1 Introduction to the Major Classes of Bioactives Present in Fruit

Anusooya Gnanavinthan

BIOACTIVES

Bioactives are compounds that produce physiological effects when present in a living material, in other words they must exert physiological benefits related to promoting health and preventing effects of a disease (e.g. blood pressure reduction, blood glucose reduction etc.) (Aluko, 2011; Awika, 2011). When bioactives are taken orally, the compound must withstand the digestion that will destroy the active structure and render it physiologically inactive. But, in some cases, the inactive part of the compound becomes active once consumed, as a result of the action of digestive enzymes present in the gastrointestinal tract (Aluko, 2011). Also, bioactive compounds may exert their physiological effect within the digestive tract and may not be absorbed. However, in most cases, the compound must be absorbed from the gastrointestinal tract into the blood circulatory system, from where it is carried to target organs. Foods that contains bioactives, and that are consumed as part of a normal diet, are called functional foods (Shahidi, 2009).

Plants are a rich source of bioactive compounds. Plant-derived bioactive products such as fruits, vegetables and nuts are becoming popular because of their abundance and low cost (compared to animal products), and due to the wider acceptability of plant products as a result of religious, social or moral reasons that prevent many people consuming animal-derived products (Omaye *et al.*, 2000; Aluko, 2011). Bioactives from fruits show antimicrobial activity, anticancer activity, anti-inflammatory activity, immuno-stimulatory activity and antioxidant activity and so on (Hollman and Katan, 1999; Emilio, 2007; Weston, 2010).

CLASSIFICATION OF PLANT-DERIVED BIOCTIVES

Bioactives can be classified based on molecular identity or biopolymer type that includes polyphenolic compounds, indigestible carbohydrates (dietary fibres), functional lipids (mainly in cereals and seeds), proteins and peptides and carotenoids (Figure 1.1).

Phenolic compounds

Plant phenolics are a structurally diverse class of phytochemicals (Naczk and Shahidi, 2006). Phenolic compounds are defined by the presence of at least one aromatic ring bearing one

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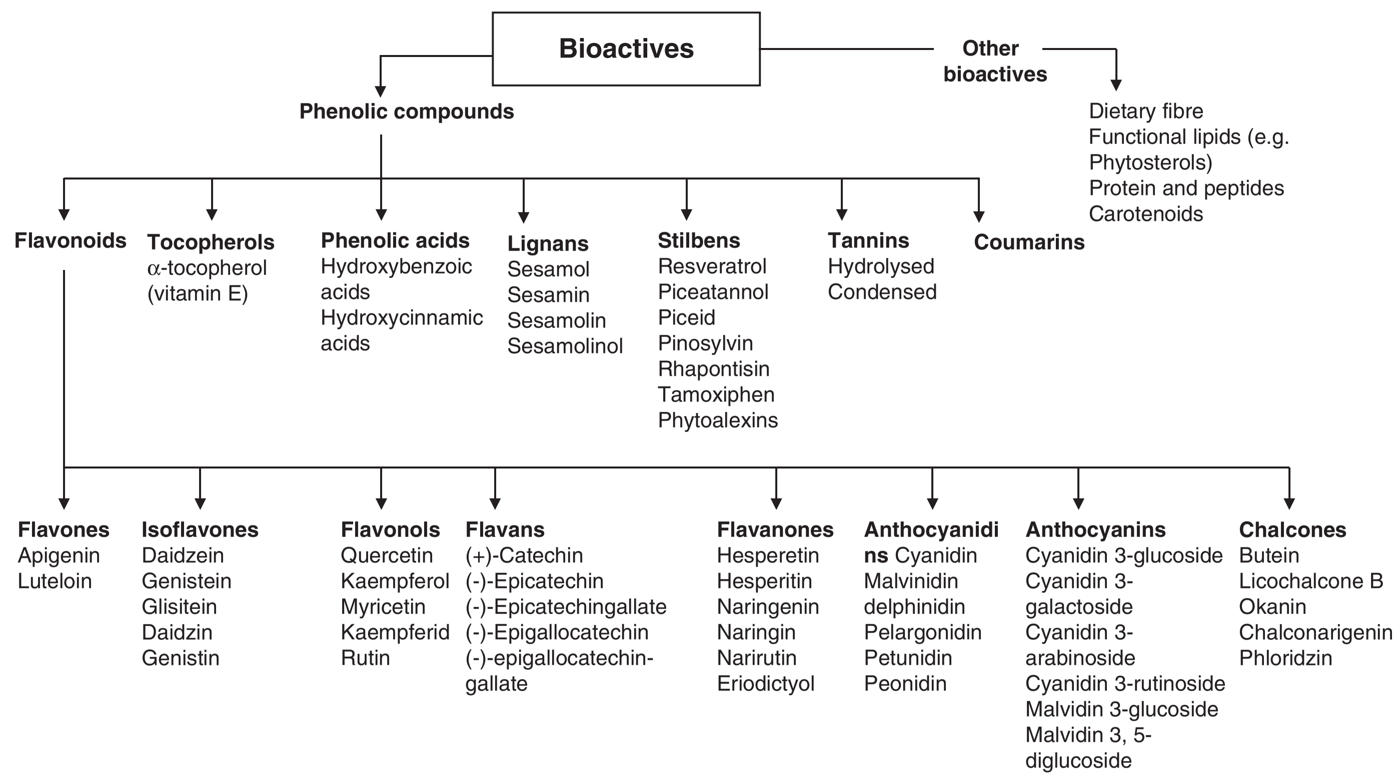


Fig. 1.1 Possible classification and examples of plant bioactive compounds (Von Elbe and Schwartz, 1996; Hollman and Katan, 1999; Tokuşoğlu and Hall, 2001; El Gharras, 2009; Naczk and Shahidi, 2006).

(phenol) or more (polyphenols) hydroxyl substituents, including their functional derivative (e.g. esters and glycosides) (Maffei, 2003). Polyphenols occur as plant secondary metabolites, are widely distributed in the plant kingdom and represent an abundant antioxidant component of the human diet (Tokuşoğlu, 2011). There has been an increased interest in the health benefits of polyphenols due to the corresponding antioxidant capacities (Wang *et al.*, 1996; Sun *et al.*, 2002).

Free radicals (reactive oxygen species) and antioxidant studies play a major role in medicine. Free radicals are produced by many biological reactions in the body and can damage crucial biomolecules. If these free radicals are not scavenged, they may lead to disease conditions (Fan *et al.*, 2007). Reactive oxygen species (ROS), such as superoxide (O_2^-), the hydroxyl radical ($^\bullet OH$), hydrogen peroxide (H_2O_2) and lipid peroxide radicals, have been implicated in playing an important role in chronic degenerative disease, such as cancer, inflammatory, cardiovascular and neurodegenerative diseases, and ageing (Mullen *et al.*, 2002; Price *et al.*, 2006; Sies, 2010). The harmful actions of free radicals can be blocked by antioxidants, by scavenging those free radicals and detoxifying the organisms (BeMiller and Huber, 1996; Fan *et al.*, 2007). Therefore, antioxidants are referred to as compounds that can counteract the damaging effects of oxygen in tissues, and the term is applied to molecules that protect from any free radical (molecule with unpaired electron) (Bilgiçli *et al.*, 2007). Antioxidants in food are defined as any substance that can relay, retard or prevent the development of food rancidity due to oxidation (Gordon, 2001). Natural antioxidants may inhibit lipid peroxidation in food and improve the quality and safety of the food (Fan *et al.*, 2007). Two inhibitory mechanisms may be involved: direct scavenging of free radicals (primary antioxidant, e.g. vitamin E – α-tocopherol) and indirect scavenging of free radicals (secondary antioxidant) (Gordon, 2001).

Types of antioxidants

1. Synthetic antioxidants: e.g. butylated hydroxyanisol (BHA), butylated hydroxytoluene (BHT), tertiary butylhydroquinone (TBHQ), ester of gallic acid and so on. BHA and BHT are heat stable and used for stabilization of fats in baked and fried foods (Gordon, 2001).
2. Natural antioxidants: the majority of natural antioxidants are phenolic compounds and grouped into **tocopherols, flavonoids, phenolic acids, cinnamic acid derivatives, lignans, stilbenes, tannins and coumarins** (Shahidi and Naczk, 1995; Von Elbe and Schwartz, 1996; Gordon, 2001; El Gharras, 2009). Natural antioxidants are more potent, efficient and safer than synthetic ones (Shi *et al.*, 2001).

Natural antioxidants

Flavonoids

Flavonoids are the main bioactive compounds found in fruits. They include a larger group of natural antioxidants (Haminiuk *et al.*, 2012). The structure of flavonoids contain a C_6–C_3–C_6 carbon skeleton (two aromatic rings linked by a three-carbon aliphatic chain which is condensed to form a pyran or a furan ring) (Shahidi and Naczk, 1995). Flavonoids comprise subclasses of flavones, isoflavones, flavonols, flavans, flavanones, anthocyanidins, anthocyanins and chalcones (Figures 1.1 and 1.2). Flavonoids that are linked to one or more sugar molecules are called flavonoid glycosides; when they are not connected to a sugar

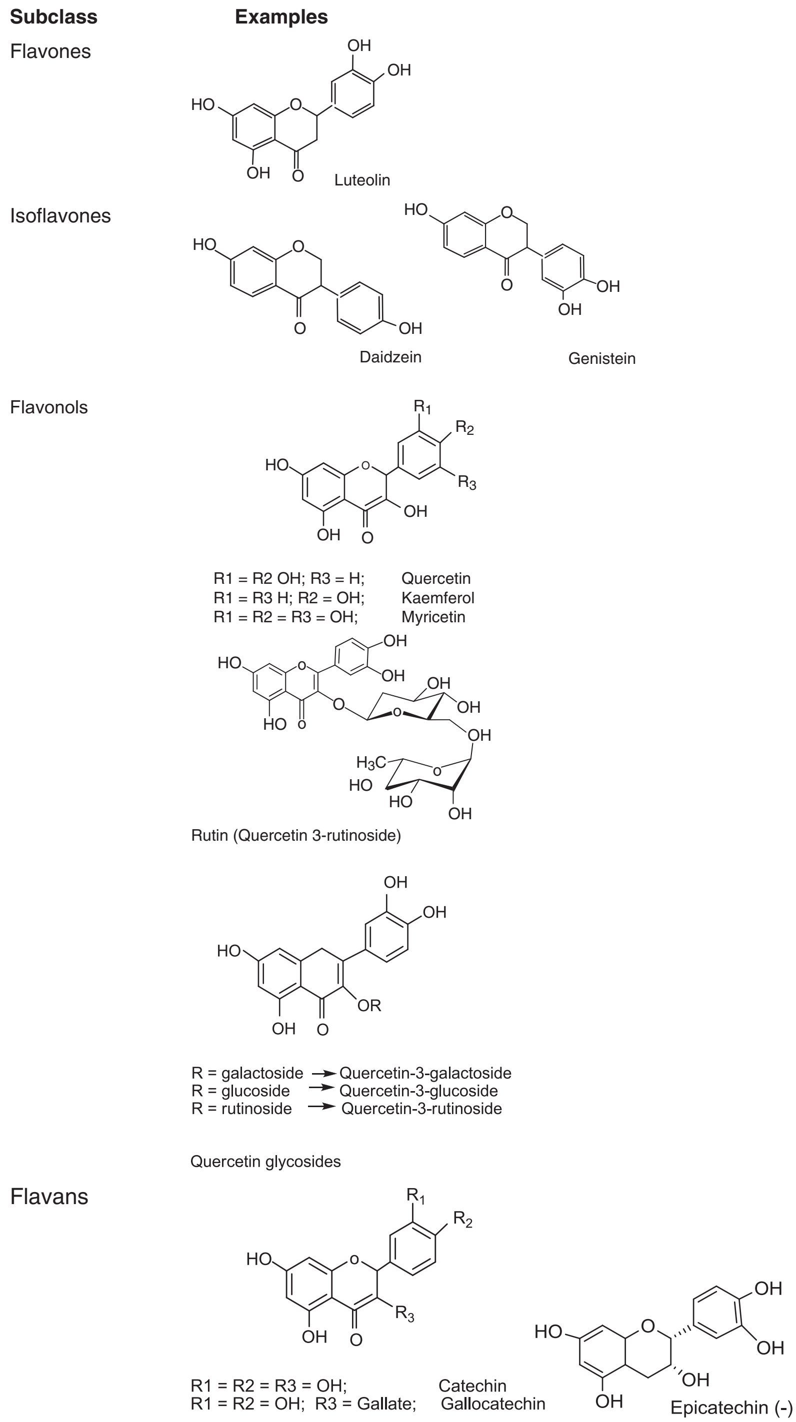


Fig. 1.2 Structures of different flavonoids (Berhow *et al.*, 1991; Hollman *et al.*, 1997a, 1997b; Sanoner *et al.*, 1999; Kähkönen and Heinonen, 2003; Robards, 2003).

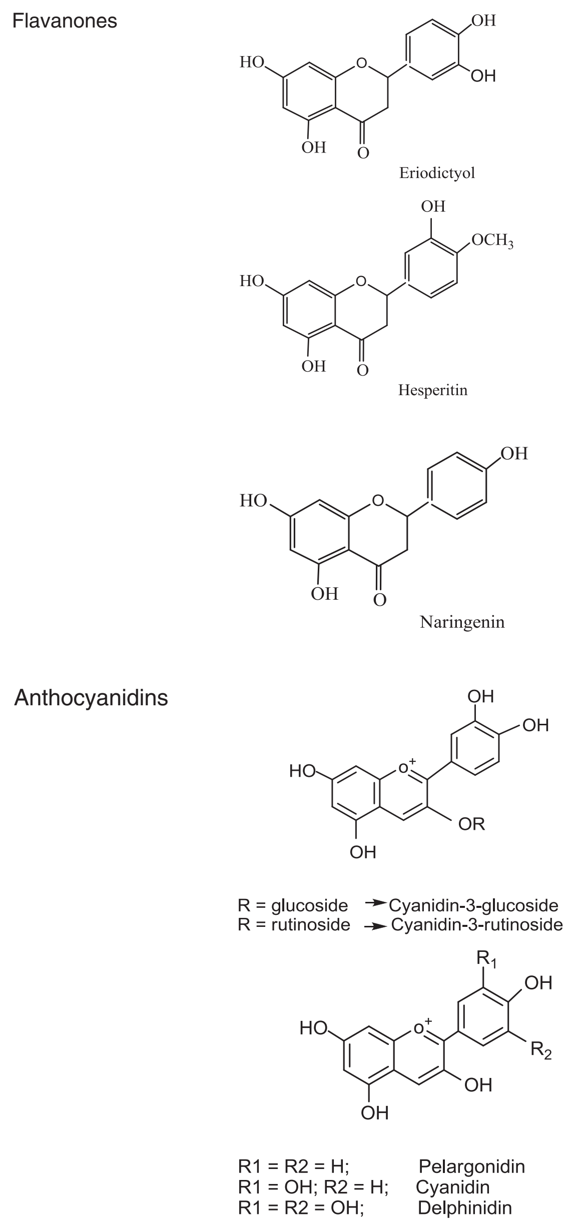
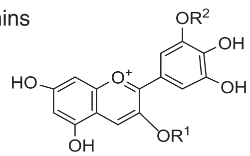


Fig. 1.2 (*Continued*) Structures of different flavonoids.

molecule are called aglycones (Haminiuk *et al.*, 2012). The flavonoids usually occur as glycosides which are less effective than aglycones. There is a relationship between structure and antioxidant activity. The groups, such as catechol moiety (Figure 1.3a – shown within the dotted ellipse), the 2, 3 double bond conjugation with a 4-oxofunction of a carbonyl group (Figure 1.3a – shown within the solid ellipse), and presence of hydroxyl groups at the 3 and 5 positions (Figure 1.3b – shown within the dotted ellipse), determine the free radical scavenging and oxidation potential (Shi *et al.*, 2001). Quercetin possesses all the

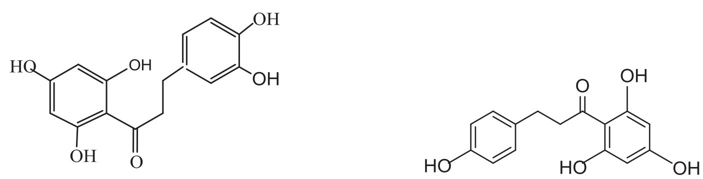
Anthocyanins



Anthocyanin compounds

R1	R2	Common name
β-D-glucopyranosyl	H	cyanidin 3-glucoside
6-*O*-α-L-rhanopyranosyl-b-D-glucopyranosyl	H	cyanidin 3-rutinoside
6-*O*-α-L-rhanopyranosyl-b-D-glucopyranosyl	OH	delphinidin 3-rutinoside
β-D-glucopyranosyl	OH	delphinidin 3-glucoside

Chalcones



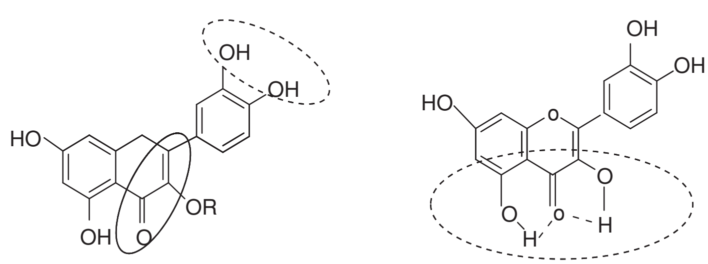
Butein

Phloretin

Fig. 1.2 (*Continued*) Structures of different flavonoids.

three structure groups, hence show higher antioxidant activity than kaempferol, which does not have catechol moiety (Shi *et al.*, 2001).

Flavonols are the most common flavanoids, occurring naturally as glycosylated forms (often glucose or rhamnose) (El Gharras, 2009). The most common flavonol aglycones are quercetin, kaempferol and myricetin (Figure 1.1) (Manach *et al.*, 2005; El Gharras, 2009). Flavones, on the other hand, consist of the glycosides of luteolin and apigenin (Manach *et al.*, 2004). Even though they are not very common in fruits, citrus fruits contain high concentrations of flavones. The main aglycones are naringenin in grapefruit, hesperetin in oranges and eriodictyol in lemons (El Gharras, 2009). Isoflavones can be aglycones or glycosides, occurring mainly in leguminous plants (e.g. soybeans). Flavanols exist in monomer (catechin) and polymer (proanthocyanidins) forms. These two flavanols are the main flavanols in fruits, whereas gallocatechin, epigallocatechin and epigallocatechin gallate are common in grapes (Manach *et al.*, 2004).



(a) (b)

Fig. 1.3 Antioxidant activity–structure relationships of flavonoids (Shi *et al.*, 2001).

Anthocyanins are pigments that impart red, blue, purple, violet and intermediate red–purple to berries and other fruits (Von Elbe and Schwartz, 1996). Similarly to other flavonoids, anthocyanins occur as glycosides. The de-glycosylated or aglycone forms of anthocyanins are known as anthocyanidins (Seeram, 2006). Hundreds of anthocyanins are known, varying in the basic anthocyanidin skeleton, such as cyanidin, delphinidin, pelargonidin, malvin, petunidin and peonidin (Table 1.1). Structural diversification is also achieved by the position at which glycosides (such as glucose, galactose, rhamnose and arabinose) and acyl groups (including phenolic acids such as caffeic, *p* coumaric, ferulic and sinapic) are attached to the skeleton (Naczk and Shahidi, 2006).

Tocopherols

Tocopherols are important biological antioxidants and widely used antioxidants. Tocopherols consist of two families, namely tocols and tocotrienols (Shahidi and Naczk, 1995). Depending on the number and position of methyl groups attached to the chromane rings, they are referred

Table 1.1 A summary of phytochemical present in different fruits (data from Nazck and Shahidi, 2006; Zadernowski *et al.*, 2009; Naczk *et al.*, 2011; Haminiuk *et al.*, 2012)

Phenolic compounds	Major Fruit source
Flavonols	
Quercetin	Blueberry, passion fruit, pomegranate
Kaempferol	Blackcurrant, fig
Myricetin	Apple, papaya
Rutin	Red grape, prunes, blueberry, apricot, apple
Flavones	
Apigeninn	Mango, durian
Luteolin	Lemon, pineapple, plum, watermelon, orange
Flavonones	
Hesperetin	Orange, grapefruit
Naringenin	Orange, grapefruit, lemon
Isoflavones	Soy beans
Flavanols	
Catechin	Grapes, cherry
Epicatechin	Apricot, cherry, grape, peach, blackberry, apple, avocado
Anthocyanins	
Cyanidin	Berry, pomegranate
Pelargonidin	Black currant, strawberry, raspberry, mangosteen
Peonidin	Blueberry, blackcurrant
Delphinidin	Black grape, blackcurrant, blueberry, grape fruit
Malvidin	Strawberry, plum, blueberry, grapefruit
Petunidin	Apple, blueberry
Hydrobenzoic acids	
Procatechuic acid	Blackberry
Gallic acid	Raspberry, banana, avocado
Vanillic acid	Avocado, strawberry
Syringic acid	Strawberry, grapes
Hydrocinnamic acids	
Caffeic acid	Papaya, peach, avocado
Chlorogenic acid	Kiwi fruit, passion fruit, blueberry, peaches
Coumaric acid	Cherry, orange, blackcurrant
Ferulic acid	Mango, orange, papaya, pineapple
Sinapic acid	Apple

to as α, β, γ, δ (Figure 1.4). Tocopherols also possess vitamin E activity; the most important antioxidant of this group is α-tocopherol (Shahidi and Naczk, 1995) (Figure 1.4). Fruits contain considerable amounts of tocopherols, whereas in animals they are only found in trace amounts. These are heat-stable and relatively weak antioxidants used in fats and oils (Gordon, 2001).

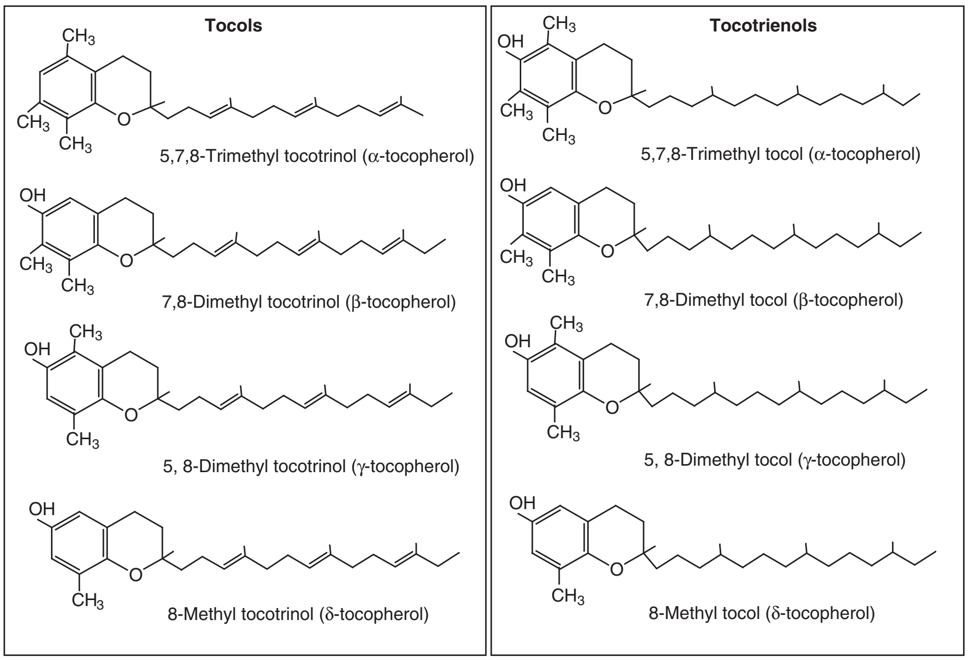


Fig. 1.4 Structures of tocopherols.

Phenolic acids
Two classes of phenolic acids have been identified – derivatives of benzoic acid and derivatives of cinnamic acid. Hydroxybenzoic acids are components of tannins (gallotannnins and ellagitannins), whereas hydroxycinnamic acids consist of *p*-coumaric, caffeic, ferulic and sinapic acids (Haard and Chism, 1996; Pontes, 2002; Manach *et al.*, 2004; Haminiuk *et al.*, 2012). Phenolic acids are rarely found as free forms but are commonly found in conjugates forms as esters and glycosides (Tiffany and Luke, 2007). Caffeic and quinic acid combine to form chlorogenic acid, which is rich in fruits (Clifford, 1999, 2000) (Figure 1.5). The antioxidant activity of phenolic acids and their esters depends on the number of hydroxyl group in the molecule. Hydroxylated cinnamic acids are more effective than their benzoic counterparts (Shahidi and Naczk, 1995; Tomás-Barberan and Clifford, 2000). Berries, plums, kiwifruit and apples contain a variety of phenolic acids which occur as derivatives of hydroybenzoic acid (e.g. gallic acid) and hydroxycinnamic acid (e.g. caffeic acid) (Figure 1.5). Concentrations typically decrease during the course of ripening (Seeram, 2006).

Other phenolic compounds
Other phenolic compounds, such as tannins, lignans, stilbenes and coumarins, are also present in plants (Figure 1.6). Lignans are formed from two phenylpropane units (Seeram,

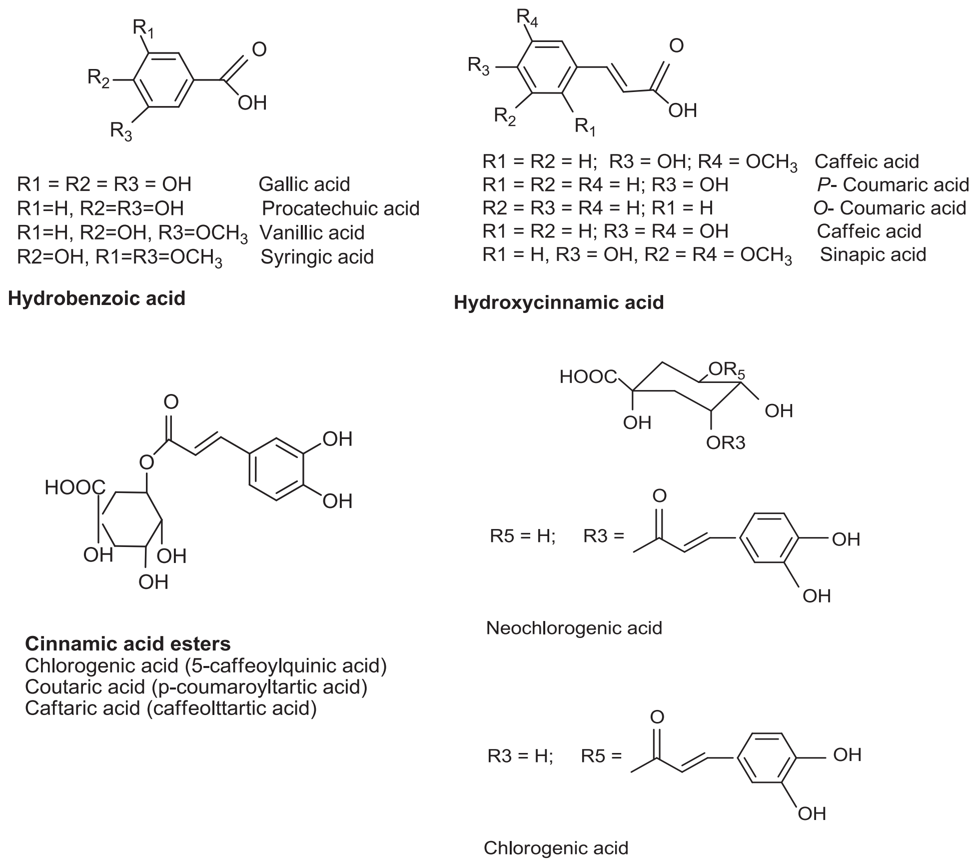


Fig. 1.5 Structures of phenolic acids.

2006; Haminiuk *et al.*, 2012). Stilbenes are phenolic based compounds such as resveratrol, which has anticancer effects and is found in small quantities in wine (Haminiuk *et al.*, 2012). Tannins, including different types of condensed tannins (e.g. proanthocyanidins, prodelphinidins etc.), and hydrolysable tannins are present in fruits. Hydrolysable tannins can be divided into gallotannins (esters of gallic acid) and ellagitannins (esters of hexahydroxydiphenic acid) (Seeram, 2006; Landete, 2011). Proanthocyanidins are dimers, oligomers and polymers of catechins that are bound together by links between C4 and C8 or C6 (Santos-Buelga and Scalbert, 2000). Proanthocyanidins are the major polypohenols in grapes and are responsible for the astringent character of fruits (El Gharras, 2009). Blueberries and cranberries contain high levels of proanthocyanidins.

Dietary fibre (DF)

Dietary fibre has been consumed for centuries and now has been recognized as having health benefits. The definition of dietary fibre was approved by the Codex Alimentarius Commission (ALINORM 09/32/A) at the FAO, Rome, Italy, on 29 July 2009, proposing that dietary fibre means carbohydrate polymers with 10 or more monomeric units which are neither digested nor absorbed in the small intestine (Cui *et al.*, 2011). Dietary fibres possess properties such as

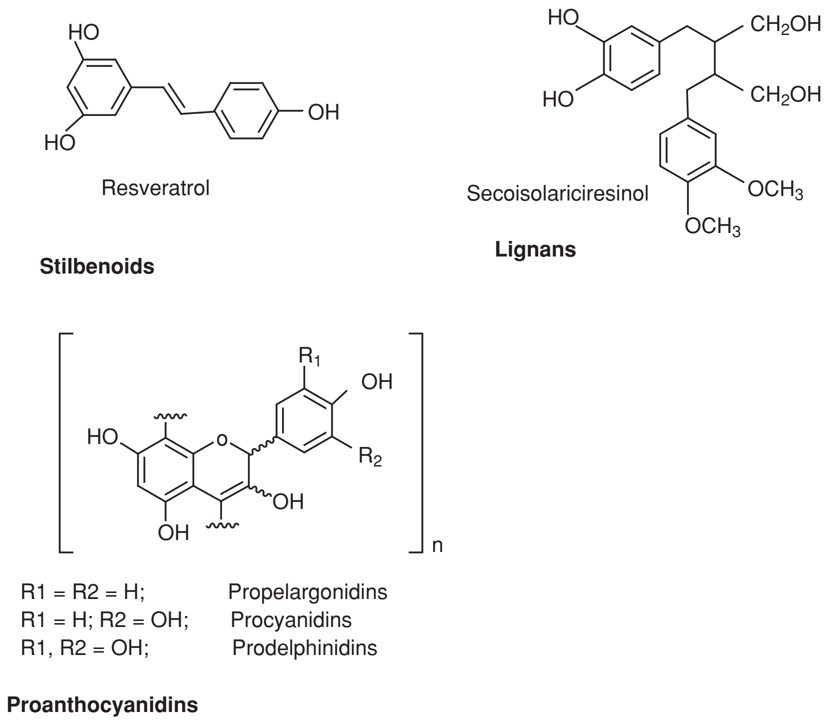


Fig. 1.6 Other phenolic compounds.

decreasing intestinal transit time and increasing stool bulk fermentable by colonic microflora, reducing blood total and LDL cholesterol levels and reducing postprandial blood glucose and insulin level, buffering the effect of excess acid in the stomach and also helping prevent constipation (Erkkila *et al.*, 1999; Brennan and Cleary, 2007; Filipovic *et al.*, 2007; Lunn and Buttriss, 2007). Low dietary fibre intake has been associated with a variety of diseases, such as diverticular disease, constipation, appendicitis, diabetes, obesity, coronary heart disease and bowel cancer (Tungland and Meyer, 2002; Slavin, 2003; Viuda-Martos *et al.*, 2010). A daily intake of approximately 25–38 g is encouraged to promote health benefits associated with fibre (King *et al.*, 2012).

Cell wall materials from fruits are good sources of dietary fibres. The major monosaccharides that form polysaccharides in the cell wall are rhamnose, fucose, arabinose, xylose, mannose, galactose, glucose, galacturonic acid and glucuronic acid (Harris and Smith, 2006). The main polysaccharides of primary cell walls are pectic, hemicellulosic (such as xyloglucans, glucomannans or galactoglucomannans and xylans) and cellulosic in varying proportions (Stevenson *et al.*, 1988; Carpita and McCann., 2000; Ridley *et al.*, 2001; Caffall and Mohnen, 2009). Different DFs from fruits such as apple, citrus as well as inulin and gums are incorporated into foods for their nutritional properties (Chau and Huang, 2004; O'Shea *et al.*, 2012).

Proteins and peptides

Bioactive peptides are protein fragments which have a positive impact on the function and condition of living beings (Pihlanto and Korhonen, 2003). Although the main role of proteins and peptides is to supply nitrogen and essential amino acids, in some instances they provide additional beneficial effects, such as antimicrobial, antioxidant, antithrombotic, antihypertensive and immunomodulatory activities (Perez Espitia *et al.*, 2012). Peptides with antimicrobial properties are produced by almost all species of life such as microorganisms, plants, animals and humans. Lunasin (found in soya bean), protease inhibitors, lupin conglutin-γ, resistant proteins, protein hydrolysates and peptides are some of the bioactives from plants having beneficial effects (Aluko, 2011).

Carotenoids

Carotenoids are lipid soluble compounds that are responsible for the yellow, orange, red and violet colours of various kinds of fruits (Von Elbe and Schwartz, 1996). Carotenoid bioactives are classified into carotenoid hydrocarbons (carotenes) and carotenoid alcohols (xanthophylls) (Fraser and Bramley, 2004). Xanthophylls consist of different derivatives, such as hydroxyl, epoxy, aldehyde and keto groups (Von Elbe and Schwartz, 1996). The carotenoid structural backbone consists of isoprene units linked together symmetrically by covalent bonds (either head-to-tail or tail-to-head) (Figure 1.7). Some structures may contain cyclic end groups (e.g. β-carotene), some contain either one or no cyclization (e.g. lycopene in tomatoes, papaya, watermelon, pink grape fruit and apricots), some contain shorter hydrocarbon skeletons (known as apocarotenal). The provitamin-A activity of some carotenoid bioactives helps in preventing chronic diseases such as cardiovascular disease and skin cancer (Mercke Odeberg *et al.*, 2003; Coyne *et al.*, 2005; Ramadan, 2011).

Functional lipids

Plant sterols (phytosterols) can occur either in the free form or esterified to fatty acids, sugar moieties or phenolic acids. They stabilize phospholipid bilayers in cell membranes (Kritchevsky and Chen, 2005). Though seeds are rich in phytosterols, fruits (e.g. berries, apricots) contain minor quantities (Kritchevsky and Chen, 2005; Seeram, 2006). Phytosterols are characterized by the number and location of double bonds and methylation at the C4

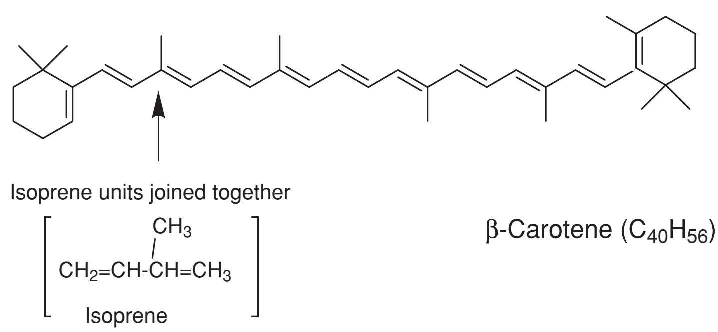


Fig. 1.7 Structure of β-carotene.

position on the ring system and alkylation and double bonds on the side chain. The common sterols found in fruits are sitosterol, campersterols, stigmasterol and avenasterols (Figure 1.8) (Tiffany and Luke, 2007; Plumb *et al.*, 2011; Sanclemente *et al.*, 2011). Phytosterols possess anticancer activity and help to reduce low-density cholesterol (Wolfreys and Hepburn, 2002; Kritchevsky and Chen, 2005; Seeram, 2006).

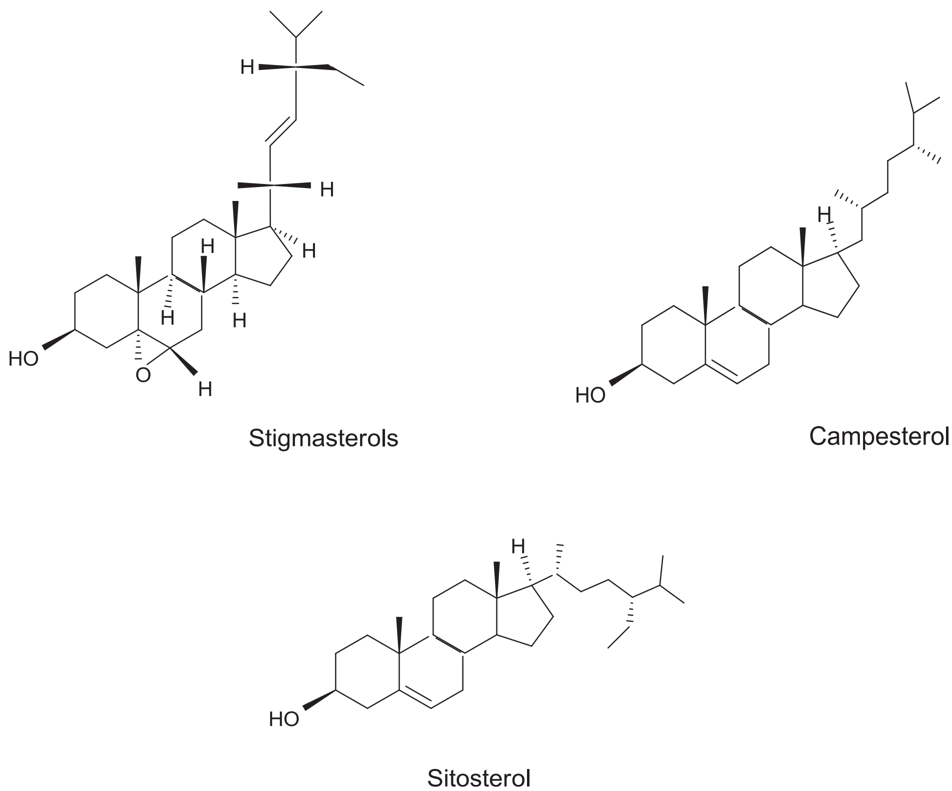


Fig. 1.8 Structure of some common phytosterols.

BIOACTIVES IN FRUITS

Berries such as cranberries, blackberries, raspberries, black raspberries, blueberries, whortleberry, rowanberry, choke berry, bilberry and strawberries are consumed in fresh and processed forms such as beverages, yoghurts, jellies and jams (Seeram, 2008). Berries provide significant health benefits because of their high antioxidant, vitamin, mineral and fibre content (Kähkönen *et al.*, 2001; Ramadan, 2011). Laboratory and animal studies have shown that berries have anticancer properties due to the high content of bioactive phytochemicals (Tiffany and Luke, 2007; Seeram, 2008). Phenolics are the predominant phytochemicals present in berries (Tokuşoğlu and Stoner, 2011, Seeram *et al.*, 2006; Talcott, 2007; Wang, 2007). The bioactive phytochemicals are flavanoids (anthocyanins, flavonols and flavanols), condensed tannins, hydrolysed tannins, stilbenoids, phenolic acids and ligans (Seeram and

Nair, 2002; Manach *et al.*, 2004). The predominant phenolic acids in berries are hydroxybenzoic acids and hydroxyl cinnamic acids. Strawberries, raspberries and blackberries are high in ellagitannins. Blueberries and cranberries contain high levels of proanthocyanidins. Catechin and epicatechin are the main flavanols found in berry fruits (Seeram, 2006). Lignans are found in strawberry, blackberry, raspberry, cloudberry, cranberry, lingonberry and blueberry (Seeram, 2006). Although phenolic compounds are predominant in berries, nonpolar compounds such as ursolic acid, triterpene hydroxycinnamates and β-sitosterol are also reported to be found in berries (Murphy *et al.*, 2003).

Apricots are a rich source of bioactives, mainly polyphenols, carotenoids and vitamins (Tokuşoğlu, 2011). Chlorogenic acid (5-*O*-caffeoyquinic acid) is the most dominant phenolic compound in apricots (Erdogan-Orhan and Kartal, 2011). Some common phenolic acids found in apricots are neochlorogenic acid, caffeic acid, *p*-coumaric acid and their esters. Flavanols occur as glucosides and rutinosides of quercetin and kaempferol, but quercetin 3-rutinoside (rutin) is predominant (Dragovic-Uzelac *et al.*, 2005, 2007). Apricots are also a source of procyanidin B_1, procyanidin B_2, procyanidin B_3 and carotenoids (Dragovic-Uzelac *et al.*, 2007).

Plums are rich in bioactive compounds such as vitamins (A, C and E), anthocyanins and other phenols and carotenoids (Stacewicz-Sapuntzakis, 2012). Chlorogenic acid and its isomers are the major phenolic compounds in plums and prunes (Kim *et al.*, 2003). Neochlorogenic acid (3-*O*-caffeoylquinic acid) is a predominant polyphenol along with chlorogenic acid (5-*O*-caffeoylquinic acid), and cryptochlorogenic acid (4-*O*-caffeoylquinic acid) (Fang *et al.*, 2002; Kim *et al.*, 2003). Dried prunes contain higher amounts of phenolic compounds than fresh ones, since the dehydration process concentrates the constituents, although there is a partial degradation (Lombardi-Boccia *et al.*, 2003; Lombardi-Boccia, 2007). Phenolic acids, flavonols and flavans and small amounts of caffeic acids and coumaric acids are reported in plums and prunes. Cyanidin-3-glucosides and cyanidin 3-rutinosides are the major anthocyanins in plums (Chun *et al.*, 2003a, 2003b).

Apples are in rich in flavans (catechins, epicatechins), flavonols (rutin, quercetin and its derivatives), dihydrochalcones, hydrocinnamic acid derivatives and procyanidins (Lee *et al.*, 2003; McGhie *et al.*, 2005). Phlorizins (phloretin 2-β-D-glucoside) and phloretin 2-β-D-xylosyl-(1-6)-β-D-glucoside are the major hydrochalcones found in apples (Guyot *et al.*, 1998; Sanoner *et al.*, 1999).

Peaches and nectarines are rich in bioactives such as ascorbic acid (vitamin C), carotenoids (provitamin A) and phenolic compounds (Tomás-Barberan and Espín, 2001; Lavelli *et al.*, 2008; Cantín *et al.*, 2009; Tokuşoğlu and Hall 2011). The phenolic profiles in peaches and nectarines show similar trends. Peaches and nectarines are rich in chlorogenic acids and anthocyanin compounds (Gil *et al.*, 2002).

Palm dates possess antioxidant and antimutagenic activities, and are also considered as high energy fruit due to the sugar content (Tokuşoğlu, 2011). Dates contain anthocyanins, free phenolic acids (gallic acid, procatechuic acids, vanillic acid, syringic acid and ferulic acids), bound phenolic acids (gallic acid, procatechuic acid, *p*-hydrobenzoic acid, vanillic acid, caffeic aicd, syringic acid, *p*-coumaric acid, ferulic acid, *o*-coumaric acid), tannins and carotenoids (Al-Farsi *et al.*, 2005). Condensed tannins and phenolic acids are responsible for astringency in dates (Tokuşoğlu, 2011).

Pomegranates are a very rich source of anthocyanins (cyanidin 3, 5-di and 3-*O*-glucoside, delphinidin 3, 5-di and 3-*O*-glucoside, pelargonidin, 3, 5-di and 3-*O*-glucoside), ellagic acid, punicalagin isomers, flavanols (catechin, epicatechin, gallocatechin, epigallocatechin) and tannins (Gil *et al.*, 2000; Adams *et al.*, 2006; Nazck and Shahidi, 2006). Malic acid and citric acid are present in abundant amounts (Nazck and Shahidi, 2006; González-Molina *et al.*, 2009).

Citrus fruits are a rich source of flavonoids, cinnamic acid derivatives, coumarins, citric acid and vitamin C. Among the flavonoids, citrus fruits contain hesperidin and eriocitrin (flavanones), together with small amounts of flavones, minor flavonoids (quercetin and myricetin), and hydroxycinnamic acids (Manthey and Grohmann, 2001; González-Molina *et al.*, 2009). Grapefruit are rich in flavonones such as naringin and its derivatives; sweet oranges are rich in narirutin, hesperidin and hesperidin 7-rutinoside; sour oranges are rich in naringin, neohesperidin and hesperetin 7-neohesperidoside (Berhow *et al.*, 1991; Kanes *et al.*, 1993; El Gharras, 2009). A summary of phytochemical present in different fruits is given in Table 1.1.

CONCLUSION

Fruits are excellent sources of bioactives, which impart health benefits. The growing interest in bioactive substances is mainly because of their antioxidant potential and association between their consumption and the prevention of some diseases. Polyphenolic compounds are the most desirable food bioactives because of their antioxidant activity – their ability to scavenge oxygen radicals and other reactive species. These features make phenols a potentially interesting material for the development of functional foods.

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