31 to 99.48) and environment science (from 170.20 to 98.10), as against increase in agricultural and biological sciences (from 45.05 to 101.49), medicine (from 84.0 to 100.43), chemistry (from 78.03 to 100.59), immunology and microbiology (from 75.88 to 100.65) and energy (from 0.0 to 102.71) from 1935-1997 to 1998-19. Chemistry, among various subjects, registered the highest citation impact per paper of 26.85 and agricultural and biological sciences the least (15.12) (Table 4).

Significant Keywords

A number of significant keywords (66) have been identified from the literature *Moringa oleifera* research, which throws some light on the trends of research in this field. The keywords are arranged in the decreasing order of appearance in the literature (Table 5).

Profile of Top 25 Most Productive Organizations

In all 547 organizations participated in global research on *Moringa oleifera*: 312 organizations published 1-5 papers each, 156 organizations 6-10 papers each, 58 organizations 11-21 papers, 17 organizations 21-50 papers and 4 organizations 51-72 papers each. The top 25 organizations published 19 to 72 papers and together account for 25.04% (798) global publications share and 24.71% (13934) global citations share during 1980-2019. Of the 25 organizations, 6 are from Brazil, 5 from Nigeria, 4 from Pakistan, 3 from South Africa, 2 from Malaysia and 1 each from

Table 1: Growth of Global Research Publications on *Moringa oleifera* during 1935-2019.

Period	TP	TC	CPP	Period	TP	TC	CPP
1935	1	1	1.00	2000	12	701	58.42
1946	1	4	4.00	2001	11	677	61.55
1963	1	2	2.00	2002	22	1218	55.36
1967	1	1	1.00	2003	30	2778	92.60
1979	2	43	21.50	2004	18	3240	180.00
1980	2	253	126.50	2005	33	2109	63.91
1982	2	161	80.50	2006	43	1757	40.86
1984	3	49	16.33	2007	87	3976	45.70
1985	3	91	30.33	2008	55	1980	36.00
1985	1	5	5.00	2009	93	3000	32.26
1987	5	170	34.00	2010	106	3437	32.42
1988	7	84	12.00	2011	163	4024	24.69
1989	3	51	17.00	2012	185	4601	24.87
1990	3	104	34.67	2013	196	3572	18.22
1991	3	154	51.33	2014	226	3347	14.81
1992	4	303	75.75	2015	221	2919	13.21
1993	3	29	9.67	2016	306	2887	9.43
1994	6	370	61.67	2017	373	2197	5.89
1995	11	1414	128.55	2018	420	1262	3.00
1996	10	535	53.50	2019	474	459	0.97
1997	12	519	43.25	1935-97	84	4343	51.70
1998	13	909	69.92	1998-19	3103	52048	16.77
1999	16	998	62.38	1935-19	3187	56391	17.69

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

Table 2: Top 10 Most Productive Countries Global Publication Output and Share on *Moringa oleifera* during 1935-2019.

S.No	Country Name	Total Papers			Share of Papers			TC	CPP	ICP	%ICP	RCI
		35-97	98-19	35-19	35-97	98-19	35-19					
1	India	29	791	820	34.52	25.49	25.73	15656	19.09	86	10.49	1.08
2	Nigeria	6	261	267	7.14	8.41	8.38	2573	9.64	63	23.60	0.54
3	Brazil	0	263	263	0.00	8.48	8.25	3524	13.40	31	11.79	0.76
4	Pakistan	7	165	172	8.33	5.32	5.40	4514	26.24	55	31.98	1.48
5	Malaysia	0	166	166	0.00	5.35	5.21	3400	20.48	47	28.31	1.16
6	Egypt	0	165	165	0.00	5.32	5.18	1267	7.68	57	34.55	0.43
7	South Africa	1	164	165	1.19	5.29	5.18	2118	12.84	46	27.88	0.73
8	USA	1	160	161	1.19	5.16	5.05	4102	25.48	97	60.25	1.44
9	China	0	154	154	0.00	4.96	4.83	1002	6.51	48	31.17	0.37
10	Indonesia	0	112	112	0.00	3.61	3.51	224	2.00	11	9.82	0.11
	Total of 10 countries	44	2401	2445	52.38	77.38	76.72	38380	12.04			0.68
	Global Total	84	3103	3187				56391				
	Share of top 10 countries in global total	52.38	77.38	76.72				68.06				

Table 3: Collaborative Linkages among top 10 countries during 1935-2019.

S.No	Collaborating Countries	The number of collaborative linkages with other 9 countries	Total collaborative linkages (countries)
1	India	2(1), 4(4), 5(3), 6(3), 7(6), 8(17), 9(4)	38 (7)
2	Nigeria	1(1), 3(7), 4(2), 5(6), 6(2), 7(8), 8(3), 9(8)	37(8)
3	Brazil	2(7), 4(1), 8(3)	11(3)
4	Pakistan	1(4), 2(2), 3(1), 5(7), 6(1), 7(2), 8(9), 9(9)	38(8)
5	Malaysia	1(3), 2(6), 4(7), 6(1), 7(4), 8(3), 9(3), 10(1)	28(8)
6	Egypt	1(3), 2(2), 4(1), 5(1), 8(6), 9(4)	17(6)
7	South Africa	1(6), 2(8), 4(2), 5(4), 8(4), 9(3)	27(6)
8	USA	1(17), 2(3), 3(3), 4(9), 5(3), 6(6), 7(4), 9(9), 10(1)	55 (9)
9	China	1(4), 2(8), 4(9), 5(3), 6(4), 7(3), 8(9), 10(1)	41(8)
10	Indonesia	5(1), 8(1), 9(1)	3(3)

Table 4: Subject-Wise Breakup of India's Publications on *Moringa oleifera* during 1935-2019.

S.No	Subject*	Number of Papers (TP)			Activity Index		TC	CPP	%TP
		35-97	98-19	35-19	35-97	98-19			
1	Agricultural and biological sciences	14	1165	1179	45.05	101.49	17832	15.12	36.99
2	Pharmacology, toxicology and pharmaceuticals	31	676	707	166.36	98.20	13341	18.87	22.18
3	Biochemistry, genetics and molecular biology	20	616	636	119.31	99.48	11846	18.63	19.96
4	Medicine	12	530	542	84.00	100.43	9393	17.33	17.01
5	Environmental science	24	511	535	170.20	98.10	10857	20.29	16.79
6	Chemistry	8	381	389	78.03	100.59	10445	26.85	12.21
7	Chemical Engineering	0	265	265	0.00	102.71	5029	18.98	8.32
8	Immunology and microbiology	3	147	150	75.88	100.65	3043	20.29	4.71
9	Energy	0	120	120	0.00	102.71	2564	21.37	3.77
	World Output	84	3103	3187					

- There is overlapping of literature covered under various subjects

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

Table 5: List of Significant Keywords appeared in Literature on *Moringa oleifera* during 1935-2019.

S.No	Keyword Name	Frequency	S.No	Keyword Name	Frequency
1	<i>Moringa oleifera</i>	2657	34	Vegetable Oil	72
2	Plant Extract	1058	35	Inflammation	71
3	Plant Leaf	576	36	Alkaloids	70
4	Plant Seeds	470	37	Anti-diabetic Activity	70
5	Moringa	444	38	Liver	70
6	Medicinal Plant	399	39	Catalase	63
7	Antioxidant Activity	283	40	Pathology	63
8	Coagulation	251	41	Water Quality	63
9	Water Treatment	209	42	Wastewater Treatment	63
10	Flavonoids	203	43	Chemical Water Treatment	63
11	Plant Leaves	202	44	Fatty Acids	63
12	Phytochemistry	190	45	Glutathione	63
13	Oxidation Stress	159	46	Liver Protection	62
14	<i>In vitro</i> Study	148	47	Nutritional Value	61
15	Enzyme Activity	131	48	Pollutants Removal	61
16	Anti-inflammatory Activity	123	49	Tanin Derivatives	60
17	Traditional Medicine	120	50	<i>Moringa oleifera</i> Lams	58
18	Moringaceae	117	51	<i>In vivo</i> Study	56
19	Anti-bacterial Activity	115	52	Anti-fungal Activity	56
20	Plant Root	108	53	Bacteria	54
21	Methanol	95	54	Oils and Fats	47
22	Ascorbic Acid	94	55	Oleic Acid	47
23	Fruit	93	56	Hypertension	41
24	Superoxide Dismutase	93	57	Plant Stem	39
25	Anti-neoplastic Activity	92	58	Ethnobotany	38
26	Anti-microbial Activity	91	59	DPPH Radical Scavenging	38
27	Bark	88	60	Enzyme Inhibition	37
28	Phenol Derivatives	86	61	Signal Transduction	34
29	Apoptosis	84	62	Immunomodulation	34
30	Diabetes Mellitus	80	63	Diarrhea	33
31	Water Purification	80	664	Free Radicals	33
32	Body Weight	74	65	Macrophage	23
33	Flower	73	66	Nanoparticles	21

China, Egypt, India, Saudi Arabia and Thailand. On further analysis, it was observed that (Table 6):

- Seven organizations registered their publication productivity above the group average (31.92) of all organizations: Universidade Estadual de Maringa, Brazil (72 papers), National Research Centre, Giza, Egypt (66 papers), University of Agriculture, Faisalabad, Pakistan (65 papers), Universiti Putra Malaysia (64 papers), Universidade Federal de Pernambuco, Brazil (39 papers), University of Ibadan, Nigeria (35 papers) and King Saud University, Saudi Arabia (34 papers);
- Eleven organizations registered their citation per paper and relative citation index above the group average (17.46 and 0.99) of all organizations: University of Agriculture, Faisalaba, Pakistan

(38.35 and 2.17), University of Karachi, Pakistan (35.23 and 1.99), Mahidol University, Thailand (27.35 and 1.55), Universidade Federal do Ceara, Brazil (26.46 and 1.50), Universiti Putra Malaysia (26.14 and 1.48), Central Food Technological Research Institute, Mysore (25.05 and 1.42), University of Fort Hare, South Africa (22.86 and 1.29), Universiti Sains Malaysia, Malaysia (22.33 and 1.26), Universidade Federal de Pernambuco, Brazil (22.15 and 1.25), Universidade Federal de Uberlandia, Brazil (18.84 and 1.07) and King Saud University, Saudi Arabia (18.24 and 1.03).

Profile of Top 25 Most Productive Authors

In all 622 authors unevenly participated in global research on *Moringa oleifera*: 486 authors published 1-5 papers each, 101 authors 6-10 paper each, 27 authors 11-20 papers each, 7 authors 21-50 papers each and

Table 6: Scientometric Profile of Top 25 Organizations in *Moringa oleifera* during 1935-2019.

S.No	Name of the Organization	TP	TC	CPP	HI	ICP	%ICP	RCI
1	Universidade Estadual de Maringa, Brazil	72	706	9.81	16	5	6.94	0.55
2	National Research Centre, Giza, Egypt	66	364	5.52	10	17	25.76	0.31
3	University of Agriculture, Faisalaba, Pakistan	65	2493	38.35	23	23	35.38	2.17
4	Universiti Putra Malaysia	64	1673	26.14	21	17	26.56	1.48
5	Universidade Federal de Pernambuco, Brazil	39	864	22.15	18	7	17.95	1.25
6	University of Ibadan, Nigeria	35	296	8.46	10	5	14.29	0.48
7	King Saud University, Saudi Arabia	34	620	18.24	15	24	70.59	1.03
8	University of Fort Hare, South Africa	28	640	22.86	11	7	25.00	1.29
9	Universidade Federal do Ceara, Brazil	28	741	26.46	13	2	7.14	1.50
10	University of Ilorin, Nigeria	27	214	7.93	7	6	22.22	0.45
11	Universidade Estadual do Oeste do Parana, Brazil	26	375	14.42	12	2	7.69	0.82
12	Universiteit van Pretoria, South Africa	26	157	6.04	9	7	26.92	0.34
13	University of KwaZulu-Natal, South Africa	25	360	14.40	10	2	8.00	0.81
14	Bahauddin Zakariya University, Pakistan	25	364	14.56	10	13	52.00	0.82
15	Universiti Sains Malaysia, Malaysia	24	536	22.33	9	8	33.33	1.26
16	University of Veterinary and Animal Sciences Lahore, Pakistan	24	130	5.42	8	1	4.17	0.31
17	University of Nigeria	23	396	17.22	7	5	21.74	0.97
18	South China Agricultural University	23	186	8.09	6	2	8.70	0.46
19	Federal University of Technology, Akure, Nigeria	22	125	5.68	6	9	40.91	0.32
20	University of Karachi, Pakistan	22	775	35.23	10	2	9.09	1.99
21	Central Food Technological Research Institute India	21	526	25.05	14	4	19.05	1.42
22	UNESP-Universidade Estadual Paulista, Brazil	20	148	7.40	5	2	10.00	0.42
23	Ahmadu Bello University, Nigeria	20	340	17.00	7	6	30.00	0.96
24	Mahidol University, Thailand	20	547	27.35	11	4	20.00	1.55
25	Universidade Federal de Uberlandia, Brazil	19	358	18.84	10	2	10.53	1.07
	Total of 25 organizations	798	13934	17.46	278	182	22.81	0.99
	Global total	3187	56391	17.69				
	Share of 25 organizations in global total	25.04	24.71					

1 author 65 papers. The top 25 authors published 12 to 65 papers and together account for 15.97% (509) global publications share and 18.77% (10586) global citations share during 1980-2019. Of the top 25 authors, 13 are from Brazil, 3 each from Italy and Pakistan, 2 each from Malaysia and Spain and 1 each from Botswana and China. On further analysis, it was observed that (Table 7):

- Eight authors registered their publications output above the group average of 20.36: Bergamasco, R. (65 papers), Paiva, P.M.G.(36 papers), Coelho, L.C.B.B (34 papers), Nishi, L. (28 papers), Napoleão, T.H. and Vieira, A.M.S. (27 papers each), Basra, S.M.A. and Vieira, M.F. (22 papers each);
- Nine authors registered their citation per paper and relative citation index above the group average (20.80 and 1.18) of all authors: Anwar, F. (124.21 and 7.02), Beltrán-Heredia, J.(36.07 and 2.04), Sánchez-Martín, J. (34.69 and 1.96), Muchenje, V. (33.06 and 1.87), Fakurazi, S.(32.12 and 1.82), Arulselvan, P. (24.19 and 1.37), Paiva, P.M.G. (23.0 and 1.30), Coelho, N.M.M. (22.83 and 1.29) and Coelho, L.C.B.B. (21.35 and 1.21).

Medium of Communication

Journals contributed the largest share (94.01%, 2997 papers) of global publications on *Moringa oleifera* followed by conference proceedings

(2.79%, 89 papers each), book series (2.29%, 73 papers), books (0.75%, 24 papers) and trade publications (0.13%, 4 publications) during 1980-19.

366 journals unevenly participated in research on *Moringa oleifera* by contributing 2998 articles in journal medium: 242 published 1-5 papers each, 71 published 6-10 papers each, 32 published 11-20 papers each, 19 published 21-50 papers each and 2 published 51-62 papers each during 1980-2019.

The top 25 most productive journals accounted for 20.45% share of total global journal output during 1980-19. However, their individual contribution varied from 14 to 62 papers per journal. The top 5 most productive journals were: South African Journal of Botany (62 papers), *Journal of Ethnopharmacology* (61 papers), *Desalination and Water Treatment* (44 papers), *Industrial Crops and Products* and *Livestock Research for Rural Development* (31 papers each). *Journal of Ethnopharmacology* ranked at the top in number of citations (2536), followed by *Water Research* (2285 citations), *Food Chemistry* (1727 citations), *Phytotherapy Research* (1443 citations) and *Industrial Crops and Products* (848 citations). *Water Research* (120.26) tops the list in citation per paper, followed by *Phytotherapy Research* (75.95), *Food Chemistry* (63.96), *Journal of Ethnopharmacology* (41.57), *Indian Journal of Experimental Biology* (33.33) and *Industrial Crops and Products* (27.35) (Table 8).

Table 7: Scientometric Profile of Top 25 Most Productive Authors in *Moringa oleifera* during 1935-2019.

S.No	Name of the Author	Affiliation of the Author	TP	TC	CPP	HI	ICP	%ICP	RCI
1	Bergamasco, R.	Universidade Estadual de Maringa, Brazil	65	688	10.58	16	4	6.15	0.60
2	Paiva, P.M.G.	Universidade Federal de Pernambuco, Brazil	36	828	23.00	17	7	19.44	1.30
3	Coelho, L.C.B.B.	Universidade Federal de Pernambuco, Brazil	34	726	21.35	17	7	20.59	1.21
4	Nishi, L.	Universidade Estadual de Maringa, Brazil	28	234	8.36	9	0	0.00	0.47
5	Napoleão, T.H.	Universidade Federal de Pernambuco, Brazil	27	553	20.48	14	1	3.70	1.16
6	Vieira, A.M.S.	Universidade Estadual de Maringa, Brazil	27	328	12.15	9	2	7.41	0.69
7	Basra, S.M.A.	University of Agriculture, Faisalabad, Pakistan	22	401	18.23	12	6	27.27	1.03
8	Vieira, M.F.	Universidade Estadual de Maringa, Brazil	22	262	11.91	7	0	0.00	0.67
9	Iori, R.	IRCCS Centro Neurolesi Bonino Pulejo, Italy	19	351	18.47	11	10	52.63	1.04
10	Fakurazi, S.	Universiti Putra Malaysia	17	546	32.12	14	2	11.76	1.82
11	Mazzon, E.	IRCCS Centro Neurolesi Bonino Pulejo, Italy	17	248	14.59	10	7	41.18	0.82
12	Muchenje, V.	University of Fort Hare, South Africa	17	562	33.06	9	2	11.76	1.87
13	Arulselvan, P.	Universiti Putra Malaysia	16	387	24.19	11	5	31.25	1.37
14	Bramanti, P.	IRCCS Centro Neurolesi Bonino Pulejo, Italy	15	244	16.27	10	6	40.00	0.92
15	Nouman, W.	Bahauddin Zakariya University, Pakistan	15	281	18.73	10	8	53.33	1.06
16	Anwar, F.	University of Agriculture, Faisalabad, Pakistan	14	1739	124.21	13	6	42.86	7.02
17	Beltrán-Heredia, J.	Universidad de Extremadura, Spain	14	505	36.07	12	2	14.29	2.04
18	Fagundes-Klen, M.R.	Universidade Estadual do Oeste do Parana, Brazil	14	202	14.43	9	0	0.00	0.82
19	Kwaambwa, H.M.	University of Botswana,	14	241	17.21	8	8	57.14	0.97
20	Gomes, R.G.	Universidade Estadual de Maringa, Brazil	13	161	12.38	7	0	0.00	0.70
21	Silva, M.F.	Universidade Estadual de Maringa, Brazil	13	90	6.92	6	0	0.00	0.39
22	Sánchez-Martín, J.	Universidad de Extremadura, Spain	13	451	34.69	11	3	23.08	1.96
23	Vasconcelos, I.M.	Universidade Federal do Ceara, Brazil	13	246	18.92	8	1	7.69	1.07
24	Chen, X.	South China Agricultural University	12	38	3.17	3	1	8.33	0.18
25	Coelho, N.M.M.	Universidade Federal de Uberlandia, Brazil	12	274	22.83	8	0	0.00	1.29
		Total of 25 authors	509	10586	20.80	10.44	88	17.29	1.18
		Global total	3187	56391	17.69				
		Share of 25 authors in global total	15.97	18.77					

Highly-cited Papers

Of the total global output on *Moringa oleifera* (3187 publications), only 97 (3.04% share) cumulated 100 to 798 citations per paper (cumulative total 17841 citations) since their publication during 1980-2019, averaging to 183.93 citations per paper.

The distribution of 97 highly cited papers is skewed. Seventy three papers were in citation range 100-194 per paper, 16 papers were in citation range 2011-285, 5 papers in citation range 315-426 and 3 papers in citation range 686-798 citations.

- Of the 97 highly cited papers, 48 resulted from contribution by single organizations per paper (non-collaborative papers) and 49 from two or more organizations per paper (33 national collaborative and 16 international collaborative papers).
- Among highly cited papers, India published 29 papers, followed by Pakistan (12 papers), Malaysia and USA (8 papers each), Germany (7 papers), Japan (5 papers), U.K. (4 papers), Australia, Brazil, Canada and Singapore (3 papers each), Bangladesh, Greece, Guatemala, Oman, South Africa and Thailand (2 papers each), Hong Kong, Iran, Israel, Kenya, Malawi, Nicaragua, Philippines, Portugal, Saudi Arabia, South Korea, Sweden and Thailand (1 papers each):
 - The 97 highly cited papers belonged to 399 authors and 260 organizations.
 - The leading organizations participating in highly cited papers were: University of Hopenheim, Institute for Animal Production in the Tropics and Subtropics, Stuttgart, Germany, University of Agriculture, Faisalaba, Pakistan, University of Sindh, Jamshoro and Universiti Putra Malaysia (5 papers each), Bhabha Atomic Research Center, Bombay, National Botanical Research Institute, Lucknow and Sri Venkateswar University, Tirupati (4 papers each), Avinashilingam University, Coimbatore, University of Karachi, Pakistan and Universidade Federal do Ceara, Brazil (3 papers each), and University of Fort Hare, South Africa, University of Mysore and Mahidol University, Thailand and Agha Khan University, Karachi (2 papers each), etc;
 - 97 highly-cited papers are published in 55 journals, of which 11 papers published in *Journal of Ethnopharmacology*, 8 papers in *Water Research*, 7 papers in Food Chemistry, 4 papers each in *Food and Chemical Toxicology* and *Journal of Agriculture and Food Chemistry*, 3 papers each in *Bioresource Technology*, *International Journal of Food Science and Nutrition*, *Phytotherapy Research* and *Planta Medica*, 2 papers each in *Asia Pacific Journal of Tropical*

Table 8: Top 25 Most Productive Journals in Research in *Moringa oleifera* during 1980-2019.

S.No	Name of the Journal	Total Papers			TC	CPP
		1980-99	2000-19	1980-2019	1980-2019	
1	South African Journal of Botany	0	62	62	122	1.97
2	Journal of Ethnopharmacology	6	55	61	2536	41.57
3	Desalination and Water Treatment	0	44	44	177	4.02
4	Industrial Crops and Products	0	31	31	848	27.35
5	Livestock Research For Rural Development	9	22	31	189	6.10
6	Food Chemistry	0	27	27	1727	63.96
7	International Journal of Pharmacy And Pharmaceutical Sciences	0	25	25	196	7.84
8	Asian Journal of Pharmaceutical and Clinical Research	0	23	23	173	7.52
9	Asian Pacific Journal of Tropical Biomedicine	0	23	23	537	23.35
10	Agroforestry Systems	0	22	22	164	7.45
11	Environmental Technology United Kingdom	0	21	21	261	12.43
12	Research Journal of Pharmaceutical Biological and Chemical Sciences	0	21	21	29	1.38
13	International Journal Of Agriculture and Biology	0	20	20	170	8.50
14	Phytotherapy Research	6	13	19	1443	75.95
15	Water Research	9	10	19	2285	120.26
16	International Journal of Pharma and Bio Sciences	0	18	18	129	7.17
17	Journal of Food Science and Technology	0	18	18	199	11.06
18	Pharmaceutical Biology	3	15	18	343	19.06
19	PLOS One	0	18	18	418	23.22
20	Pakistan Journal of Nutrition	0	17	17	231	13.59
21	Evidence Based Complementary and Alternative Medicine	0	16	16	262	16.38
22	Environmental Science and Pollution Research	0	15	15	82	5.47
23	Indian Journal of Experimental Biology	1	14	15	500	33.33
24	International Journal of Pharmtech Research	0	15	15	123	8.20
25	International Journal of Pharmaceutical Sciences Review And Research	0	14	14	88	6.29
	Total of 25 journals	34	579	613		
	Global total	93	2905	2998		
	Share of 25 journals in global total	36.56	19.93	20.45		

Medicine, Chemical Engineering Journal, Industrial Crops and Products, Journal of Food Composition and Analysis and Journal of Hazardous Materials and 1 paper each in 43 other journals.

CONCLUSION

The global publications on *Moringa oleifera* research resulted in 3187 publications during 1935-2019. The global annual average publications output on "*Moringa oleifera* research registered 16.18% growth and averaged to 17.69 citations per paper. 121 countries participated in global *Moringa oleifera* research output during 1935-2019, of which 76.72% global publication share and 68.06% global citation share came from top 10 countries, with India leading in rank (with 25.73% share), followed by Nigeria and Brazil (8.38% and 8.25%), Pakistan, Malaysia, Egypt, South Africa and USA (from 5.05% to 5.40%), China and Indonesia (4.83% and 3.51%) during 1935-2019. The four countries registering above average relative citation index (0.89) were Pakistan (1.48), USA (1.44), Malaysia (1.16) and India (1.08) during 1935-2019.

Agricultural and biological sciences is the leading subject contributing to *Moringa oleifera* research followed by pharmacology, toxicology and pharmaceuticals (22.18%), biochemistry, genetics and molecular

biology (19.96%), medicine (17.01%), environmental science (16.79%), chemistry (12.21), chemical engineering (8.32%) and immunology and microbiology (4.71%) during 1935-2019. As seen through activity index, the research activity have decreased in pharmacology, toxicology and pharmaceuticals, biochemistry, genetics and molecular biology and environment science, as against increase in agricultural and biological sciences, medicine, chemistry, immunology and microbiology and energy from 1935-1997 to 1998-19.

547 organizations and 622 authors participated in global research on *Moringa oleifera* research during 1935-2019, of which the top 25 organizations and authors contributed 25.04% and 15.97% to global publication share and 24.71% and 18.77% global citation share respectively during 1935-19. The leading organizations in terms of publication productivity were: Universidade Estadual de Maringa, Brazil (72 papers), National Research Centre, Giza, Egypt (66 papers), University of Agriculture, Faisalabad, Pakistan (65 papers), Universiti Putra Malaysia (64 papers), Universidade Federal de Pernambuco, Brazil (39 papers), University of Ibadan, Nigeria (35 papers) and King Saud University, Saudi Arabia (34 papers). The leading organizations in terms of citation impact per paper and relative citation index were: University of Agriculture, Faisalaba, Pakistan (38.35 and 2.17), University of

Karachi, Pakistan (35.23 and 1.99), Mahidol University, Thailand (27.35 and 1.55), Universidade Federal do Ceara, Brazil (26.46 and 1.50), Universiti Putra Malaysia (26.14 and 1.48), Central Food Technological Research Institute, Mysore (25.05 and 1.42), University of Fort Hare, South Africa (22.86 and 1.29), Universiti Sains Malaysia, Malaysia (22.33 and 1.26), Universidade Federal de Pernambuco, Brazil (22.15 and 1.25), Universidade Federal de Uberlandia, Brazil (18.84 and 1.07) and King Saud University, Saudi Arabia (18.24 and 1.03).

The leading authors in terms of publication productivity were: Bergamasco, R. (65 papers), Paiva, P.M.G. (36 papers), Coelho, L.C.B.B. (34 papers), Nishi, L. (28 papers), Napoleão, T.H. and Vieira, A.M.S. (27 papers each), Basra, S.M.A. and Vieira, M.F. (22 papers each). The leading authors in terms of citation impact per paper and relative citation index were: Anwar, F. (124.21 and 7.02), Beltrán-Heredia, J. (36.07 and 2.04), Sánchez-Martín, J. (34.69 and 1.96), Muchenje, V. (33.06 and 1.87), Fakurazi, S. (32.12 and 1.82), Arulselvan, P. (24.19 and 1.37), Paiva, P.M.G. (23.0 and 1.30), Coelho, N.M.M. (22.83 and 1.29) and Coelho, L.C.B.B. (21.35 and 1.21).

The journals medium accounted for 94.01% share of global publications on *Moringa oleifera* during 1935-2019 research, of which the top 25 most productive journals accounted for 20.45% share of total global output in journals during 1935-2019. The top 3 most productive journals were: South African Journal of Botany (62 papers), Journal of Ethnopharmacology (61 papers) and Desalination and Water Treatment (44 papers). The top 3 most impact journals in terms of citations per paper were: Water Research (120.26), Phytotherapy Research (75.95) and Food Chemistry (63.96) during 1935-2019.

Only 97 out of 3187 global publications on *Moringa oleifera* research during 1935-2019 received 100 to 798 citations per paper. They together received a total of 7841 citations, averaging to 183.93 citations per paper. These 97 papers involved 399 authors and 260 organizations. Among 97 papers, 48 are non-collaborative, 33 national collaborative and 16 internationally collaborative India published the largest number of papers (29 papers), followed by Pakistan (12 papers), Malaysia and USA (8 papers each), Germany (7 papers), Japan (5 papers), U.K. (4 papers), Australia, Brazil, Canada and Singapore (3 papers each), Bangladesh, Greece, Guatemala, Oman, South Africa and Thailand (2 papers each), etc. Of the 97 highly-cited papers, 7 papers are published in *Food Chemistry*, 4 papers each in *Food and Chemical Toxicology* and *Journal of Agriculture and Food Chemistry*, 3 papers each in *Bioresource Technology*, *International Journal of Food Science and Nutrition*, *Phytotherapy Research* and *Planta Medica*, 2 papers each in *Asia Pacific Journal of Tropical Medicine*, *Chemical Engineering Journal*, *Industrial Crops and Products*, *Journal of Food Composition and Analysis* and *Journal of Hazardous Materials* and 1 paper each in 43 other journals

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