ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)
Vol 2, Issue 12, December 2017

Plant bioactive phytochemicals: their role in disease prevention

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***Abstract*— "Leave your drugs in the chemist's pot if you can heal the patient with food" – Hippocrates (460-377B.C), the father of medicine recommended, "Let thy food be thy medicine and thy medicine be thy food". Appropriately planned vegetarian diets are healthful, nutritionally adequate and provide health benefits in the prevention and treatment of certain diseases. Such an idea reflected the importance of diet for their therapeutic and preventive bioactive components due to their elevated margin of safety and desired range of efficacy. The above observation made centuries ago has now gained scientific verifications with epidemiological studies showing that the incidence of many chronic and degenerative diseases are least in countries like India and China where vegetables, fruits and spices form an essential part of human diet. With regard to the extensive consumption of nutraceuticals in the diet, the biological activity of these compounds is an important area of scientific investigation. Given the potential therapeutic tendencies of these compounds, one would expect to observe their favourable effects in human population..**

***Index Terms*: Anti-inflammatory, anti-bacterial, anticarcinogenic effects and phytochemicals.**

I. INTRODUCTION

India is one of the 12 mega biodiversity centres having over 45,000 plant species. About 1500 plants with medicinal uses are mentioned in ancient texts and around 800 plants have been used in traditional medicine. Of these, only about 6% have been screened for biologic activity, and a reported 15% have been evaluated phytochemically [1]. However, very little information is available on such activity of medicinal plants and, of the 400,000 plant species on Earth, only a small percentage has been systematically investigated for their biological activities. Additionally, there is a rich local ethnobotanical bibliography describing the species most frequently used by the population to cure various diseases. The importance of a plant lies in its biologically active principles. There are two types of plant chemicals, primary metabolites such as sugars, proteins, amino acids and chlorophylls and secondary metabolites, which includes alkaloids, terpenoids, saponins and phenolic compounds. These chemicals exert a significant physiological effect on the mammalian system [2]. Some of these phytochemicals are known as nutraceuticals because of their biological activities [3]. Identifying bioactive compounds and establishing their health effects are active areas of scientific inquiry. In recent years, these secondary metabolites are being used, either directly as precursors or as lead compounds, in the pharmaceutical industry and it is expected that plant extracts showing target sites other than those used by antibiotics will be active against drug-resistant pathogens. Research on phytochemicals has been driven in recent years by their beneficial health effects, including antioxidant, anticarcinogenic, and antimutagenic activities [4] and their ability to reduce the risk of coronary heart disease and other degenerative diseases [5]. The screening of the plants for their biological activity is done on the basis of either their chemotaxonomic investigation or ethnobotanical knowledge for a particular disease. Identification of a particular compound against a specific disease is a challenging long process. Although the screening of Indian medicinal plants has revealed varying degrees of biological activity, there is still a lack of experimental scientific studies and antioxidant properties of a great number of these remedies. Thus, it is considered worthwhile to screen the medicinal plants that have been used in traditional medicine [6].

II. ROLE OF BIO-ACTIVE PHYTOCHEMICALS IN DISEASE PREVENTION

Healthy food choices, with regular physical activity and non smoking habits, can prevent over 80% of CHD, 70% of stroke, and 90% of type-2 diabetes. Epidemiological (retrospective and prospective) investigations, case control studies and dietary intervention studies have strongly suggested or shown the importance of plant foods rich in antioxidants in the prevention against several chronic human diseases. It is well accepted that prevention is the most persistent, cost-effective strategy to deal with chronic diseases. Thus, natural foods rich in antioxidants could be employed as diets could be the best example to review the health-promoting effects of plant food ingredients. Comparisons between vegetarians and non-vegetarians (omnivores) had shown that vegetarians have in general, lower risk of mortality from ischemic heart disease, hypertension, stroke, type 2 diabetes and certain cancers [7].

ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)
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Differences have also been noticed regarding body mass index, total serum LDL levels, and blood pressure. However, it seems that persons following a vegetarian regimen, especially vegans, possibly will need to include some fortified foods or supplements, providing e.g. vitamin D, vitamin B12, ω-3 fatty acids, iron, calcium, zinc and iodine, to equilibrate their diet and to maintain optimal health [8].

Antioxidants in their natural matrices are generally assumed to be safe. Furthermore, it is thought that the advantageous effects of antioxidants in natural food sources are due to their additive and synergistic action. Among additional mechanisms independent from antioxidant properties, several antioxidative mechanisms are proposed as being responsible for maintaining optimal health and also preventing diseases. The protection against free radical-mediated lipid peroxidation, DNA and protein oxidation, and oxidative stress related mitochondrial dysfunction constitutes the principal way of natural antioxidants for the prevention against several diseases including cancer, cardiovascular complications, neurodegenerative diseases and the side effects of aging. Other antioxidative protective mechanisms such as absorption of UV blue light by certain carotenoids could also play a role in prevention. Further prospective studies, both with whole food items and individual dietary constituents are warranted and needed [9].

III. PHYTOMEDICINE AS SOURCE OF PHYTOCHEMICALS

In recent years, phytotherapy is rapidly evolving throughout the world. Phytochemicals, naturally occurring bio-chemicals in the plants, contribute colour, flavour, smell and texture. They may help in the prevention of diseases like cancer and heart diseases besides their role to inhibit the microorganisms causing many diseases in human beings. More than 88,000 secondary metabolites and every year, some 4,000 new ones are being reported [10]. Phytochemicals in plants have a defensive role against disorders, which helps in lowering the threat of cancer, heart disease, hypertension and stroke as suggested by epidemiological studies. Polyphenols and vitamins (vitamin C and E) are the chief groups of phytochemicals contributing to the total antioxidant ability of plant [11] thereby preventing the inception and/or development of many human degenerative disorders. Protective effects of antioxidants from plants by counteracting reactive oxygen species has lead to the certainty of its health promoting effects [12].

Phytochemicals are non-nutritive, naturally occurring bioactive plant chemicals found in different fractions of plants, such as vegetables, fruits, medicinal plants, aromatic plants, leaves, flowers and roots, which possess an array of protective or disease preventive properties, acting in unison with nutrients [13]. Phytochemicals, depending on their protective role are divided as primary constituents comprising of common sugars, amino acids, proteins and chlorophyll and secondary constituents comprising of alkaloids, terpenoids, flavonoids, saponins, tannins etc. which are the prominent bioactive constituents in plants (Fig. 6 and 7) [14].

IV. PHYTOCHEMICALS AND THEIR THERAPEUTIC VALUE

In view of the deleterious side effects of the synthetic antioxidant supplements on human health, the present day's focus is on antioxidants from natural sources [15]. Fruits and vegetables form the primary source for these antioxidants with nutraceutical values. Many natural antioxidants such as anthocyanidin, quercetin, rutin [16], kaempferol, catechin, catechol etc. have already been revealed to show therapeutic efficacy in various pathological conditions [17]. Designing an optimal nutritional counter measure against these free radicals could be achieved through the antioxidative activity of dietary phytochemicals which have been linked to reduction in human degenerative diseases in populations that consume high amounts of fruits and vegetables [18]. Plant foods contain many components that are beneficial to human health. Phenolic compounds are widely distributed in plants and known to be excellent antioxidants [19]. The antioxidant system comprises different types of functional components classified as the first line, second lines, third line and fourth line defenses. The first line defense comprises preventive antioxidants that act by quenching of superoxide radical, decomposition of H2O2 and sequestration of metal ions. The antioxidants belong to this category are enzymes like superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx), glutathione reductase and non enzymatic molecules like minerals and some proteins [20]. The antioxidants in the second line defense include antioxidative vitamins like vitamin C, E, β - carotene (pro-vitamin A) which are some important scavengers of free radicals not synthesized by the body and therefore, are required from the diet [21].

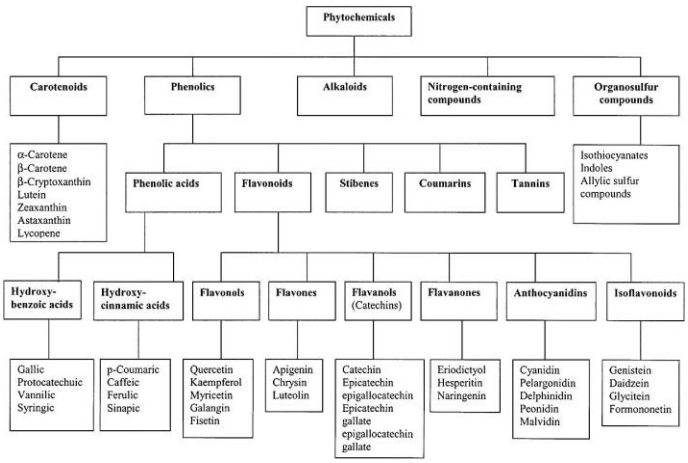

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Fig. 6 Classification of phytochemicals [11]

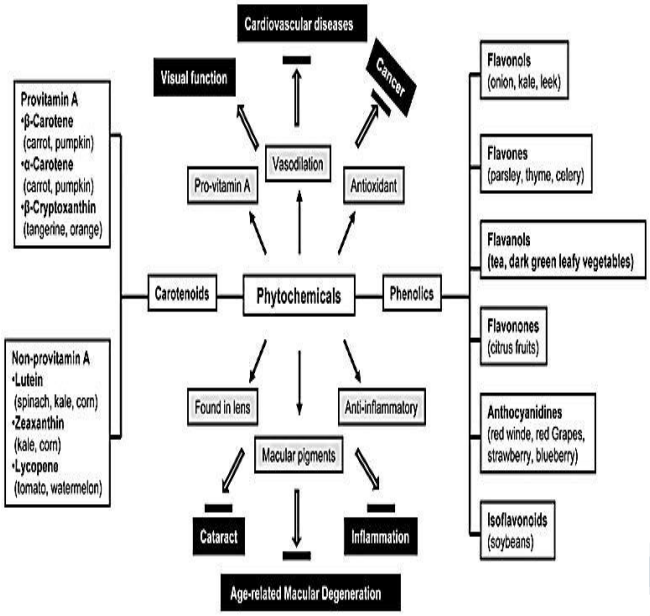

Fig. 7 Multiple health benefits of phytochemicals [11]

Phytochemical pigments with potent antioxidative and bioactive properties like flavanoids, anthocyanins, polyphenols etc., also belong to the second line of defense [22]. The retinoids like β - carotene, provitamin A and vitamin A are essential for vision, reproduction, growth and maintenance of epithetial tissues. β-carotene is an established excellent scavenger of singlet oxygen produced during photosensitivity [23]. Vitamin C and dehydroascorbic acid interact directly with radicals like O2– and HO● in plasma, thus preventing red cell membrane damage and probably assists α- tocopherol in the inhibition of lipid peroxidation by recycling the tocopherol radical. Ascorbate (radical) is reduced by intracellular GSH and is an admirable scavenger of many free radicals like O2, various lipid hydroperoxides and helps to detoxify many inhaled oxidizing air pollutants like ozone and NO2 and free radicals in cigarette smoke in the respiratory tract [24].

Vitamin E, a fat soluble antioxidant vitamin responsible for protecting PUFA (poly unsaturated fatty acid) present in cell membrane scavenges peroxyl radical intermediates in lipid peroxidation [25].

Carotenoids are indispensable cellular components in humans [26] which interact with free radicals that initiate harmful reactions such as lipid peroxidation besides having highest vitamin A activity [27].

Polyphenols are a large group of antioxidants naturally present in fruits and vegetables believed to have an antioxidative property by scavenging the free radicals, quenching hydroxyl radical (●OH), superoxide anion radical (O2●), DPPH radical etc. [28].

Flavanoids (Fig. 8) are a group of polyphenolic compounds that exhibit a wide range of biological effects including antibacterial, antiviral, anti-inflammatory, antiallergic and vasodilatory actions and exert effects as antioxidants, free radical scavengers [29]-[31]band divalent cation chelators [32].

Anthocyanins are natural colorants belonging to the flavanoid family, with anti-inflammatory and anticancer activity falling under the major dietary group of phytochemicals [29]-[31].

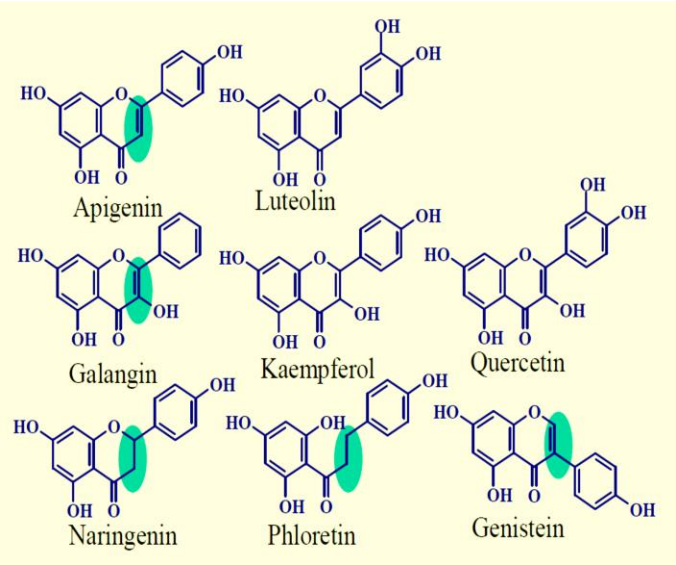

Fig. 8 Structure of some common flavonoids in herbs and spices [33]

They naturally occur in fruits and vegetables forming an integral part of human diet [34]. Two approaches have been recommended for the exploitation of medicinal plants for drugs. One is to extract the active ingredients from the original traditional medicinal sources and identify their chemical nature, establish its detailed pharmacology and develop it into a drug for clinical trials and distribution. The other is to evaluate the herbal remedy as it is used, by traditional healer without purification. If the crude product is found to be effective, further studies should focus on toxicity, dosage standardization, clinical trials and finally the inclusion of that preparation in modern Pharmacopoeia [35]. Besides natural antioxidants, chemists have synthesized and extracted many effective agents (e.g. butylated hydroxyl toluene and butylated hydroxyl anisole) to inhibit "free radicals" and oxidative damage from many different materials. Due to toxicity of artificial antioxidants, natural ones are more demanded. There are several kinds of natural components in "herbs" which possess antioxidative activity such as anthocyanins phenolic

compounds, flavonoids [36], and particularly the inclusion of "Culinary herbs" that provide varied health benefits pertaining to the above mentioned components [37].

IV. SPICES AS NUTRACEUTICALS

Spices widely used since ages for culinary purpose and in preservation also acts as functional foods. Spices have laxative, antibacterial, antipyretic, etc.) and have been effectively used in India as well as in other countries [38]. Increasing evidences suggest the inclusion of plant-based foods in regular diet to lower the risk of most chronic diseases, so spices are emerging as agents for prevention and treatment of various diseases, than just flavor aids. Besides, suppressing inflammatory pathways, spice-derived nutraceuticals can suppress initiation and progression of cancerous tissues. Overall attempt propose "adding spice to your life" may serve as delectable way to defend against tumor and other diseases [39].

Among the varied diversity of plant derived phytochemicals, flavonoids constitute largest family of protective phytochemicals present in fruits and vegetables. As a result of budding evidences of the versatile health effects from flavonoids through epidemiological studies there has been an increased attention in the research of flavonoids from dietary sources. It is important to evaluate flavonoids for humans since occurrence of flavonoid is directly associated with human dietary antioxidant consumption on a daily basis. Several epidemiological studies suggest that diets rich in antioxidant phytochemicals play a major role in health and disease. Numerous flavonoids possess antioxidant activity, scavenging potential, cardiovascular disease prevention, and anti-carcinogenic activity, while some flavonoids exhibit potential for anti human immunodeficiency virus infection. Thus it is very important to increase the awareness of consumer regarding the beneficial effects of plant based foods.. In recent years extracts of many plants have been screened for their antioxidant activities. Since flavonoids are rich source of antioxidants, it is desirable to assess the antioxidant potential of the flavonoids by extracting them from the natural sources and analyzing them using various analytical techniques [40].

V. CONCLUSION

Research activities in phytonutrients and their role in disease prevention are currently being pursued with great vigour. Studies carried out during the past 2–3 decades have shown that these phytochemicals have an important role in preventing chronic diseases like cancer, diabetes, coronary heart disease etc. Indian habitual diets, which are based predominantly on plant foods like cereals, pulses, oils and spices, are all good sources of these classes of phytochemicals, particularly dietary fibre, vitamin E, carotenoids and phenolic compounds. There is, however, much scope for further systematic research in screening Indian foods and diets for these phytochemicals and assessing their potential in protecting against chronic diseases.

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