Chapter

Phenolic Compounds

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Abstract

Phenolic compounds represent a group of molecules and its functions in the growth and development with a defense mechanism in plant. It includes pigments, signaling molecules, and flavors which will protect the plant against insects, fungi, bacteria, and viruses and plays a role to attract or repulse them. This current chapter includes different aspect of phenolic compounds were discussed such as the definition, chemical properties, classification, the biosynthesis process of phenolic compounds, extraction technologies in plants also includes the shikimate, pentose phosphate and phenylpropanoid pathways. They were having many health benefits like UV screens, attractants, signal compounds, and other response chemicals from different types. As per the human physiology, they are vital in protection and plays an important role in prevention and treatment of many chronic diseases. It also acts as antioxidant, antiseptic, anti-proliferative activities, antidiabetic, anti-inflammatory and anti-aging. They are useful to eat such plant foods that contains high antioxidant content, which can hamper the incidence of certain chronic diseases, such as cardiovascular diseases, diabetes and cancers, through the management of oxidative stress. Overall the phenolic compounds are a gift of god in our day to day lives.

Keywords: phenolic compound, chemical properties, biosynthesis, extraction technologies, health benefit

1. Introduction

Grains, mainly cereals and legumes, are important in every diets of human in any part of the world. They are rich in diverse nutrients and phytochemicals, and possess manifold bioactivities, such as antioxidant, antidiabetic, and anticancer effects [1–3]. Phenolic compounds [PC] are distributed everywhere in most of the plant tissues which includes the parts such as roots, stems, fruits, seeds, leaves, etc. [4]. There are more than 8000 individual plant with great chemicals isolated, structural variability and nearly 200000 were identified with diverse structures [5] and classes from higher plants around the planet. They are classified as primary metabolite and secondary metabolite [6]. The primary metabolite is required for cell nourishment, such as carbohydrates, proteins, fatty acids and nucleic acids. The secondary metabolite is essential to plant survival which directly involved in photosynthetic or respiratory metabolism. As differentiated from primary metabolite, the chemicals and structures of secondary metabolite are responsible for plant defense. They also protect the plant from oxidants and ultraviolet radiation and also act as attracting pollinators or animals for seed dispersion and signal compounds [6–8].

The secondary metabolite is classified according to their biosynthetic routes and structure; they are divided into three major groups: (1) flavonoids, allied phenolic,

and polyphenolic compounds; (2) terpenoids, and (3) nitrogen-containing alkaloids and sulfur-containing compounds. These compounds are linked to primary metabolite by biosynthetic enzymes and building blocks [8]. Phenolic compounds (flavonoids, allied phenolic, and polyphenolic compounds) are one among the secondary metabolites more cosmopolitan in plants. The shikimate, pentose phosphate and phenylpropanoid pathways are extract from plants. These compounds perform an important role in the growth and reproduction of plants, giving protection against pathogens and predators. In vegetables and fruits, PC contribute to color and sensory characteristics [8, 9].

2. Phenolic compounds: definition, chemical properties, classification, biosynthesis, extraction technologies and medical importance

2.1 Definition

The compounds that have one or more hydroxyl groups connected straightway to the ring of an aromatic. The whole category is based on the arrangement of phenol (**Figure 1**).

In phenols, the hydroxyl group is linked to a chain of carbons which are alike to alcohols of aliphatic structures. Due to the existence of the aromatic ring, the phenolic hydroxyl group is affect. The hydrogen of the phenolic hydroxyl is unstable caused by the aromatic ring, that build the phenols as a weak acid [10].

Its structure consists of an aromatic ring that contain 1 or more hydroxyl substituents. It may be classified into simple phenolic molecule and extremely polymerized compounds. The PC occur naturally is associated with one or more phenolic groups when combine with mono- and polysaccharides. In addition, they also can be linked to esters and methyl esters. They have a wide range in structure diversity that occurs in nature. More than 8000 structures of phenolic compound are studied till now [8].

2.2 Chemical properties of phenolic compounds

2.2.1 Benzene ring

The carbon's atomic number is 6, i.e. it has 6 electrons and 6 protons. Electrons are around the atom's nucleus in orbitals. The benzene ring is representing one of two mesmeric complex. The double arrow indicates, the two drawn structures and the true structure of the molecule lies in between. Hence, as the six C-C bonds of the ring are identical, with the π-electrons over the entire ring which is more accurate to use structure. The affects of reactivity of aromatic compounds is due

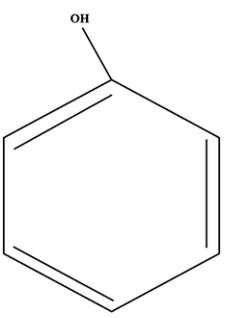

Figure 1.
Phenol.

to delocalization of the π-electrons is very much favorable and also have tendency to refurbishing aromaticity. Aromatic compounds do not easily undergo any addition reactions and a double bond is replaced by two single bonds, as we see in regular alkenes i.e., linear chains of carbon atoms containing at least one double bond. Aromatic compounds show a partially replaced the reactions, that means the replacement of atoms [9, 10].

2.2.2 Phenolic hydroxyl group

It depends upon the chemical properties of the benzene with a hydroxyl group ring and the foremost property is acidity which are generally weak acids. As compared to hydroxyl group of unsubstituted aliphatic alcohols, phenolic OH-group is more acidic [8–10].

2.3 Classification

The word phenolics includes a very wide group of chemical compound. They can be classified in many ways. Harborne and Simmonds (1964) classified these compound into groups depends upon the numeral of carbons in the molecule. (**Table 1**) [9].

An another classification represented by Swain and Bate-Smith (1962). They categorized the phenols as "common[typical]" and "less common [less typical]".

Structure	Class
C6-C1	simple phenolics
C6-C2	phenolic acids and related compounds
C6-C3	acetophenones and phenylacetic acids
C6-C3	cinnamic acids, cinnamyl aldehydes, cinnamyl alcohols
C15	coumarins, isocoumarins, and chromones
C15	chalcones, aurones, dihydrochalcones
C15	Flavans
C15	Flavones
C15	Flavanones
C15	Flavanonols
C15	Anthocyanidine
C15	Anthocyanine
C30	Biflavonyls
C6- C1- C6, C6- C2- C6	benzophenones, xanthones, &$$$;tilbenes
C6, C10, C14	Quinones
C18	Betacyanine
Lignans, neolignans	Dimers or oligomers
Lignin	Polymers
Tannins	oligomers or polymers
Phlobanhenea	Polymers

Table 1.
Classification of phenolic compounds.

Ribéreau-Gayon (1972) classified the phenols into three origins which is as follows: [10].

1. It is widely distributed in all plants or in a specific plant.

2. It is less widely distributed to known in confined number of compounds.

3. Phenolic component exists as polymers.

2.4 Biosynthesis of phenolic compounds

The biosynthesis of PC to exhibit the origin of the various families which precursors. The review of accepted pathways, newly illuminated steps in the biosynthesis for isolation of protein, gene cloning, and protein characterization.

2.4.1 Protein isolation and purification

The conventional methodology for the isolation of proteins includes the techniques for the separation of biochemical, where the protein is isolated from the other proteins based on its special chemical and physical properties. This involves molecular mass i.e. size, shape, net charge and hydrophobicity. The isolation procedure starts with the mixture of a cell extract is recognize in the course of the enzyme activity. This mostly involves crushing of the tissue in an extraction buffer and the contents of the cell [proteins] become accessible. To avoid proteolytic degradation of the enzyme, add protease inhibitors i.e. phenylmethyl sulphonylfluoride (PMSF), in the mixture of the extraction buffer. The first step is a centrifugation where the enzyme is precipitated or otherwise ends up in the supernatant which is bound to the cell wall or the cell membrane, Soluble proteins are usually separated from one another by their solubility in high-salt solutions with supported variation. Add a salt, followed by centrifuge to remove the precipitated proteins that will be fruitful strategy for proteins to separate from each other. During saturation, ammonium sulfate is usually used to precipitate proteins, as most of the proteins in the solution of this salt. The quantity of ammonium sulfate must be mixed in order to avoid subset of the proteins in the extract which can be determined by enzyme activity assays on the various fractions. Likewise, other salts, trifluoroacetic acid, protamine sulfate, polyethylene glycol, apolar solvents etc. are often used for the proteins precipitation. The next step used for further purifying the enzyme is chromatography such as High-performance liquid chromatography (HPLC), Hydrophobic interaction chromatography (HIC), Ion exchange chromatography(IEC) Bio-affinity chromatography (BAC), fast protein liquid chromatography (FPLC) and Gel filtration or size exclusion chromatography (GFC). When a fraction is obtained is the only protein during this procedure then purification is completed to homogeneity, or any contaminants are remained below the level of observation [8, 10, 11].

2.4.2 Gene cloning

It depends upon the phenolic content or its composition that are present in mutants that can altered incapable cloning of the mutated gene and cloning of the wild type of the gene [normal]. If a plant lacks in a particular phenolic compound as which is the results of a mutation, the wild type of the gene will indicate as the wild-type allele that plays an important role in the compound for biosynthesis process. The sequence of the protein encoded by the gene and this sequence of the gene can

be used to deduce the amino acid present in the compound. The polymerase chain reaction was revolutionized the clone genes and it involves three steps:

a. Denaturation: To separate the two DNA strands of the template performed at 94 °C.

b. Primer annealing: It was performed at 45-70 °C depending on the GC-content and length of the primer.

c. Extension: It was performed at specific temperature recommended by the manufacturer of the enzyme Particularly at 72 °C, during which the polymerase synthesizes the DNA delineated by the primers. This procedure is repeated 20-40 times, and in each cycle every template strand is being replicated. PCR is the preferably used technique in plant, animal and microbial biology also as medicine. PCR is also considered for cloning of genes and cDNA's, and taken for genotyping using molecular markers [10, 11].

2.4.3 Insertional mutagenesis

On the basis of known sequence, which is also referred as tag in the gene of interest. There are two methods done for cloning purposes.

1. Tagging: A spontaneous or chemically induced mutant, which was been identified with no information accessible about the mutant gene.

2. Random Tagging: It is based on Principle of insertion of any gene. All the genes managing the trait of interest were rarely covered, until the mutation is not lethal [10, 11].

2.4.4 Map-based cloning

It involves identification of the molecular marker(s) which are associated with the mutation. The mutant plants will show mutation when closely linked with predominant marker allele from the mutant parent, whereas wild-type parent marker allele will show wild-type plant Once the accurate mapping is achieved, the gene sequence will be obtained on the availability of genome sequence [10, 11].

2.4.5 Candidate-gene approach

This approach is possible once there is establishment of protein databases and large DNA then the candidate gene is defined as defective gene that can originate the mutant phenotype. Once the candidate gene is identified the sequence databases were searched to identify DNA or protein sequences from the candidate gene [10–12].

2.4.6 Quantitative trait locus mapping

This can show the position of the identified candidate gene. QTL; the abbreviation for the quantitative trait loci), that can be defined as a genetic locus described by two molecular markers on a genetic map affecting a quantitative trait which is identified in 2 parental lines which differs from each other and are identified in F2 population. The F2 population are evaluated to separate the genetic and environmental effects on the trait in several locations and for years. Later the QTL was mapped to the sector of chromosome [10, 11].

2.4.7 Isolation and characteristics of recombinant proteins

Data of the purified recombinant proteins obtained from in-vitro assays can be interpreted much easily than data of crude or partially purified protein extracts that are stored from experiments. It can be due to these reasons:

1. No competing proteins with similar action.

2. No enzymes present which convert the enzyme of interest, and it reduce the concentration [10, 11].

2.5 Other biosynthesis of phenolic compounds

2.5.1 Carbohydrate catabolism

The carbohydrates for plants are acquired from photosynthesis process from the atmosphere, a fixed CO_2 is converted to carbohydrates from sunlight. The photosynthesis process within the cell for carbon-based metabolites including phenolic compounds helps the carbohydrates to form the building blocks. The two catabolic processes are the precursors of plant phenolic compounds within the plant cell. This includes many pathways such as glycolysis, pentose phosphate, phenylpropanoid pathways etc.

2.5.1.1 Glycolysis

It is also known as Embden-Meyerhof-Parnas pathway, carbohydrates generated during photosynthesis from the catabolic process are broken into pyruvate, and ultimately CO_2. This method plays two fundamental roles:

1. Building blocks for anabolism.

2. Oxidization for hexoses to urge ATP reductant, and pyruvate [10–14].

2.5.1.2 The pentose phosphate pathway

It is used to generate NADPH (nicotinamide adenine dinucleotide phosphate) It is to interrupt glucose, break down that can be used by plant. It provides sugar links that delivered as building blocks for nucleic acids and aromatic amino acids.

This pathway is divided into two phases:

1. Oxidative phase: In this phase, the glucose-6-phosphate is converted to ribulose5-phosphate,

2. Non-oxidative phase: in this phase, by reversible reactions two pentose-phosphate residues are transform to sugar- phosphate molecules [8, 10–13].

2.5.1.3 The shikimate pathway

It includes the biosynthesis of chorismate, which may later work as a precursor for the biosynthesis of the aromatic amino acids like tyrosine phenylalanine and tryptophan. This pathway was reviewed by Weaver and Herrmann [17] and Hermann and Weaver [18] in biochemistry. It was seen in both plants and microorganisms. Shikimate was synthesized from the substrates erythrose 4-phosphate

and phosphoenolpyruvate. By glycolysis and the pentose phosphate pathway, these two precursors are extracted respectively, and by the enzyme DAHP synthase, they are condensed to 3-deoxy-D-arabino-heptulosonate 7- phosphate. This steps end in the formation of 3-dehydroquinate by the enzyme 3- dehydroquinate synthase, 3-dehydroshikimate and 3- dehydroquinate dehydratase, and finally shikimate by the enzyme shikimate dehydrogenase. Shikimate was converted to shikimate 3-phosphate by shikimate kinase, then to 5-enolpyruvylshikimate 3-phosphate by 5-enolpyruvylshikimate 3-phosphate synthase. EPSP is then obtained to chorismate by chorismate synthase. Chorismate is bifurcate tryptophan on the one hand, and phenylalanine and tyrosine on the opposite hand for the biosynthesis of aromatic amino acids [8, 10–16].

2.5.1.4 The general phenylpropanoid pathway

It was generating a substratum to phenylpropanoid compounds which includes coumarins, monolignols, hydroxycinnamic acids, flavonoids, stilbenes and sinapoyl esters. This pathway starts with phenylalanine via the shikimate pathway. It catalyzed phenylalanine by the enzyme phenylalanine ammonia lyase (PAL) and ends in cinnamic acid. Later, it was hydroxylated by cinnamic acid 4- hydroxylase (C4H) transfer to p-coumaric acid [10, 11].

2.5.2 Biosynthesis of phenolic acids

Phenolic acids are not abundant in most plants. There are in the form of gallic acid and salicylic acid. Gallic acid may be a precursor for the ellagitannins and gallotannins. Salicylic acid is an important defense property that mediates systemic acquired resistance (SAR), and it is also used as a signaling molecule to relay information on pathogen attack to other parts of the plant. After receiving the SA signal, a defense response is trigger the biosynthesis of pathogenesis-related (PR) proteins [8, 10].

2.5.3 Biosynthesis of flavonoids and condensed tannins

In the process of flavonoid biosynthesis, the identification and isolation of genes by the flavonoids which are a colored compound. Mutant phenotypes are identifiable from variation in color easily. The flavanonols can converted to anthocyanins. Condensed tannins transformed from polymerization of flavonoids [8, 11].

2.5.4 Monolignol biosynthesis

They are synthesized from pcoumaroyl-CoA via the shikimate and phenylpropanoid pathways and are the component of lignans and lignin, and some of them are serve as precursors for sinapoyl esters and hydroxycinnamic acids [8, 10, 11].

2.5.5 Lignan biosynthesis

In this process, the oxidative coupling of monolignol radicals are synthesized. *The monolignol radicals are generated through the action of laccases or peroxidases*. Lignans are active, and a typical pair of chemical compound which is present in some species and it binds in between the monolignols [regio-chemical control], thereby both the coupling sites and their position of the 2 monomers are controlled [10, 11].

2.5.6 Lignin biosynthesis

It involves many enzymes where the genes encoding of these enzymes need to be uniformly communicate. Lignin is a complex polymer obtained from the oxidizing the coupling of monolignol radicals. The plant's cell wall contains the polymerization of lignin, thus the monolignols has to be transferred from the cytosol and get synthesized in the cell wall [10, 11].

2.5.7 Hydroxycinnamic acid biosynthesis

By the action of 4CL as well as the corresponding CoA-esters, the biosynthesis of the hydroxycinnamic acids caffeic acid, ferulic acid, 5-hydroxyferulic acid, and sinapic acid from p-coumaric acid, the hydroxycinnamic acids are synthesized through the oxidation of aldehydes, instead of ring substitutions of the free acids. It suggests that the glucosides are messenger of th Coenzme A ester and the ring appears at the level of free acid in the lignin biosynthetic pathway [8, 11].

2.5.8 Biosynthesis of sinapoyl esters

In the phenylpropanoid pathway, Sinapaldehyde is acquired from the amino acid phenylalanine which is followed by a number of reactions of the hydroxylation and methylation [10, 11].

2.5.9 Coumarin biosynthesis

The coumarins and hydroxycoumarins are synthesized from trans-p-coumaric acid and trans-cinnamic acid in plants respectively, but the complete mechanism of its synthesis is still unknown. The possible way to biosynthetic route that coumarin is through hydroxylation to give coumaric acid, followed by glycosylation to result in trans-coumaric acid-2-O-glucoside [8, 11].

2.5.10 Stilbene biosynthesis

It has been a target for genetic engineering of disease resistance in plants, which appears similar to chalcone synthase and it is derived from the condensation of p-coumaroyl-CoA with three malonyl-CoA residues [10, 11].

2.5.11 Biosynthesis of gallotannins and ellagitannins

They are inventing from the hydrolysable tannins and 1,2,3,4,6-penta-O-galloyl-β-D-glucopyranose. Gallotannins consist of 10-12 gallic acid moieties per molecule. Ellagitannins are construct from the oxidative of gallic acid residues in pentagalloylglucose molecules which gives in the formation of C-C coupled 3,4,5,3′,4′,5′-hexahydroxydiphenoyl (HHDP) residues [10, 11].

2.6 Extraction technologies for phenolic compounds

2.6.1 Solid–liquid extraction

By using aqueous organic solvents from solids, the soluble constituents are removed. The selection of solvents should be accurate so that chemical or physical intervention should be within the matrix. In this method, variable such as

temperature, pH, particle size, time, solvent polarity, solid–liquid ratio and riveting should be improved in order to obtained high yields of recovery of the compound which was selected. Few drawbacks of this method includes cost, toxicity, solvent combustible and also prolonged extraction times. It can be used to get PCs from herbal substance. Some methods in this extraction includes the use of poisonous solvents, low cost and can be used in combination with any other extraction techniques [4, 10, 17–19].

2.6.2 Soxhlet extraction

It usually contains the matrix with pure and hot solvent. In this way the extracted will be greater in the substance. This method is inexpensive related to energy, time and reactant. Soxhlet extraction were done in small scales in batches and can be adapted to continuously in industrial procedure. The main privilege than novel method, such as ultrasound assisted, microwave-assisted, fastidious fluid, and accelerated solvent extractions in terms of industrial implementation, consistency, effectiveness, and extract manipulation. The main disadvantage was the sensitivity of some compounds to the temperature conditions of extraction. The variants of this technique are: high-pressure, automated, ultrasound-assisted, and microwave-assisted Soxhlet extraction [4, 20].

2.6.3 Pressurized fluid extraction and supercritical fluid extraction

The extraction method is like Soxhlet extraction, then again, actually the solvents are utilized in tightening influences close to their supercritical area, so the raised temperature permits a more prominent dispersion and dissolvability of the solute to be extricated. At the point when the high pressing factor applied to the framework, the dissolvable beneath its limit is permitting the better focus in the network. These working conditions permit the utilization of low dissolvable volumes and lessen extraction times. The second extraction strategy comprises of the detachment of a compound (strong or fluid) from a grid, utilizing liquid as a dissolvable under supercritical conditions. Under supercritical conditions a liquid coincides in both fume and fluid states. The most ordinarily utilized liquids is carbon dioxide (CO2), which is joined with ethanol to change its extremity. The upsides of CO2 as extraction liquid are: moderate supercritical conditions (31.1 °C and 73.8 MPa), nonattendance of harmfulness, substance security, simple to reuse, and ease. The upsides of supercritical extraction will be: extraction limit like fluid natural solvents and the concentrates are cleaner. Mechanical utilization of supercritical liquid extraction was restricted since this strategy were created in detachment of other handling steps that are important to acquire an item [4, 18].

2.6.4 Ultrasound-assisted extraction

They used to remove bioactive mixtures, similar to cancer prevention agents, fundamental oils, steroids, and lipids from plants. The utilization of ultrasound improves the entrance of the dissolvable into cell materials, encouraging mass exchange and the arrival of the mixtures to be removed. The recurrence of ultrasound impacts the yield and extraction energy. At frequencies >20 kHz sound waves produce extension pressure cycles, in a fluid this outcome in the arrangement of air pockets that develop and breakdown close to the strong network, encouraging extraction [4, 21].

2.6.5 Microwave-assisted extraction

Microwaves are electromagnetic waves comprising of an electric field and an attractive field that waver oppositely to one another at frequencies somewhere in the range of 0.3 and 300GHz. The microwave energy acts straightforwardly on the particles by ionic conduction and dipole revolution, motivation behind why just polar materials can be warmed as such. The microwave-helped extraction relies upon the dielectric defenselessness of both dissolvable and network. Since the water inside the lattice assimilates microwaves, the interruption of the material is controlled by an inward overheating, which likewise improves the recuperation of the extricated compound. Microwave-helped extraction is characterized into shut and open frameworks. In a shut framework, the extractions are done in a fixed vessel under uniform warming; in this framework the high pressing factor and temperature permit fast and proficient extraction. Then again, open frameworks are more reasonable for extricating thermolabile mixtures, since they work under less extraordinary conditions [4, 22].

2.6.6 Pulsed electric field extraction

The cellular wall and cell membranes act as protective layer that prevent the bioactive compounds extraction in animal and plant tissues. The transmembrane segment of the cell lead to pores or electroporation by the application of an electric field. The power of the electrical pulses provides is changeable or unchangeable may form the electroporation. The pores are small associated to the whole area of the current or electric and its membrane breakdown may vary. On the contrary, increasing the intensity and time of the treatment, it is irreversible to the permeability of cell membrane [4, 23].

2.6.7 Enzyme-assisted extraction

An alternative method to solvent-based extraction. It depends on the enzymes to selectivity and catalyze reactions in aqueous humor. On the constituent of cell membranes, the enzymes with hydrolytic activity such as cellulases, hemicellulases, pectinases, etc. increases cell wall permeability and bioactive compounds extraction was yield such as antioxidants, pigments and compounds with pharmaceutical applications [4, 10, 11, 24].

2.7 Medicinal importance of phenolic compounds

Current studies have associated that consuming the foods are abundant in PC are beneficial in prevention of non-communicable diseases or lifestyle disorder which includes cardiovascular diseases, certain group of cancer, and diseases associated with aging [25]. The biological effects acquired from PC were trait to antioxidant properties [26].

They are as follows.

2.7.1 Antiseptic

PC have effects on human health which was revealed by Bravo in 1998 [29]. PC was used phenol as an antiseptic from ancient times. Now a day, it is no longer used due to, its side effects on living tissues that create blister formation specially on high concentrations. As an antiseptic agent, it is effective against the bacterium *Staphylococcus aureus* i.e. 5% (w/v) solution of phenol. It is used as an oral esthetic with the concentration of 1.4% in throat pastille. It is also in sunscreens lotions. It

helps to prevent sunburns due to the presence of the aromatic ring which is an effective absorbance of the UV-B radiation (ranging from 280 and 315 nm) from the sun. It was widely used since the 1970's and nowadays due to the formation of skin rashes and acne the usage is reduced [10, 27].

2.7.2 Antioxidant

The oxidative damage and an imbalance to large biomolecules, like lipids, DNA, and proteins may be due to overproduction of oxidants in physical body. This damage includes the pathogenesis of many human diseases i.e. cardiovascular diseases (CVD), certain sorts of cancers and aging. Thus, it could be a crucial role for the prevention and treatment of chronic diseases by antioxidant phytochemicals which are demonstrated to have antioxidant abilities in human studies. Compounds are scavenging radicals that are referred as antioxidants. The important anti-oxidants are vitamin C and vitamin E. A lack of vitamin C in the diet leads to scurvy. The symptoms include rotten gums, purple lesions on the skin, loss of teeth etc. Vitamin E is a mixture of α-, β-, γ-, and δtocopherol in that α-tocopherol is the most effective. Vitamin E is lipid-soluble and has the ability to disrupt the chain reaction at the time of lipid peroxidation. They provided many health benefits by antioxidant activity of polyphenols [10, 28].

2.7.3 Protective against cardiovascular diseases

Polyphenols are helpful for preventing and treating CVD by antioxidant activity and also by other bioactivities such as preventing platelet aggregation. Anti-inflammation and adhesion which includes oxidative stress and other damage because they owe other physiological effects, like blood pressure reduction etc. [4, 29, 30].

2.7.4 Anti-obesity activity

This activity includes quercetin which may be mediated by mitogen-activated protein kinases signaling pathways (MAPK) and the adenosine monophosphate-activated protein kinase (AMPK), respectively in mature adipocytes and pre adipocytes [4, 31].

2.7.5 Anti-diabetic activity

Due to hyperglycaemia and hyperlipidaemia, diabetes is usually associated by expand the yielding of free radicals or oxidative stress. There is a remarkable decrease in plasma antioxidants in diabetes and its complication. The metabolic homeostasis was better, and the development of T2D and its complications was observed in Cohort studies showed that was retard or prevented by taking of whole grain foods [32, 33]. PCs such as flavonoids and phenolic acids are helpful in promoting health by decreasing the high risk of metabolic syndrome and the associated complications of type 2 diabetes [33–37].

2.7.6 Antiaging activity

An important factor in aging or age-associated degenerative diseases, the free radicals and oxidative stress have been believed as an antioxidant systems are declined during aging. Antiaging activities is explained by different mechanisms and revealed by antioxidant phytochemicals [34–37].

2.7.7 Protective action on Alzheimer's disease

It is particularly susceptible due to high concentration of free radicals without appropriate levels of anti-oxidation. In elderly people, the pathogenesis of dementia or AD shows oxidative stress. The study on walnuts shows that polyphenolic compounds helps to release the oxidant and decrease the inflammatory signs on the brain cells. It also repairs, the increased neurogenesis, inter-neuronal signaling, upgrade isolation of insoluble toxic protein accumulates, that play a role in preventing AD. Thus, by decreasing the oxidant stress and acetylcholinesterase that may protect or prevent against AD [4, 38].

2.7.8 Anti- cancer activity

A huge amount of fruits and vegetables in our diet had shown, a decrease risk of human cancers such as breast cancer, lung cancer, colon cancer and prostate cancer. It is revealed that flavonoids are of special attraction and bioactive compounds in plant providing defensing effects. A study shows that in mice, it provides protection against cancer of skin which are caused through ultraviolet radiation or chemical carcinogens by consumption of tea and its polyphenolic constituents [39–43].

2.7.9 Miscellaneous

Plant PC provide a means for preventing the side effects that fungal toxins (mycotoxins) and also serving in detoxification [41]. Many of the volatile PCs, such as the main PC of cloves i.e. eugenol (a hydroxyphenyl propene), or a typical component of oregano i.e. carvacrol (phenolic terpene), curcuminoids or Curcumin (diferuloylmethane) are which found only in the rhizomes of *Curcuma longa* [turmeric] are achieved. Curcumin as we all known plays an important role of various illnesses from cancer to autoimmune, neurological, cardiovascular, and diabetic etc. in the form of preventing and treating diseases [33, 42–45].

3. Conclusion

Phenolic compounds are widely found in plants with many functions and some act as defense elements against herbivores and pathogens. There are number of vegetables and fruits that contain PCs. They are classified in a range of groups according to their structure. The biosynthesis pathway explained its metabolism in plants which are beneficial to us in many ways. The recent studies show different new technics to extract phenolic compounds and studies are still under observation in prevention of many diseases. Its variations give them diverse characteristics, which helps to prevents many chronic and lifestyle disorders, like antioxidant activity, antiseptic properties, anti-diabetic activity, anti-aging, *Alzheimer's Disease*, anti-obesity, improves cardiac activity etc. Many studies were conducted to show an essential and effective antioxidant power of phenolic compounds and extracts, considering their bioavailability and bio-efficacy of phenolic compounds, which could influence the antioxidant power response, that are necessary to improve the health and well-being of people directly or indirectly. The large number of publications available on phenolic compound research and their extraction from plants over the past decade gives signifies the importance of this chapter.

Acronyms and abbreviations

AD	Alzheimer's Disease
AMPK	adenosine monophosphate-activated protein kinase
ATP	Adenosine triphosphate
BAC	Bio-affinity chromatography
CAT	catalase
C-C	Carbon Carbon
CVD	cardiovascular diseases
C4H	cinnamic acid 4- hydroxylase
cDNA	Complementary DNA
DNA	Deoxyribonucleic acid
EPSP	5-enolpyruvylshikimate 3-phosphate synthase
FPLC	fast protein liquid chromatography
GC	Guanine-cytosine
GFC	Gel filtration or size exclusion chromatography
GHz	Gigahertz
GPx	glutathione peroxidase
HHDP	3,4,5,3′,4′,5′-hexahydroxydiphenoyl
HIC	Hydrophobic interaction chromatography
HPLC	High-performance liquid chromatography
IEC	Ion exchange chromatography
kHz	kilohertz
MAPK	Mitogen-activated protein kinases
MPa	megapascal
NADPH	nicotinamide adenine dinucleotide phosphate
NF-κB	nuclear factor kappa light chain enhancer of activated B cells
OH	Hydroxy
PABA	para-aminobenzoic acid
PAL	phenylalanine ammonia lyase
PC	phenolic compound
PCR	polymerase chain reaction
PH	potential of hydrogen
PMSF	phenylmethyl sulphonylfluoride
PR	pathogenesis-related
QTL	Quantitative trait locus
RNS	reactive nitrogen species
ROS	Reactive oxygen
SAR	systemic acquired resistance
SOD	superoxide dismutase
T2D	Type 2 diabetes
UV	Ultra violet
4CL	4-coumarate-CoA ligase
%	percentage
(w/v)	concentration of solution

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