Research on *Nigella sativa*: A Scientometric Assessment of Global Publications' Output during 1989–2018

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Abstract

Aim: The present study aimed to perform scientometric assessment of global publications' output of research on *Nigella sativa* during 1989–2018.

Materials and Methods: The present study examined 3718 global publications on *N. sativa*, as indexed and covered in international Scopus database during 1989–2018, with a view to understand their growth rate, global publication share, citation impact, international collaborative papers' share, distribution of publications by broad subjects, productivity and citation profile of top organizations and authors, preferred media of communication, and bibliographic characteristics of highly cited papers. The global publications on *N. sativa* registered 20.87% annual average growth rate, and its citation impact averaged to 19.08 citations per paper.

Results: The global share of top ten countries on *N. sativa* ranged from 3.15% to 23.91%, with the largest share (23.91%) from India, followed by Iran (9.58%), Egypt (9.06%), the USA (7.15%), etc., Nearly 81.31% and 75.74% of the global publication and citation share came from the top 10 countries during 1989–2018. The cumulative global share of the top 10 countries increased from 70.56% to 82.58% from 1989–2003 to 2004–2018. Five countries registered relative citation index above the world average of 0.93 as follows: Germany (1.86), the USA (1.54), Turkey (1.33), Saudi Arabia (1.16), and Egypt (0.94) during 1989–2018. Pharmacology, toxicology, and pharmaceutics contributed the largest global publication share of 33.97%, followed by agricultural and biological sciences (32.92%); medicine (30.10%); biochemistry, genetics, and molecular biology (24.74%); chemistry (12.40%); immunology and microbiology (6.97%); environmental science (5.38%); and veterinary science (3.60%) during 1989–2018. A total of 432 organizations and 642 authors participated in the global research on *N. sativa* during 1989–2018, of which the top 15 most productive research organizations and the authors collectively contributed 23.45% and 6.64% of the global publication share and 21.82% and 8.04% of the global citation share, respectively, during 1989–2018. Among 3655 journal papers (in 364 journals) in global *N. sativa* research, the top 15 most productive journals together contributed 13.54% of global share of the total journal publication output during 1989–2018.

Conclusion: One hundred and twenty-six publications were found to be highly cited, as they registered citations from 100 to 2971 during 1989–2018 and they together received 23,426 citations, averaging to 185.92 citations per paper.

Keywords: Bibliometrics, global research output, medicinal plant, *Nigella sativa*, scientometrics

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INTRODUCTION

Medicinal plants have been a major source of nutrition, health-care, and therapeutic agents since ancient times to cure human diseases. However, scientific research interest in medicinal plants received a thrust during the mid-1970s when the World Health Organization (WHO) proposed the incorporation of traditional medicine into the health-care system. In 1978, the World Health Assembly called for a comprehensive approach to the medicinal plants that included the designation of research and training centers for the study and use of medicinal plants. According to WHO, about 80% of the population in the world relies on traditional medicine for the treatment of various diseases. Nowadays, there is a manifold increase in the medicinal plant-based industries due to interest in the use of medicinal plants throughout the world, which is growing at the rate of 7%–15% annually. *Nigella sativa* (also known as black pepper and black cuminis) is a widely used medicinal plant throughout the world. It is very popular in various traditional systems of medicine such as Unani and Tibb, Ayurveda, and Siddha. Its seeds and oil have a long history of folklore usage in various systems of medicines and food. The seeds of *N. sativa* have been widely used in the treatment of different diseases and ailments. In Islamic literature, it is considered one of the greatest forms of healing medicine available. The Islamic prophet Muhammad once stated that the black seed can heal every disease except death. Avicenna, most famous for his volumes called "The Canon of Medicine," refers to *Nigella* as the seed that stimulates the body's energy and helps recovery from fatigue and dispiritedness. It is also included in the list of natural drugs of "Tibb-e-Nabawi" or "Medicine of Prophet (Mummad)."[1]

N. sativa has been widely used as antihypertensive, liver tonics, diuretics, digestive, antidiarrheal, appetite stimulant, analgesics, antibacterial, and in skin disorders. Extensive studies on *N. sativa* have been carried out by various researchers, and a wide spectrum of its pharmacological actions have been explored which may include antidiabetic, anticancer, immunomodulator, analgesic, antimicrobial, anti-inflammatory, spasmolytic, bronchodilator, hepatoprotective, renal protective, gastroprotective, and antioxidant properties. Black cumin (*N. sativa* L.) seeds contain both fixed and essential oils, proteins, alkaloids, and saponin. Much of the biological activity of the seeds has been shown to be due to thymoquinone (TQ), the major component of the essential oil, but which is also present in the fixed oil. The pharmacological actions of the crude extracts of the seeds (and some of its active constituents, for example, volatile oil and TQ, that have

been reported include protection against nephrotoxicity and hepatotoxicity induced by either disease or chemicals.[2,3]

The published findings provide clear evidence that both the oil and its active ingredients, in particular TQ, possess reproducible antioxidant effects through enhancing the oxidant scavenger system, which as a consequence lead to antitoxic effects induced by several insults. The oil and TQ have also shown potent anti-inflammatory effects on several inflammation-based models including experimental encephalomyelitis, colitis, peritonitis, edema, and arthritis through suppression of the inflammatory mediators' prostaglandins and leukotriens. The oil and certain active ingredients have shown beneficial immunomodulatory properties, augmenting the T-cell and natural killer cell-mediated immune responses. Most importantly, both the oil and its active ingredients have proven to express antimicrobial and antitumor properties toward different microbes and cancers. Coupling these beneficial effects with its use in folk medicine, *N. sativa* seed is a promising source for active ingredients that would be with potential therapeutic modalities in different clinical settings.[4]

Literature review

Only one bibliometric study made a bibliometric assessment of *N. sativa* research in the past. Anwar[5] carried out a bibliometric analysis of the literature on *N. sativa* (Habbat al-barakah or black seed). The purpose was to study the periodic growth of literature, author patterns, topical focus, and geographic origin of literature on the subject. Twenty related databases and several online catalogues of libraries were searched to identify a final list of 530 citations. This data set was analyzed using various bibliographic characteristics. However, similar bibliometric studies have been published on other individual medicinal plants such as *Aloe vera*,[6] *Azadirachta indica*,[7] *Curcuma longa*,[8] *Glycyrrhiza glabre*,[9] *Ocimum santum*,[10] *Pheonix dactylifera*,[11] *Tinospora cordifolia*,[12] and *Phyllanthis emblica*.[13]

MATERIALS AND METHODS

Objectives

The literature on *N. sativa* is widely scattered and difficult to identify due to the the interdisciplinary nature of research on this plant. There is a need to identify and analyze this literature in order to study its various aspects. This can be done through bibliometric analysis of the literature. The present study examined the quantitative and qualitative aspects of global *N. sativa* research output, in terms of select bibliometric indicators during 30 years (1989–2018), based on publications indexed in Scopus database. Its objectives are (i) to study the growth and distribution

of global literature on *N. sativa;* (ii) to examine the scientometric profile and characteristics of the ten most productive countries, 25 most productive organizations, and 25 most productive authors; (iii) to study the distribution of publication output by broad subject areas and identification of significant keywords; and (iv) to identify the medium of communication and the bibliographic characteristics of highly cited publications on *N. sativa.*

Methodology

The world's top ten most productive countries' global publications on *N. sativa* were sourced from Scopus international database (http://www.scopus.com), using two keywords "*Nigella sativa*" or "Black Pepper" for the years 1989–2018. The Key world tag and Title of papers (as shown in search string below) tags was searched for the two keywords restricting the hit to the period 1989–2018 in "date range" tag. The statement becomes the main search string. The main search string was further restricted to individual ten countries in "country" tag one by one for obtaining publication data of these countries. On further restricting global search string by "subject area tag," "country tag," "source title tag," "journal title name," and "affiliation tag," statistics on the distribution of publications by subject, collaborating countries, author wise, organization wise, and journal wise, etc., were obtained. Citation data were obtained from the date of publication till December 30, 2018. Select bibliometric indicators have been used to study the performance of global *N. sativa* research.

(KEY ["*Nigella sativa*" or "Black Pepper"] OR TITLE ["*Nigella sativa*" or "Black Pepper"]) AND PUBYEAR > 1988 AND PUBYEAR < 2019.

Analysis

The global research output in the field of *N. sativa* consisted of 3718 cumulated publications in 30 years during 1989–2018. The *N. sativa* annual research output increased from 6 in the year 1989 to 286 publications in the year 2018, registering 20.87% growth per annum. The global cumulative output in *N. sativa* research in 15 years (1989–2003) increased from 394 to 3324 publications during the succeeding 15-year period (2004–2018), registering 743.65% growth. The citation impact of global publications on *N. sativa* in 30 years averaged to 19.08 citations per publication (CPPs) during 1989–2018; 15-yearly impact averaged to 47.19 CPP for the period 1989–2003, which sharply declined to 15.75 CPP in the succeeding 15 years (2004–2018) [Table 1]. Of the total global publications, 87.41% (3250) appeared as articles, 7.88% (293) as reviews, 1.53% (57) as conference papers, and the rest have below 1% share: articles in

Table 1: Annual and cumulative publication world output in *Nigella sativa* research, 1989-2018

Publication period	World		
	TP	TC	CPP
1989	6	83	13.83
1990	13	297	22.85
1991	7	686	98.00
1992	15	488	32.53
1993	20	1008	50.40
1994	9	123	13.67
1995	17	1504	88.47
1996	18	312	17.33
1997	26	603	23.19
1998	22	897	40.77
1999	28	1309	46.75
2000	30	2674	89.13
2001	33	1535	46.52
2002	55	2812	51.13
2003	95	4262	44.86
2004	83	3092	37.25
2005	114	4879	42.80
2006	113	3965	35.09
2007	144	4321	30.01
2008	166	7935	47.80
2009	161	3355	20.84
2010	216	5330	24.68
2011	270	4501	16.67
2012	249	3720	14.94
2013	276	3524	12.77
2014	325	3110	9.57
2015	273	2119	7.76
2016	317	1598	5.04
2017	331	734	2.22
2018	286	167	0.58
1989-2003	394	18,593	47.19
2004-2018	3324	52,350	15.75
1989-2018	3718	70,943	19.08

TP: Total paper, TC: Total citation, CPP: Citations per paper

press (0.70%), book chapters (0.62%), notes (0.56%), letters (0.51%), erratum (0.35%), editorials (0.22%), short surveys (0.19%), and book (0.03%).

Top ten most productive countries in *Nigella sativa* research

102 countries participated in global research in *N. sativa* research during 1989–2018, of which, 47 published 1–10 papers each, 37 countries 11–50 papers each, 6 countries 51–100 papers each, 11 countries 101–400 papers each, and 1 country 889 papers. The top ten most productive countries in *N. sativa* research contributed 117–889 publications each during 1989–2018. The top ten most productive countries in *N. sativa* research accounted for 81.31% global publication share and 75.64% citation share during 1989–2018. Their 15-yearly output accounted for 70.56% global publication share during 1989–2003 which increased to 82.58% during the succeeding 15-year period (2004–2018). Country wise, the global publication share of the top ten countries varied widely from 3.15% to 23.91% during 1989–2018, with India accounting for the highest publication share (23.91%),

followed by Iran (9.58%), Egypt (9.06%), the USA and Saudi Arabia (7.15% and 7.07%), Turkey (6.62%), Pakistan (5.7%), Malaysia, China, and Germany (from 3.15% to 4.92%) during 1989–2018 [Table 2].

The global publication share registered an increasing publication share varying from 0.35% to 8.16% in seven countries namely Iran, Malaysia, China, Pakistan, India, Turkey, and Egypt, as against decrease from 1.17% to 5.28% in three countries, namely Saudi Arabia, the USA, and Germany in 15-year period (1989–2003 and 2004–2018). Five of the top ten countries scored relative citation index above the world average of 0.93: Germany (1.86), the USA (1.54), Turkey (1.33), Saudi Arabia (1.16), and Egypt (0.94) during 1989–2018. India has though emerged as one of the world leaders in research productivity of *N. sativa* research, its performance in terms of relative citation index (0.68) has been below the world average.

International collaboration

The international collaborative output of the top ten most productive countries in *N. sativa* research as a national share in the country-wise output varied widely from 11.24% to 53.61%, with average share of 28.02% during 1989–2018. The highest international collaborative publication share comes from Saudi Arabia (53.61%), followed by Germany (50.43%), Malaysia (48.63%), the USA (48.50%), Egypt (42.14%), China (33.77%), Pakistan (28.77%), Turkey (13.41%), India (11.36%), and Iran (11.24%) during 1989–2018. Most surprisingly, India's international collaborative share in its national output in *N. sativa* research has been comparatively small and one of the lowest, 11.36%.

Subject-wise distribution of research output

N. sativa, as a medicinal and nutritional plant, became the focus of interest among researchers from biological sciences, medical sciences, chemistry, agriculture, and veterinary sciences during the early 1970s. Here, the global *N. sativa* research output published during 1989–2018 is distributed across eight subfields (as identified in Scopus database classification), with pharmacology, toxicology, and pharmaceutics accounting for the highest publications share (33.97%), followed by agricultural and biological sciences (32.92%), medicine (30.10%), biochemistry, genetics, and molecular biology (24.74%), chemistry (12.40%), immunology and microbiology (6.97%), environmental science (5.38%), and veterinary science (3.60%) during 1989–2018. Its activity index, which computes change in research activity in the discipline over time 1989–2003 to 2004–2018 (World Average Activity index of a given subject is taken as 100), witnessed increase in immunology and microbiology (from 61.94 to 104.51), veterinary science (from 63.48 to 104.34), medicine (from 76.74 to 102.76), and environmental science (from 94.37 to 100.67), as against decrease in chemistry (from 145.34 to 94.63), pharmacology, toxicology, and pharmaceutics (from 112.82 to 98.48), biochemistry, genetics, and molecular biology (from 106.67 to 99.21), and agricultural and biological sciences (from 103.31 to 99.61).

Chemistry, among various subjects, registered the highest citation impact per paper of 25.08 CPP, followed by pharmacology, toxicology, and pharmaceutics (24.85), biochemistry, genetics, and molecular biology (21.23), immunology and microbiology (21.06), medicine (19.65), agricultural and biological sciences (18.44), veterinary science (17.78), and environmental science (13.60) during 1989–2018 [Table 3].

Profile of the top 15 most productive global organizations

Four hundred and thirty-two organizations participated in the global research on *N. sativa* during 1989–2018, of

Table 2: Global publication output and share of top 10 most productive countries in *Nigella sativa* during 1989-2018

Serial number	Name of the country	Number of papers			Share of papers			TC	CPP	ICP	Percentage ICP	RCI
		1989-2003	2004-2018	1989-2018	1989-2003	2004-2018	1989-2018			1989-2018		
1	India	84	805	889	21.32	24.22	23.91	11,538	12.98	101	11.36	0.68
2	Iran	9	347	356	2.28	10.44	9.58	5102	14.33	40	11.24	0.75
3	Egypt	35	302	337	8.88	9.09	9.06	6050	17.95	142	42.14	0.94
4	USA	44	222	266	11.17	6.68	7.15	7834	29.45	129	48.50	1.54
5	Saudi Arabia	32	231	263	8.12	6.95	7.07	5818	22.12	141	53.61	1.16
6	Turkey	25	221	246	6.35	6.65	6.62	5707	23.20	33	13.41	1.22
7	Pakistan	12	200	212	3.05	6.02	5.70	3125	14.74	61	28.77	0.77
8	Malaysia	4	179	183	1.02	5.39	4.92	1841	10.06	89	48.63	0.53
9	China	2	152	154	0.51	4.57	4.14	2492	16.18	52	33.77	0.85
10	Germany	31	86	117	7.87	2.59	3.15	4157	35.53	59	50.43	1.86
Total		278	2745	3023	70.56	82.58	81.31	53,664	17.75	847	28.02	0.93
World output		394	3324	3718				70,943	19.08			
Share of top 10 countries in world total		70.56	82.58	81.31				75.64				

TC: Total citation, CPP: Citations per paper, ICP: International collaborative paper, RCI: Relative citation index

which 344 organizations contributed 1–10 papers each, 64 organizations 11–20 papers each, 18 organizations 21–50 papers each, 5 organizations 51–100 papers each, and 1 organization 116 papers.

The productivity of the top 15 most productive global organizations in *N. sativa* research varied from 33 to 116 publications and together they contributed 23.45% (872) publication share and 21.82% (15477) citation share during 1989–2018. The scientometric profile of these top 15 organizations is presented in Table 4.

- Five organizations registered publication output greater than the group average of 58.13: Marshad University of Medical Sciences, Iran (116 papers), Indian Institute of Spice Research, India (93 papers), King Saud University, Saudi Arabia (93 papers), National Research Centre, Egypt (82 papers), and Universiti Putra, Malaysia (81 papers)
- Five organizations registered impact and relative citation index above the group average of 17.75 citations per publication and 0.93 during 1989–2018: King Saud University, Saudi Arabia (37.54 and 1.97), Imam Abdulrahman Bin Faisal University, Saudi Arabia (28.24 and 1.48), University of Karachi, Pakistan (25.40 and 1.30), Cairo University, Egypt (24.85 and 1.30), and Marshad University of Medical Sciences, Iran (18.73 and 0.98)
- Nine organizations contributed international collaborative publications share above the group average of 30.62%: King Abdulaziz University, Saudi Arabia (68.52%), Zagazig University, Egypt (64.10%), Universiti Putra, Malaysia (58.02%), Alexandria University, Egypt (55.56%), King Saud University, Saudi Arabia (44.09%), Cairo University, Egypt (41.46%), University of Karachi, Pakistan (35.71%), Ain Shams University, Egypt (33.33%), and University of Agriculture, Faisalabad, Pakistan (31.11%).

Profile of the top 25 most productive authors

Six hundred and forty-two authors participated in the global research on *N. sativa* during 1989–2018, of which

Table 3: Subject-wise breakup of global publications in *Nigella sativa* research during 1989-2018

Serial number	Subject*	Number of papers (TP)			Activity index		TC	CPP	Percentage TP
		1989-2003	2004-2018	1989-2018	1989-2003	2004-2018			1989-2018
1	Pharmacology, toxicology and pharmaceutics	151	1112	1263	112.82	98.48	31387	24.85	33.97
2	Agricultural and biological sciences	134	1090	1224	103.31	99.61	22570	18.44	32.92
3	Medicine	91	1028	1119	76.74	102.76	21987	19.65	30.10
4	Biochemistry, genetics and molecular biology	104	816	920	106.67	99.21	19536	21.23	24.74
5	Chemistry	71	390	461	145.34	94.63	11561	25.08	12.40
6	Immunology and microbiology	17	242	259	61.94	104.51	5454	21.06	6.97
7	Environmental science	20	180	200	94.37	100.67	2719	13.60	5.38
8	Veterinary science	9	125	134	63.38	104.34	2382	17.78	3.60
World output		394	3324	3718					

There is overlapping of literature covered under various subjects. TP: Total paper, TC: Total citation, CPP: Citations per paper

Table 4: Scientometric profile of top 15 most productive global organizations in *Nigella sativa* research during 1989-2018

Serial number	Name of the organization	TP	TC	CPP	HI	ICP	Percentage ICP	RCI
1	Marshad University of Medical Sciences, Iran	116	2173	18.73	27	5	4.31	0.98
2	Indian Institute of Spice Research, India	93	713	7.67	16	4	4.30	0.40
3	King Saud University, Saudi Arabia	93	3491	37.54	29	41	44.09	1.97
4	National Research Centre, Egypt	82	1036	12.63	18	18	21.95	0.66
5	Universiti Putra, Malaysia	81	1112	13.73	20	47	58.02	0.72
6	King Abdulaziz University, Saudi Arabia	54	648	12.00	12	37	68.52	0.63
7	Aligarh Muslim University, India	46	673	14.63	14	7	15.22	0.77
8	University of Agriculture, Faisalabad, Pakistan	45	761	16.91	15	14	31.11	0.89
9	University of Karachi, Pakistan	42	1067	25.40	18	15	35.71	1.33
10	Cairo University, Egypt	41	1019	24.85	11	17	41.46	1.30
11	Zagazig University, Egypt	39	540	13.85	11	25	64.10	0.73
12	Ain Shams University, Egypt	36	350	9.72	10	12	33.33	0.51
13	Alexandria University, Egypt	36	489	13.58	11	20	55.56	0.71
14	Tehran University of Medical Sciences, Iran	35	473	13.51	9	3	8.57	0.71
15	Imam Abdulrahman Bin Faisal University, Saudi Arabia	33	932	28.24	13	2	6.06	1.48
Total of 15 organizations		872	15,477	17.75	15.6	267	30.62	0.93
Total of world		3718	70,943	19.08				
Share of top 15 organizations in world output		23.45	21.82					

TP: Total paper, TC: Total citation, CPP: Citations per paper, HI: h-index, ICP: International collaborative paper, RCI: Relative citation index

499 authors contributed 1–5 papers each, 100 authors 6–10 papers each, 40 authors 11–20 papers each, and 3 authors 21–29 papers each.

The research productivity in the field of *N. sativa* research of the top 15 most productive authors varied from 12 to 29 publications. Together, they contributed 6.64% (247) global publication share and 8.04% (5707) citation share during 1989–2018. The scientometric profile of these 15 authors is presented in Table 5.

- Five authors registered publications output above the group average of 16.47: H. Hosseinzadeh (29 papers), M. H. Boskabady (24 papers), M. Kanter (21 papers), M. F. Ramadan (20 papers), and A. I. Bhat (18 papers)
- Six authors registered impact and relative citation index above the group average of 19.08 citations per publication and 1.31: K. G. M. Kanter (56.29 and 2.95), A. H. Gilani (31.46 and 1.65), M. H. Boskabady (27.63 and 1.45), H. Hosseinzadeh (27.03 and 1.42), M. T. Sultan (24.92 and 1.31), and A. O. Bamosa (21.14 and 1.11)
- Five authors contributed international collaborative publications share above the group average of 14.57% of all authors: M. F. Ramadan (60.0%), A. H. Gilani (46.15%), M. S. Butt (43.75%), M. T. Sultan (41.67%), and A. E. Edris (6.67%).

Medium of research communication

Of the total world output on *N. sativa* research, 98.31% (3655) appeared in journals during 1989–2018. A total of 3655 journal papers appeared in 364 journals, of which 230 journals published 1–5 papers each, 81 journals 6–10 papers each, 38 journals 11–20 papers each, 13 journals 21–50 papers each, and 2 journals 51–89 papers each during 1989–2018.

The top 15 most productive journals reported 21–89 papers each on *N. sativa* research; together, they accounted for 13.54% (495 papers) share of total *N. sativa* output published in journals during 1989–2018. The top-ranking journal is *Journal of Ethnopharmacology* (with 89 papers), followed by *Phytotherapy Research* (54 papers), *Food Chemistry* and *International Journal of Pharmacy and Pharmaceutical Sciences* (41 papers each), *Journal of Agricultural and Food Chemistry* (36 papers), *Pharmaceutical Biology* (30 papers), etc., during 1989–2018 [Table 6].

Significant keywords

Around 88 significant keywords having potential to identify comparative research trends in *N. sativa* literature research studies including pharmacological properties and medicinal uses were discovered globally on *N. sativa*. These keywords are listed in Table 7 in the decreasing order of the frequency of their occurrence in the literature during 1989–2018.

Highly cited papers

A total of 126 highly cited papers in *N. sativa* research were identified each having 100–2971 citations (102 papers each in citation range 100–199, 13 papers each in 200–299 citation range, 4 papers each in 300–399 citation range, and 4 papers 407–2971 citation range each) in 30 years during 1989–2018. A total of 126 papers together cumulated a total of 23,426 citations, averaging 185.92 citations per paper. Of the 126 highly cited papers, 67 resulted from the participation of research organizations in their role as stand-alone (noncollaborating) institutional authors and the remaining 28 from two or more research organizations working in their role as collaborating partners per paper (20 national collaborative and 31 international collaborative). Among 126 highly cited papers, the largest participation was seen from India (19 papers), followed by the USA (18

Table 5: Scientometric profile of top 15 most productive authors in *Nigella sativa* research during 1989-2018

Serial number	Name of the author	Affiliation of the author	TP	TC	CPP	HI	ICP	Percentage ICP	RCI
1	H. Hosseinzadeh	Marshad University of Medical Sciences, Iran	29	784	27.03	15	0	0.00	1.42
2	M. H. Boskabady	Marshad University of Medical Sciences, Iran	24	663	27.63	16	0	0.00	1.45
3	M. Kanter	Trakya University, Turkey	21	1182	56.29	16	0	0.00	2.95
4	M. F. Ramadan	Technical University of Berlin, Germany	20	862		11	12	60.00	0.00
5	A. I. Bhat	Indian Institute of Spice Research, India	18	161	8.94	8	2	11.11	0.47
6	M. S. Butt	University of Agriculture, Faisalabad, Pakistan	16	294	18.38	9	7	43.75	0.96
7	M. Anandaraj	Indian Institute of Spice Research, India	15	75	5.00	4	0	0.00	0.26
8	A.O. Bamosa	King Faisal University, Saudi Arabia	14	296	21.14	8	0	0.00	1.11
9	M. Hosseini	Marshad University of Medical Sciences, Iran	14	130	9.29	7	1	7.14	0.49
10	A.H. Gilani	Aga Khan University Medical College, Karachi	13	409	31.46	7	6	46.15	1.65
11	R. Keyhanmanesh	Tabriz University of Medical Sciences, Iran	13	2381	18.31	8	0	0.00	0.96
12	B. Sasikumar	Indian Institute of Spice Research, India	13	132	10.15	7	1	7.69	0.53
13	S. H. Shah	Aligarh Muslim University, India	13	88	6.77	6	0	0.00	0.35
14	A. E. Edris	National Research Centre, Cairo, Egypt	12	94	7.83	6	2	16.67	0.41
15	M. T. Sultan	University of Agriculture, Faisalabad, Pakistan	12	299	24.92	9	5	41.67	1.31
Total of 15 authors			247	5707	273.14	9.13	36	14.57	
Total of world			3718	70,943	19.08				
Share of top 15 authors in world total output			6.64	8.04					

TP: Total paper, TC: Total citation, CPP: Citations per paper, HI: h-index, ICP: International collaborative paper, RCI: Relative citation index

Table 6: Top 15 most productive journals in *Nigella sativa* research during 1989-2018

Serial number	Name of the journal	Number of papers
1	Journal of Ethnopharmacology	89
2	Phytotherapy Research	54
3	Food Chemistry	41
4	International Journal of Pharmacy and Pharmaceutical Sciences	41
5	Journal of Agricultural and Food Chemistry	36
6	Pharmaceutical Biology	30
7	Pakistan Journal of Pharmaceutical Sciences	26
8	Nature Product Research	24
9	PLOS One	24
10	Evidence-based Complementary and Alternate Medicine	23
11	Asian Journal of Pharmaceutical and Clinical Research	22
12	BMC Complementary and Alternate Medicine	22
13	Industrial Crops and Products	21
14	Phytomedicine	21
15	Planta Medica	21
Total of 15 journals		495
Total global journal output		3655
Share of top 15 journals in global journal output		13.54

papers), Egypt (17 papers), Saudi Arabia (13 papers), Turkey (12 papers), Germany (11 papers), Morocco (7 papers), Iran (6 papers), Japan, Singapore, and the UK (5 papers each), China and Thailand (4 papers each), Austria, Australia, Brazil, Libya, Pakistan, and Tunisia (3 papers each), Canada, France, Italy, and South Korea (2 papers each), Cameroon, Bangladesh, Belgium, Hungry, Israel, Jordan, Malaysia, the Netherlands, South Korea, Spain, and Switzerland (1 paper each).

These 126 highly cited papers involved the participation of 492 personal authors and 362 research organizations in total across the globe. Of the 126 highly cited papers, 107 were published as articles, 19 as review papers, and 1 as letter. These 126 highly cited papers were published in 77 journals, with 18 papers in the *Journal of Ethnopharmacology,* 8 papers in *Food Chemistry*, 6 papers in *Phytotherapy Research*, 5 papers in *Planta Medica*, 4 papers each in the *Journal of Agricultural and Food Chemistry and Phytomedicine*, 3 papers each in *Cancer Letters* and *International Immunopharmacology*, 2 papers each in *Food and Chemical Toxicology*, *BMC Complementary and Alternate Medicine*, *Parasitology,* and *World Journal of Gastroenterology,* and 1 paper each in other journals.

RESULTS AND CONCLUSION

Research publications' output on *N. sativa*, sourced from the Scopus database, were analyzed in this study to provide a quantitative and qualitative description of its global

Table 7: List of significant keywords in literature on *Nigella sativa* research during 1989-2018

Serial number	Keyword	Frequency
1	*Nigella sativa*	1931
2	Black pepper	1149
3	Black cumin	1014
4	Plant extract	873
5	*Piper nigrum*	694
6	Plant seed	616
7	Medicinal plant	469
8	Chemistry	468
9	Thymoquinone	437
10	Drug effect	427
11	Antioxidant activity	385
12	Essential oils	327
13	Piperine	293
14	Metabolism	291
15	Phytotherapy	283
16	Oxidation stress	270
17	Herbaceous agent	263
18	Drug efficacy	251
19	Antioxidantsz	244
20	Enzyme activity	234
21	Vegetable oils	229
22	Drug mechanism	226
23	Drug effects	219
24	Spice	213
25	Benzoquinones	210
26	Plant oils	201
27	Traditional medicine	186
28	Anti-inflammatory activity	177
29	Pepper	166
30	Anti-bacterial activity	157
31	Drug screening	157
32	Anti-neoplastic activity	153
33	Apoptosis	153
34	Fruit	152
35	*Nigella sativa* oil	148
36	Phytochemistry	169
37	Lipid peroxidation	168
38	Drug isolation	145
39	Plant leaf	141
40	Herbal medicine	135
41	Superoxide dismutare	147
42	Glucose	138
43	*Staphylococcus aureus*	135
44	Malonaldehyde	134
45	*Escherichia coli*	131
46	*Piper longum*	131
47	Glutathione	129
48	Alkaloids	128
49	Anti-microbial activity	128
50	Alanine aminotransferase	125
51	Diabetes mellitus	124
52	Clove	121
53	Protein expression	119
54	Body weight	115
55	Piperidines	114
56	Glucose blood level	113
57	Catalase	112
58	Drug activity	111
59	Aspartale aminotransferase	109
60	Cholesterol	109
61	Cytoxity	106
62	Benzoquinone derivatives	105
63	*Piperaceae*	104
64	Polyunsaturated alkamides	103

Table 7: Contd...

Serial number	Keyword	Frequency
65	Benzodioxoles	102
66	Drug structure	99
67	Genetics	98
68	Inflammation	96
69	Pathology	95
70	*Ranunculaceae*	95
71	Liver	94
72	Anti-infective agents	93
73	Physiology	91
74	Placebo	90
75	Diet supplement	89
76	Amide	88
77	*Bacteria*	88
78	Liver protection	87
79	Drug safety	86
80	Drug formulation	82
81	Volatile oils	82
82	DPPH radical scavenging assay	38
83	Bacterium	37
84	*Bacillus cereus*	32
85	Gamma interferon	28
86	Glutamyltranserase	22
87	DNA	20
88	Sclipta prostate	20
89	Fatty lever	19

research output covering 30-year period (1989–2018). The study showed that annual and 15-year cumulative global output of *N. sativa* registered 20.87% and 743.65% growth. Its global citation impact averaged to 19.08 citations per paper during 1989–2018, which declined from 47.19 during 1989–2003 to 15.75 during 2004–2018.

One hundred and two countries participated in global research in *N. sativa* research during 1989–2018, of which the top ten most productive countries together accounted for 81.31% global publication share and 75.64% citation share. Their 15-yearly output accounted for 70.56% global publication share during 1989–2003 which increased to 82.58% during the succeeding 15-year period (2004–2018).

India took the lead and accounted for the highest publication share (23.91%), followed by Iran (9.58%), Egypt (9.06%), the USA and Saudi Arabia (7.15% and 7.07%), Turkey (6.62%), Pakistan (5.7%), and Malaysia, China, and Germany (from 3.15% to 4.92%) during 1989–2018. Iran, Malaysia, China, Pakistan, India, Turkey, and Egypt registered increasing global publication share varying from 0.35% to 8.16%, as against decrease from 1.17% to 5.28% in three countries, namely Saudi Arabia, the USA, and Germany from 1989–2003 to 2004–2018. Five countries scored relative citation index above the world average of 0.93: Germany (1.86), the USA (1.54), Turkey (1.33), Saudi Arabia (1.16), and Egypt (0.94) during 1989–2018.

Pharmacology, toxicology, and pharmaceutics were the most sought-after subject areas of *N. sativa* research accounting for the highest publications share (33.97%), followed by agricultural and biological sciences (32.92%), medicine (30.10%), biochemistry, genetics, and molecular biology (24.74%), chemistry (12.40%), immunology and microbiology (6.97%), environmental science (5.38%), and veterinary science (3.60%) during 1989–2018. The research activities showed increase in immunology and microbiology, veterinary science, medicine, and environmental science, as against decrease in chemistry, pharmacology, toxicology and pharmaceutics, biochemistry, genetics and molecular biology, and agricultural and biological sciences from 1989–2003 to 2004–2018.

A total of 432 organizations and 642 authors participated in global research on *N. sativa* during 1989–2018, of which the top 15 most productive research organizations and the authors collectively contributed 23.45% and 6.64% global publication share and 21.82% and 8.04% global citation share, respectively, during 1989–2018.

The leading organizations in terms of publication productivity were: Marshad University of Medical Sciences, Iran (116 papers), Indian Institute of Spice Research, India (93 papers), King Saud University, Saudi Arabia (93 papers), National Research Centre, Egypt (82 papers), and Universiti Putra, Malaysia (81 papers). The leading organizations in terms of citation impact per paper and relative citation index were: King Saud University, Saudi Arabia (37.54 and 1.97), Imam Abdulrahman Bin Faisal University, Saudi Arabia (28.24 and 1.48), University of Karachi, Pakistan (25.40 and 1.30), Cairo University, Egypt (24.85 and 1.30), and Marshad University of Medical Sciences, Iran (18.73 and 0.98).

The leading authors in terms of publication productivity were: H. Hosseinzadeh (29 papers), M. H. Boskabady (24 papers), M. Kanter (21 papers), M. F. Ramadan (20 papers), and A. I. Bhat (18 papers). The leading authors in terms of citation impact per paper and relative citation index were: K. G. M. Kanter (56.29 and 2.95), A. H. Gilani (31.46 and 1.65), M. H. Boskabady (27.63 and 1.45), H. Hosseinzadeh (27.03 and 1.42), M. T. Sultan (24.92 and 1.31), and A. O. Bamosa (21.14 and 1.11).

The journals' medium accounted for 98.13% global share in *N. sativa* research, with the top 15 most productive journals accounting for 13.54% of the total publications output in journals during 1989–2018. The *Journal of Ethnopharmacology* contributed the largest number of papers (89), followed by *Phytotherapy Research* (54 papers), *Food Chemistry* and

International Journal of Pharmacy and Pharmaceutical Sciences (41 papers each), *Journal of Agricultural and Food Chemistry* (36 papers), *Pharmaceutical Biology* (30 papers), etc., during 1989–2018.

Of the total *N. sativa* global research output, 126 publications registered high citations, in the range of 100–2971 citations per paper, and collectively these highly cited papers received a total of 23,426 citations, averaging to 185.92 citations per paper. India's participation was the highest (19 papers) in highly cited papers, followed by the USA (18 papers), Egypt (17 papers), Saudi Arabia (13 papers), Turkey (12 papers), Germany (11 papers), Morocco (7 papers), Iran (6 papers), etc.

These 126 highly cited papers involved the participation of 492 personal authors and 362 research organizations in total across the globe and were published in 77 journals. The leading journals were *Journal of Ethnopharmacology* (18 papers), followed by *Food Chemistry* (8 papers), *Phytotherapy Research* (6 papers), *Planta Medica* (5 papers), *Journal of Agricultural* and *Food Chemistry* and *Phytomedicine* (4 papers each), etc.

It was noticed that, although India leads in research output among the top ten countries, it had registered low citation impact per paper (12.68) and low relative citation index (0.68) compared to other leading countries. It is, therefore, suggested that India in particular needs to give higher priority to plant-based research and needs to coordinate, monitor, and prioritize their R and D efforts, with higher financial and workforce investment in R and D and increase their international collaboration, with a view to increase their research output and improved research impact.

In the last few years, ethno-botanical and traditional uses of natural compounds, especially of plant origin, received serious attention as they are well tested for their efficacy and generally believed to be safe for humanities. They obviously deserve scrutiny on modern scientific lines such as phytochemical investigation, biological evaluation on experimental animal models, toxicity studies, and investigation of molecular mechanism of actions of isolated phytoconstituents. *N. sativa* is reported to possess antitumor, antidiabetic, cardiovascular, pulmonary, gastroprotective, antifertility, diuretic, central nervous system depressant, antispasmolytic, anti-inflammatory, antimicrobial, antioxidant, anticonvulsants, antinociceptive, anti-urolithatic, anxiolytic, neophroprotective, heptoprotective, immunomodulatory, and anthelmintic activities, but a number of other pharmacological activities are yet to be explored. In future studies, it is suggested that isolated principles from seeds need to be evaluated in a scientific manner using specific experimental animal models, and clinical trials need to be undertaken to understand the molecular mechanism of action in search of lead molecules from natural resources.

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Conflicts of interest
There are no conflicts of interest.

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