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Ten years of research on phenolics (2005–2015): A status report

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ABSTRACT

The purpose of this review article is to present to the readers a comprehensive progress report on the research performed on phenolics. Publications registered on the Scopus database from 2005 to 2015 were identified using various filters and keywords, and a critical analysis of the results was completed based on the publication trends. This review discusses and elucidates the intervention of phenolics in different disease areas with an emphasis on lifestyle diseases, occurrence of phenolics in different plant parts, methods used in extraction of phenolics, chromatographic techniques used in the detection of phenolics, and the standings of the top three countries based on research related to phenolics.

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1. Introduction

The utility of phenolics in today's world where we face immense threat from free radicals is without question [1]. The threats from free radicals are such that they can complicate any existing pathological conditions and even create new pathological conditions. As a result, oxidative stress becomes a major pathological mechanism and contributes significantly to the onset of several diseases, which has made reactive oxygen species a deadly entity for mankind [2]. Thus, phenolics are popular dietary supplements, which play a vital role in reducing the risk of onset of several diseases, including cancer and neurodegenerative diseases [3]. There have been numerous studies promoting the health features and chemistry of phenolics [4–6]. This is clearly evident from the fact that Scopus database contains 1823 review articles and 48,932 articles having the word “phenolics” in the title, keywords or abstract body of the published paper [7]. This reflects the magnitude of research underway in the field of phenolics. In recent times the use of synthetic antioxidants has come under scrutiny due to the negative effects of these compounds on the human body [8]. This has also given a huge

boost to the research on phenolics. This review article aims to present a comprehensive report on the research on phenolics based on the publications registered in Scopus database from 2005 to 2015. This 10-year progress report based on the publication trends in phenolics shall try to identify the different areas where research on phenolics has been prioritized. This review can be a useful module for any researcher planning research related to phenolics. This review is entirely based on analysis and interpretation of data obtained from the literature found on the Scopus database, and hence, the references are kept to a minimum. The different settings of Scopus used for obtaining the search results are summarized in Table 1.

2. Critical analysis

2.1. Intensity of phenolic interventions in different diseases

As previously mentioned, 48,932 articles that referenced phenolics were found in the Scopus database; all these articles did not necessarily relate to natural products, but they could also include synthesized phenolic compounds; The total number of papers published regarding research on phenolics obtained from plant extracts as potential drug treatments for various lifestyle diseases is shown in Fig. 2. To identify only those articles that dealt with research on phenolics using crude plant extract, the search

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Table 1

Details of the search parameters and operational settings used to perform the Scopus search.

Search parameters	Operational settings
Search term text	<.....>
Search field type	Article title, abstract, keywords
Data range	2005–2015
Document type	<article>
Subject areas	Life sciences, health sciences and physical sciences
Operator used between two search terms	<and>, <or> depending upon the search requirement

parameters were modified slightly. Subsequently, a total 16,757 articles were identified that were based on research of phenolics using crude plant extract. This generalization was performed by the inclusion of the words “phenolics” and “extract” in the above-mentioned search field type. It was anticipated that inclusion of the word “extract” in the search text would likely identify only those articles that were based on crude extracts (plants). However, there still can be some margin of error because extracts can also be obtained from microorganisms or environmental samples, but assuming that phenolic compounds are more predominant in plants, the above generalization can thus be drawn.

The antioxidant properties of several phenolics play a critical role in management of the body's oxidative balance by providing additional protection against oxidants, oxidative reactions and reactive species. Despite having chemical diversity, phenolic compounds mainly exhibit their specific bioactivity through a series of polyvalence reactions and are able to strengthen the potential of other compounds, block side effects of some constituents and also acquire other biological properties [8]. Herbal therapy is believed to act via synergism and through a multi-modal system, acting either through multiple pathways or possibly by repetitive hitting of a target by several entities [2]. Hence, the presence of phenolics with antioxidant property provides therapeutic synergism support to plant-based bioactivity in the management or cure of different diseases.

Research related to the involvement or contribution of phenolics in the cure and management of several diseases using crude extracts of medicinal plants was screened from Scopus within the stipulated 10-year time frame, and the results are shown in Fig. 1. Publication trends clearly showed that involvement of phenolics is predominantly found in areas pertaining to antibacterial, anticancer and anti-inflammatory research, typically for the search of drug candidates using crude extracts of different medicinal plants [9].

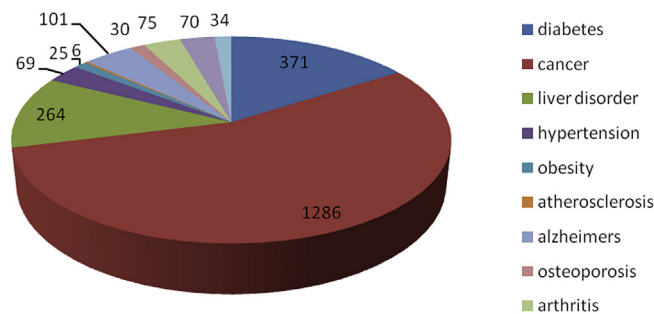


Fig. 2. Publication records (2005–2015) of various lifestyle diseases with phenolic intervention in terms of research on plant extracts.

Searching for antibacterial properties from natural products yielded the highest percent contribution in terms of phenolic involvement, followed by hepatoprotective and anti-cancer properties. Anti-bacterial, anti-inflammatory and free radical scavenging properties are the major dominant bioactivities of phenolics which are responsible for the cure and management of various diseases. Reactive oxygen species (ROS) are produced in all aerobic cells as by-products of oxygen metabolism, and an oxidative stress situation is created when ROS generation overpowers the cellular antioxidant defence capacity [10]. Phenolic compounds can effectively scavenge these ROS threats, thus participating in the prevention of DNA adduct formation and enhanced carcinogen elimination [11]. However, they can also exert chemopreventive effects through interference with ROS, which act as secondary messengers in signalling pathways crucial for cancer cell proliferation and invasion. Additionally, phenolic plant compounds are capable of inhibiting inflammation and tumour promotion by deactivating a range of pro-oxidative enzymes [12].

The intervention of phenolics in different lifestyle diseases was also interpreted via Scopus data. The total number of papers published regarding research on phenolics obtained from plant extracts as potential drug treatments for various lifestyle diseases is shown in Fig. 2. The total contribution of phenolic involvement in lifestyle diseases was found to be 13.9% when compared to total research performed related to phenolics using plant extracts (16,757). This indicates that phenolics research has a wide scope in terms of lifestyle diseases. The fact that phenolics are predominantly present in various edible plant parts and can be consumed in a regular human diet makes them preferred candidates for patients with lifestyle diseases.

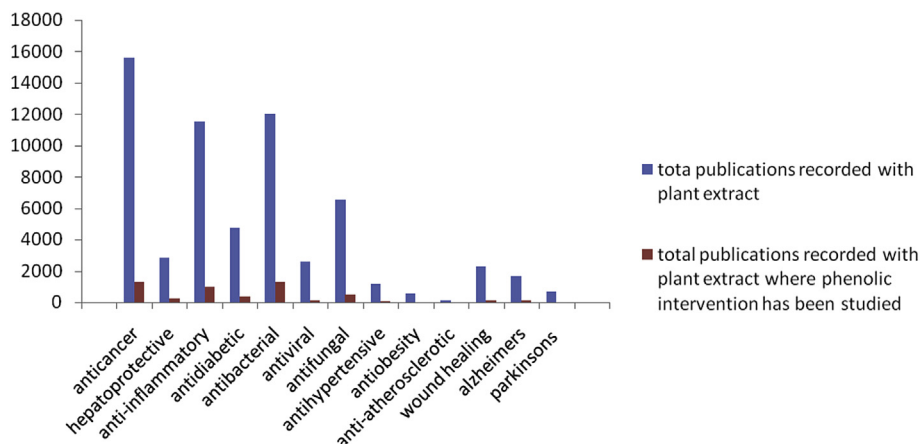


Fig. 1. Publication records (2005–2015) from Scopus of different diseases with phenolic interventions.

2.2. Phenolics and plant parts

The abundance of phenolics in different plant parts was also scrutinized. A 10-year search (2005–2015) was conducted using the words “phenolics” and “<name of plant part>” in the search field. The results in terms of the number of publications recorded for phenolic involvement obtained from different plant parts are shown in Fig. 3. The results indicate that leaves were rich sources of phenolics; this gives a clear indication that accumulation of phenolics after they are synthesized takes place predominantly in the leaves. Moreover, collection of leaves in large quantities, as required in natural product research, shall not jeopardize the biodiversity because leaves can be grown back easily compared to other plant parts [13].

2.3. Extraction of phenolics

A comparison of conventional and more recent methods for the extraction of phenolics was performed using the Scopus database. The results depicted in Fig. 4 clearly show that conventional methods (maceration, decoction and Soxhlet) are still hugely preferred over newer techniques (ultrasound assisted extraction, microwave assisted extraction and supercritical fluid extraction). A total of 889 publications were recorded for phenolics based on conventional methods in comparison to 521 publications recorded for extraction of phenolics with newer techniques (Fig. 4). The Scopus search indicates that the use of newer techniques has drastically increased since 2010. The above-mentioned newer techniques have gained significant research interest in the last 5 years, mainly because of their fast, selective and eco-friendly extraction norms. In terms of the solvents commonly used for extraction, it was observed that methanol had been used frequently, followed by ethanol and aqueous medium. As far as detection of phenolics is concerned, HPLC had been most frequently used, followed by GC (Fig. 5).

2.4. Phenolics: a global picture

The top three countries, according to the research papers registered in Scopus database (2005–2015), that have published research on phenolics using plant extracts are shown in Fig. 6. India's and China's appearances as the top two countries can be explained on the basis of their richly documented traditional medicinal knowledge known as Ayurveda and traditional Chinese medicine, respectively [14]. As far as usage of leaves for phenolics research is concerned, India occupies the top position, with 1273 publications registered in Scopus. Additionally, as far as conventional use of the extraction technique Soxhlet is concerned, India still occupies the top position, with 354 publications. However, this

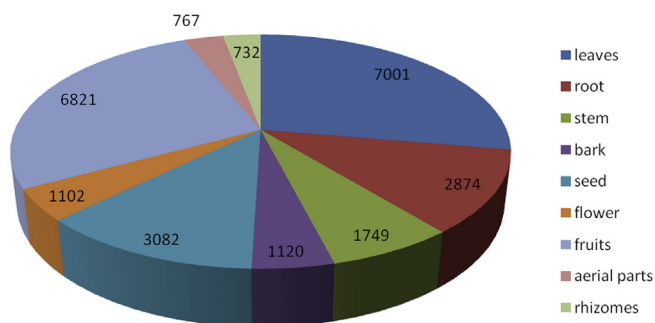


Fig. 3. Publication records (2005–2015) from Scopus on phenolics obtained from different plant parts.

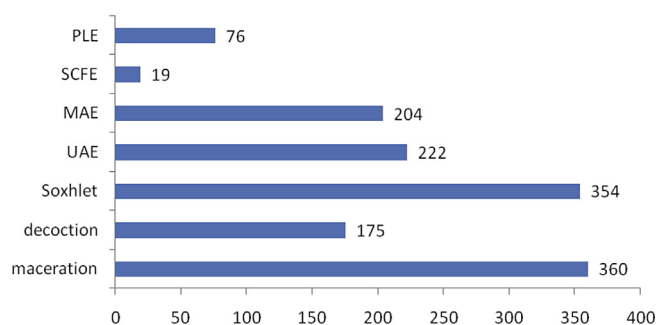


Fig. 4. Publication records (2005–2015) from Scopus of different techniques used for extraction of phenolics. PLE: pressurized liquid extraction, SCFE: Supercritical fluid extraction, MAE: Microwave assisted extraction, UAE: Ultrasound assisted extraction.

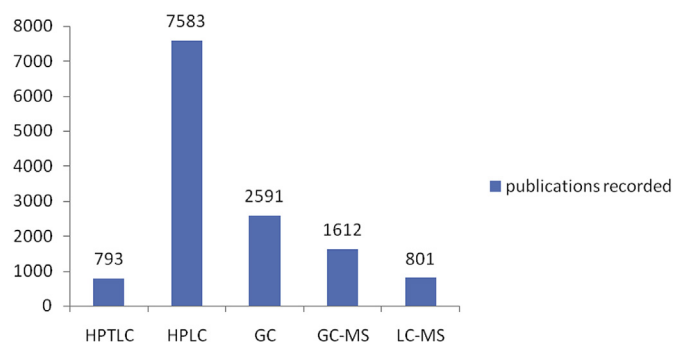


Fig. 5. Publication records (2005–2015) from Scopus on the use of different chromatographic methods for the detection of phenolics.

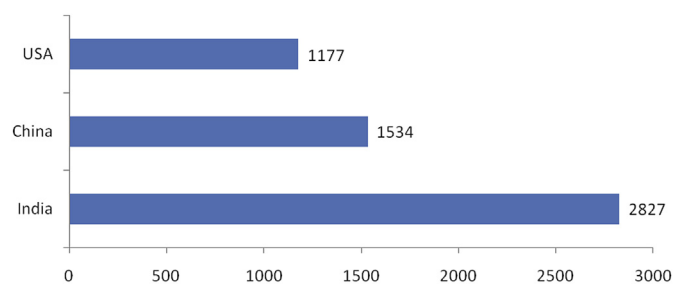


Fig. 6. Publication records (2005–2015) from Scopus for the top three countries for research on phenolics using plant extracts.

is not a positive indication because it can suggest that India is slow in adapting to newer technologies (ultrasound assisted extraction and microwave assisted extraction) for botanical extraction. As far as adopting newer extraction techniques for phenolics is concerned, China occupies the top position.

3. Conclusion

Publication trends on phenolics discussed in this review article give a clear indication that there is a wide scope of research regarding the effect of phenolics on lifestyle diseases and that there is still much left to be explored. After critical analysis, some of the key research areas pertaining to phenolics were found to be evaluation of the mechanism of action of different phenolics for the management of chronic and lifestyle diseases, identification of phenolics in edible plants and their use as biomarkers for standardization of crude extracts, preparation of phenolic-enriched

fractions and evaluation of their protective role in the management of different diseases, and extraction method development for the large-scale extraction of phenolics to meet the growing need of nutraceutical/pharmaceutical industries. Recently, oxidative stress-related disorders have received special attention, and in this regard, phenolics may be developed as key antioxidants for combating the menace of free radicals. Extraction of phenolics has also been revolutionized with the introduction of MAE, PLE and UAE, which are all eco-friendly in their operation and also assure exhaustive and selective extraction that occurs rapidly. The use of hyphenated chromatographic techniques for detection of phenolics is also increasing. Overall, phenolics are constant targets for research in natural products from both analytical and ethno-pharmacology perspectives, and the more it unfolds the deeper it becomes. We believe that this review article shall serve as a preliminary report to provide vital leads regarding global research trends in phenolics and shall also help us to learn more on the different options and opportunities that can be explored by researchers interested in the field of research in phenolics.

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