

# A Quantitative Literature Analysis of the Research on Holy Basil (Tulsi)

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## ABSTRACT

Holy Basil (Tulsi) has been well recognized for traditional medicine purposes, and its essential oil is commonly used in Ayurveda. However, to date, there has been no bibliometric analysis published specifically for this aromatic perennial plant. Thus, the current analysis aimed to present a comprehensive bibliometric epitome of the literature available on Tulsi. Data for the present analysis were extracted from the Web of Science Core Collection database, employing the search terms related to “Tulsi”, and analyzed by the VOSviewer software. The search yielded 1,465 manuscripts. The ratio of original articles to reviews was 14.3:1. A peak in the number of publications was seen since 2007. Most substantial contributing countries were India, United States, Thailand, Pakistan, and South Korea. These articles were published under scientific disciplines: Pharmacology Pharmacy, Plant Sciences, Chemistry, Agriculture and Food Science Technology. Tulsi's effects were studied against oxidative stress and diabetes by *in-vitro* studies. Tulsi was extensively studied for antioxidant, antimicrobial and antibacterial properties. Recent work included synthesis of metal oxide nanoparticles from Tulsi through green synthesis. This study will assist researchers to comprehend the current status of the research on Tulsi and to visualize the future impact of such a useful medicinal plant.

**Keywords:** Tulsi, Tulasi, Holy Basil, *Ocimum tenuiflorum*, *Ocimum sanctum*, Bibliometric Analysis.

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## INTRODUCTION

In traditional medicine, medicinal plants have been used for over 1000 years, according to literature. Plants are the major source of medicines in modern complementary and alternative medicine, and any part of the plant, including the seeds, root, stem, leaves, and fruit, may contain bioactive components. Aromatic herbs are a rich source of physiologically active chemicals that may be used in agriculture as well as medicine. Due to its purported therapeutic properties, *Ocimum tenuiflorum*, commonly known as *Ocimum sanctum*, Tulsi (in Hindi), Tulasi (in Sanskrit), or Holy Basil (in English), from the *Lamiaceae* family, has been labeled the “Queen of Plants” and the “Mother Medicine of Nature”.<sup>[1]</sup> Tulsi is used in a variety of ways in traditional medicine; aqueous extracts from leaves (fresh or dehydrated as powder) are often used in herbal teas or combined with other herbal ingredients or honey to boost the therapeutic efficacy. The antibacterial effects of tulsi leaf extracts can be attributed to bioactive compounds such as camphor, eucalyptol, eugenol,

alpha bisabolene, beta bisabolene, and beta-caryophyllene.<sup>[2]</sup> Tulsi aqueous extracts have been used to treat stomach aches, common colds, headaches, malaria, inflammation, and heart disease. Scientific evidence suggests that tulsi have varied health-protective activities such as anticancer, antioxidative, antihypertensive, antilipidemic efficacy, anti-inflammatory, antipyretic, antibacterial, antiviral, antifungal activities, antidiabetic, immunomodulatory, hepatoprotective, antiulcer, antiarthritic, antistress, anticataract, anticoagulant, prophylactic, cardioprotective, chemo preventive and radioprotective.<sup>[3,4]</sup> Investigations also suggest the inclusion of tulsi in one's regular diet and/or as an adjuvant to medication therapy can help prevent or reduce a variety of health problems.<sup>[5]</sup>

Owing to the antiviral and immunity-boosting properties of tulsi, it was anticipated that the flavonoids and polyphenolic acids of tulsi would be helpful as inhibitors of main protease of SARS-CoV-2 virus<sup>[6]</sup> and several investigations were conducted in this regard since the onset of COVID-19 pandemic. *In silico* screening of phytochemicals of tulsi against protease of SARS-CoV-2 virus suggested that the flavonoids and polyphenolic compounds, especially luteolin-7-O-glucuronide and chlorogenic acid may covalently bind to the active residue Cys145 of the main protease and irreversibly inhibit the viral enzyme.<sup>[7]</sup> Another study by Baruah *et al.*<sup>[8]</sup> also found that the flavonoids, orientin, and vicenin-1 in tulsi,

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showed energetically favored docking with the functionally critical amino acid residues of COVID main protease, RNA dependent RNA polymerase, Spike protein, nucleocapsid, and 3a proteins of SARS-CoV-2 virus. These findings suggest that orientin and vicenin-1 might be explored further as possible treatment medicines for SARS-CoV-2 infections.

Therefore, we intend to explore the research conducted on tulsi and conduct a bibliometric analysis to identify and quantitatively analyze the major themes of the tulsi research literature. The present analysis on tulsi was aimed to outline the contributing factors in terms of countries/regions, affiliations, and funding agencies. It also aimed to disclose, based upon publications, the major research issues presented in the literature on tulsi in the Web of Science database. These sources of evidence should allow readers to easily gain a summary of the tulsi literature, including major journals, major countries of production, and dominant study topics and patterns. The information presented can also be used to recognize potentially interesting research avenues and provide initial guidance for more in-depth searches to identify appropriate publications or research opportunities.

## METHODOLOGY

### Data search

The online database Clarivate Analytics-owned Web of Science (WoS) Core Collection was used to assess the publications related to tulsi from 1981 to 9 June 2021. The search terms, “Tulsi”, “Tulasi”, “Holy Basil”, “*Ocimum tenuiflorum*”, “*Ocimum sanctum*” were used along with the boolean word “OR” at appropriate places. The exact query used in WoS was “Tulsi OR Tulasi OR Holy Basil OR *Ocimum tenuiflorum* OR *Ocimum sanctum*”. A total of 1,465 research publications were obtained using these combinations.

### Data extraction

The data that was extracted from the research publications obtained from the above search included publication year, document type, subject/research area, journal name, country, author affiliation and funding agency. The full records of all the research publications were downloaded from WoS database and applied for the bibliometric analysis using VOSviewer software (version 1.6.16, 2020).

VOSviewer software is intended primarily for analyzing bibliometric networks. It is capable of extracting and analyzing the semantic contents of the titles, abstracts, and keywords of publications, relating them to the citation count data and generating a network map to visualize the results.<sup>[9]</sup> Default parameters were used for the analyses and creation of network maps. The font size of the words in the network map indicates their frequency of occurrence (multiple appearances in a single publication count as one). Two words are nearer

to each other if they co-occurred in the evaluated publications more frequently. Only words that appeared in at least 1.0% ( $n = 14$ ) of the manuscripts were analyzed and visualized. For the keyword map, the full counting method was used, meaning that each co-occurrence link carried the same weight. The default “association strength method” was used for the normalization of the co-occurrence matrix with default values of attraction and repulsion.

## RESULTS AND DISCUSSION

The literature search has resulted in a total of 1,465 research publications. The earliest articles indexed in WoS about tulsi were in 1981 ( $n=4$ ). A peak in the number of publications was seen since 2007 ( $n=45$ ). A steady increase in the research articles was seen since then and the number of publications was highest in 2020 ( $n=142$ ) (Figure 1). This could be attributed to the onset of the COVID-19 pandemic when researchers’ interest focused on improving immunity using such medicinal plants. It was interesting to note that among

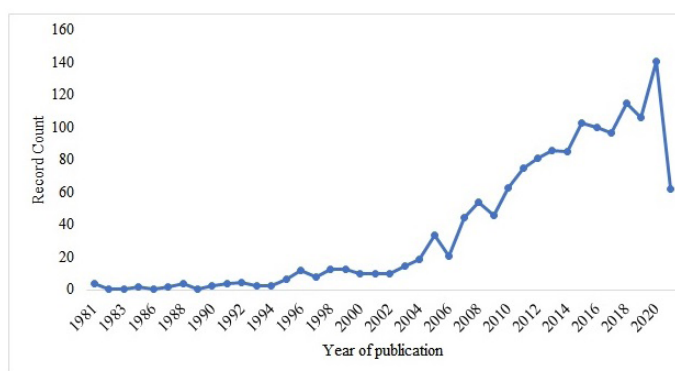


Figure 1: Trends of publications.

the 142 articles published in 2020, 95 publications were from a single country, India followed by the United States of America ( $n=7$ ) and China ( $n=6$ ).

Most of the manuscripts published were original articles (1248; 85.2%) followed by review papers (87; 5.9%) and were in the ratio of 14.3:1. Apart from these, 60 proceeding papers, 52 meeting abstracts and 21 book chapters were published pertaining to the literature on holy basil/tulsi during the period 1980-2021 contributing to about 9% of the total publications. The majority of the publications were written in English ( $n=1448$ ; 98.3%). Contributions came from 1545 organizations located in 52 countries/territories and were published in 740 journals. The top five contributors with regard to journal, organization, funding agencies, and WoS subject areas are listed in Table 1. The top 5 cited articles dealt with the anti-diabetic properties of medicinal plants and the synthesis of silver nanoparticles using tulsi leaf extracts (Table 2).

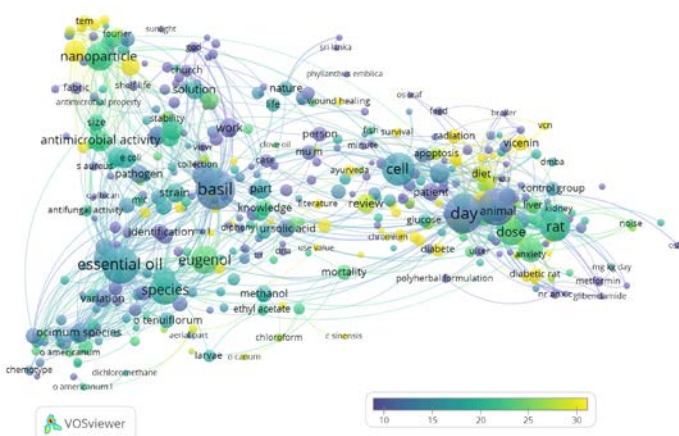
**Table 1: The Top five contributor journals, organizations, countries, funding agencies and subject area of the 1,465 manuscripts.**

Contributor	Publication Count (% of total)
<b>Journal</b>	
Journal of Ethnopharmacology	42 (2.88)
International Journal of Pharmaceutical Sciences and Research	32 (2.18)
Industrial Crops and Products	18 (1.23)
Indian Journal of Pharmacology	16 (1.09)
Acta Horticulturae	15 (1.02)
Phytotherapy Research	15 (1.02)
Planta Medica	15 (1.02)
<b>Organization</b>	
All India Institute of Medical Sciences	40 (2.73)
Banaras Hindu University	24 (1.64)
University Delhi	21 (1.43)
CSIR	18 (1.23)
Chiang Mai University	17 (1.16)
Indian Institute of Technology	17 (1.16)
<b>Funding Agencies</b>	
University Grants Commission, India	87 (5.94)
Council of Scientific Industrial Research CSIR India	59 (4.03)
Department of Science Technology (DST), India	34 (2.32)
Indian Council of Medical Research (ICMR)	26 (1.77)
Department of Biotechnology (DBT), India	17 (1.16)
<b>Subject area</b>	
Pharmacology Pharmacy	332 (22.66)
Plant Sciences	208 (14.19)
Chemistry	160 (10.92)
Agriculture	141 (9.62)
Food Science Technology	127 (8.67)

**Table 2: The Top five cited articles.**

Manuscript details	Citation count
Medicinal plants of India with anti-diabetic potential <sup>[10]</sup>	865
Indian herbs and herbal drugs used for the treatment of diabetes <sup>[11]</sup>	362
Rapid synthesis of silver nanoparticles using dried medicinal plant of basil <sup>[12]</sup>	327
Biosynthesis of silver nanoparticles using <i>Ocimum sanctum</i> (Tulsi) leaf extract and screening its antimicrobial activity <sup>[13]</sup>	291
Comparative evaluation of hypoglycaemic activity of some Indian medicinal plants in alloxan diabetic rats <sup>[14]</sup>	273

VOSviewer software supports overlay visualization in which the color of a node indicates a definite property of the node. In this paper, nodes represent terms appearing in titles and abstracts of the manuscripts and the color of a node or term indicates the number of times a term has recurred as indicated



**Figure 2: Bubble map visualizing words from titles and abstracts of 1465 publications:** There were 433 terms that appeared in at least 1.0% of the evaluated research article. The word size signifies the frequency of the appearance of words (multiple appearances in a single manuscript count as one). Two words are closer to each other if they co-occurred more frequently in the evaluated research publications. Bubble colors indicate the averaged citations of the terms.

in the color bar. We used VOSviewer software to analyze and visualize the recurring terms from titles and abstracts considering only those words that appeared in at least 1.0% ( $n = 14$ ) of the publications (Figure 2).

The top twenty most recurring words in the title and abstracts of the selected papers are listed in Table 3. It can be seen that the terms are directed towards research related to the extracts (essential oils and active component Eugenol) and its ‘constituents’ from various species of the basil plant. The included publication also mentioned dosage of Tulsi extracts which is evident from the recurring terms such as ‘mg Kg’ and ‘yield’ and its effectiveness on cells using ‘animal’ models such as ‘rat’ and ‘mouse’. Identification of its dosage, and effectiveness on cells using animal models. Common terms such as ‘day’ and ‘group’ also occurred in the analysis indicating the intervention studies carried out using various species of Basil for different durations (number of days) and comparative impact among the various study groups. Terms also indicated research on the preparation and ‘extraction’ of silver nanoparticles through a green route using leaves of *Ocimum* varieties displaying its antimicrobial properties.

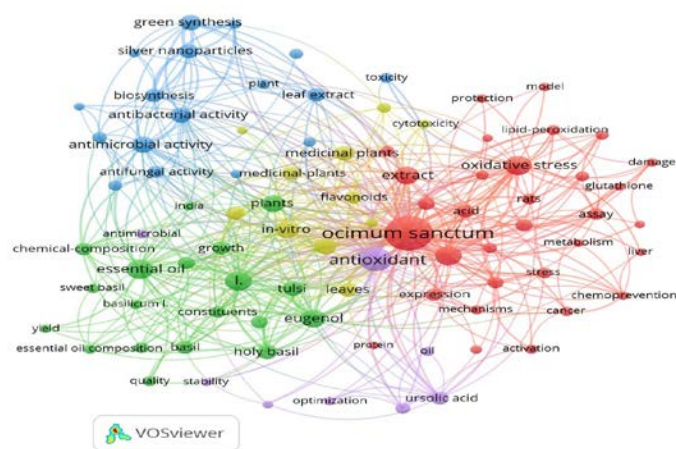
The network visualization map to study the co-occurrence of keywords in the 1465 holy basil/tulsi publications was developed using VOSviewer. The distance between two keywords in the visualization approximately suggests the relatedness of the keywords in terms of co-citation links (Figure 3). Typically, the closer two keywords are established to each other, the stronger their relatedness. The strongest co-citation links between keywords are also denoted by lines. The keywords were divided into clusters. The color of a keyword circle is deliberated by the cluster to which it belongs.

**Table 3: The Top 20 recurring terms from titles and abstracts.**

Term	Occurrence (% of 1465 Publications)
Basil	497 (33.9%)
Day	474 (32.3%)
Group	447 (30.5%)
Essential oil	446 (30.4%)
Cell	346 (23.6%)
Rat	305 (20.8%)
Species	304 (20.7%)
Eugenol	251 (17.1%)
Nanoparticle	246 (16.8%)
Dose	240 (16.4%)
mg Kg	196 (13.4%)
Yield	172 (11.7%)
Tenuiflorum	166 (11.3%)
Constituent	159 (10.8%)
Antimicrobial activity	153 (10.4%)
Mouse	149 (10.2%)
Silver nanoparticle	144 (9.8%)
Extraction	141 (9.6%)
Animal	138 (9.4%)
Temperature	137 (9.3%)

**Table 4: The Top 20 recurring keywords.**

Term	Occurrence (% of 1465 Publications)
Ocimum sanctum	353 (24.1%)
Essential oil	133 (9.1%)
Antioxidant	130 (8.8%)
Extract	113 (7.7%)
basilicum I.	104 (7.1%)
Medicinal plants	92 (6.3%)
Holy basil	91 (6.2%)
Oxidative stress	82 (5.6%)
Eugenol	70 (4.8%)
In vitro	65 (4.4%)
Plants	64 (4.3%)
Antioxidant activity	63 (4.3%)
Antimicrobial activity	59 (4.0%)
Antibacterial activity	55 (3.75%)
Green synthesis	55 (3.75%)
Tulsi	51 (3.5%)
Leaves	46 (3.1%)
Growth	42 (2.9%)
Acid	41 (2.8%)
Biosynthesis	39 (2.6%)



**Figure 3: Bubble map visualizing keywords of 1465 publications:** The terms were divided into five clusters with different colors: effect (red), holy basil/tulsi (green), active principles (blue), extracts (yellow), and components (violet).

Around 97 significant keywords were identified from the literature which shed light on the research trends in *Ocimum sanctum* research including its pharmacological properties and medicinal uses. These keywords are listed in Table 4 in the decreasing order of the frequency of their occurrence in the

literature during 1980–2021. It is very evident that the research concentrated on studying the antioxidant, antimicrobial and antibacterial properties of various parts of the *Ocimum sanctum* plant. The use of this medicinal plant was studied in relation to reduction in oxidative stress and related disease conditions. The Tulsi plant has been extensively researched in recent times using green synthesis technology for the synthesis of metal oxide nanoparticles.

All the publications (1981–June 2021), were divided into four groups, to analyze the decade-wise research publications. However, publications of the first decade (1981–1990) were only 19 research articles. Therefore, we selected publications since 1991, categorized them into three decades, and analyzed the top 20 recurring keywords (Table 5). All the decades shared the most common and expected keyword, the scientific name of Tulsi. However, analyzing the other keywords showed how the research interest has evolved from each decade. In 1991–2000, the research primarily focused to explore the health benefits of Tulsi as a chemo preventive, mutagenesis, oxidative stress (S-transferase and Glutathione s-transferase activities). Although less, investigations were focused on understanding the mechanisms and were also conducted in animal models (rats). In the next decade (2001–2010), animal studies (mice)



**Table 5: The Top 20 recurring keywords decade-wise.**

1991-2000	Occurrence (% of 78)	2001-2010	Occurrence (% of 317)	2011-2021	Occurrence (% of 1051)
<i>Ocimum sanctum</i>	18 (23%)	<i>Ocimum sanctum</i>	101 (31.8%)	<i>Ocimum sanctum</i>	231 (21.9%)
Fixed oil	6 (7.6%)	Antioxidant/s	39 (12.3%)	Essential oils	110 (10.4%)
Chemo prevention	5 (6.4%)	Extract	27 (8.5%)	Antioxidant/s	103 (9.8%)
Glutathione	5 (6.4%)	Essential oils	22 (6.9%)	<i>basilicum l.</i>	97 (9.2%)
Assay	5 (6.4%)	Holy basil	19 (5.9%)	Extract	85 (8.08%)
Inhibitors	4 (5.1%)	Medicinal plants	19 (5.9%)	Holy basil	71 (6.7%)
Mutagenesis	4 (5.1%)	Oxidative stress	19 (5.9%)	Oxidative stress	63 (5.9%)
Acid	3 (3.8%)	Antioxidant activity	15 (4.7%)	Antioxidant activity	57 (5.4%)
Chemical carcinogenesis	3 (3.8%)	Mice	15 (4.7%)	Eugenol	56 (5.3%)
Liver	3 (3.8%)	Plants	13 (4.1%)	<i>In-vitro</i>	56 (5.3%)
Cancer	3 (3.8%)	Tulsi	11 (3.4%)	Green synthesis	54 (5.2%)
Eugenol	3 (3.8%)	Assay	10 (3.1%)	Antimicrobial activity	51 (4.8%)
Carcinogenesis	3 (3.8%)	Bone marrow	10 (3.1%)	Plants	50 (4.7%)
Lipid peroxidation	2 (2.5%)	Antibacterial activity	9 (2.8%)	Silver nanoparticle	47 (4.4%)
Mechanism	2 (2.5%)	Leaves	9 (2.8%)	Antibacterial activity	45 (4.2%)
Rat	2 (2.5%)	Antimicrobial activity	8 (2.5%)	Medicinal plants	45 (4.2%)
S-transferase activities	2 (2.5%)	Leaf extract	8 (2.5%)	Tulsi	40 (3.8%)
Glutathione s-transferase	2 (2.5%)	Plant extracts	8 (2.5%)	Biosynthesis	37 (3.5%)
Growth	2 (2.5%)	Diabetes	7 (2.2%)	Leaves	37 (3.5%)
Inhibition	2 (2.5%)	<i>In-vitro</i>	7 (2.2%)	Growth	35 (3.3%)

and *in-vitro* investigations progressed. More attention was given to extract the beneficial compounds of Tulsi (leaf, plant extract, essential oils), and research focused on one of the rising metabolic diseases, diabetes. Advanced research was seen in the last decade (2011–2021), where research was centered on subjects related to green synthesis or biosynthesis and extracted essential oil (Eugenol) and techniques of silver nanoparticles indicated the use of technology to utilize the bioactive molecules of Tulsi in most effective therapeutic way possible.

We further identified the top five countries with the greatest number of publications. India topped the list with 1021 (69.7%) publications followed by the United States (88; 6%), Thailand (58; 3.9%), Pakistan (34; 2.3%) and South Korea (25; 1.7%). Thus, the five most productive countries were from Asia, except the United States.

We then analyzed the top 20 recurring keywords among them (Table 6). The topmost recurring terms were the scientific name of Tulsi or its English name and its most beneficial action which is the antioxidant capacity. Further, studies in

the top 4 countries explored the essential oils of Tulsi, which is the most important bioactive component of the plant. It was interesting to see that all the countries have analyzed Tulsi in *in-vitro* investigations. It was also analyzed in view of other essential functions such as antibacterial and antimicrobial activities, immunomodulation, apoptosis, and metastasis. Tulsi was also studied in association with relatively rare subject areas such as gene expression, which can lead to exploring this plant in the area of nutrigenomics. The recurring terms such as microencapsulation, silver nanoparticle, and gold nanoparticle indicate its exploration in the area of nutraceuticals and effective delivery systems (in India and South Korea).

## CONCLUSION

A bibliometric analysis was used to evaluate research articles related to Tulsi (using the WoS database from 1981–June 2021). The findings revealed that India, the USA, Thailand, Pakistan, and South Korea were the major contributing countries. Most of the investigations focused on pharmacology pharmacy indicating the use of Tulsi as therapeutics, and other areas

**Table 6: The top 20 recurring keywords used in the publications contributed by the top five most productive countries (in descending order).**

India	USA	Thailand	Pakistan	South Korea
<i>Ocimum sanctum</i>	<i>Ocimum sanctum</i>	Holy basil	<i>Ocimum sanctum</i>	<i>Ocimum sanctum</i>
Antioxidant	Antioxidant	Antioxidant	Oxidative stress	Green synthesis
Extract	Holy basil	Essential oil	Antioxidant	Biosynthesis
Essential oil	Essential oil	Chemical composition	<i>In-vitro</i>	<i>In-vitro</i>
<i>Basilicum I.</i>	<i>Ocimum basilicum</i>	<i>Basilicum I.</i>	Medicinal plant	Silver nanoparticle
Medicinal plants	<i>Basilicum I.</i>	Antioxidant activity	Essential oil	Inhibition
Oxidative stress	Eugenol	Microencapsulation	Flavonoids	Antibacterial activity
Eugenol	Expression	Agent	Antioxidant activity	Sensor
Green synthesis	<i>In-vitro</i>	Antimicrobial activity	<i>Basilicum I.</i>	Antimicrobial activity
Antimicrobial activity	<i>Ocimum tenuiflorum</i>	Encapsulation	Gene expression	Expression
Tulsi	Apoptosis	Efficacy	Dopamine	Eugenol
Plants	Antioxidant activity	Meat	Memory	Gold nanoparticle
Extract	Oxidative stress	Storage	Serotonin	Apoptosis
<i>In-vitro</i>	Growth	mechanism	Immunomodulation	Antioxidant activity
Silver nanoparticle	Tulsi	Rosmarinic acid	Oxidative burst	Bacteria
Antioxidant activity	Sweet basil	Inhibition	Active toxicity	Growth factors
Ursolic acid	Quality	Eugenol	Biosynthesis	Metalloproteinases
Leaf extract	Constituents	Films	Green synthesis	Metastasis
Acid	Ursolic acid	Plants	Leaf extract	Modified electrode
Growth	Medicinal plant	Rosemary	Lipid peroxidation	Optical properties

such as plant sciences, chemistry, agriculture, and food science technology. VOSviewer software was used to visualize and analyze the trend of recurrence of major keywords pertaining to Tulsi research. The analyses revealed that most of the publications explored its various health benefits, majorly its role as an antioxidative agent against oxidative stress. Extraction of a leaf or plant extracts, essential oils, and *in-vitro* and animal studies have been conducted to understand the mechanism of action of Tulsi. The emerging themes of Tulsi research can be in gene expression as a bioactive molecule, films as an antibacterial/antimicrobial agent, and novel properties of Tulsi including optical properties. The latest research focused on applying Tulsi in the nutraceutical industry (exploring techniques such as microencapsulation, silver/gold nanoparticles) to improve the delivery system's efficiency to the target sites (especially in research involving animal models or clinical trials). In bibliometric analysis, although the author's contribution also highlights interesting pointers, we could not analyze the authorship of the Tulsi publications which can be seen as a limitation to the present work. Many Indian authors (a country with the highest publications) have similar initials, hence causing inaccurate counting. Besides, some publishing records only contained author initials, analyzing authorship

by using authors' full names was also impossible. Furthermore, although 18 varieties of Tulsi are identified, we have studied only two varieties i.e., *Ocimum tenuiflorum* and *Ocimum sanctum* in the present analysis since these were the most commonly described varieties in scientific publications. This, however, limits the analysis' ability to provide a comprehensive review of the research on Tulsi.

## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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