

## Regular food chemicals as antioxidant towards prevention of diseases – An insight review

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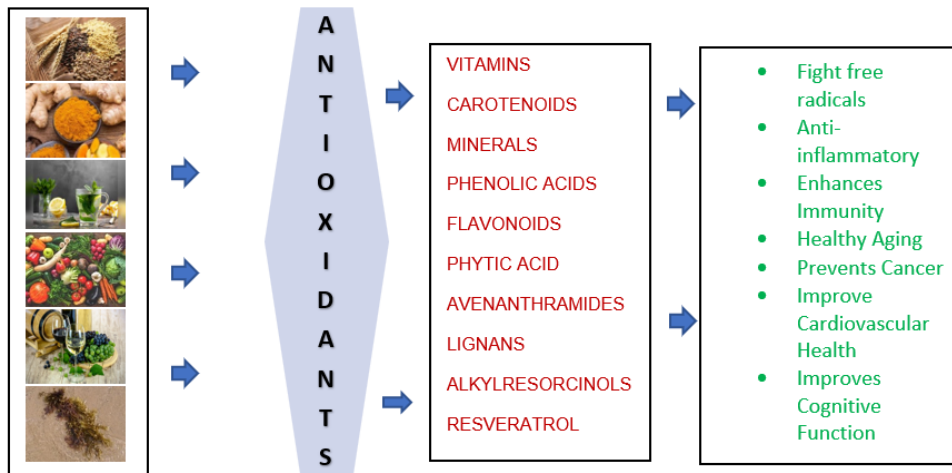
Review

### ABSTRACT

Oxidative stress is an imbalance between pro-oxidant and antioxidant activities occurring in the body. Excess of oxidative activities may result in molecular and cellular damage. Also, oxidative stress plays a crucial role in the development of chronic degenerative diseases. Our body endogenous protective system can be supported by natural antioxidants present in various food components. Fruits and vegetables are best sources of antioxidants.

Their protective effect is attributed to presence of antioxidant compounds in them like vitamins, minerals and phenolic acids and flavonoids. Cereals are rich in phenolic acids, phytic acid, flavonoids, lignans and alkylresorcinols which help to destroy free radicals. Seaweeds and sponges are rich source of bioactive compounds having the antioxidant activities. They possess several disease prevention properties due to presence of phenolic compounds, polysaccharides, and organic acids. Several medicinal plants and spices are also known to possess antioxidants with several beneficial therapeutic effects. Beverages like tea, coffee, cocoa have phenolics which neutralizes free radicals and helps in preventing oxidative stress. Resveratrol present in red wine prevents cardiovascular diseases by neutralizing free oxygen radicals and reactive nitrogenous radicals.

**Keywords:** Antioxidants; Food Chemicals, Disease Prevention, Vitamins, Cancer



### INTRODUCTION

Antioxidants are the compounds having ability to prevent or slow down the damage to the body cells caused by free radicals. Free radicals are the molecules that contain impaired electrons, which make them highly reactive. They cause damage to the body by attacking healthy cells and making them vulnerable to diseases. Free radicals may be produced from normal body activities such as breathing, physical exercise, but mainly formed due to exposure to environmental hazards, such as pesticides, air pollution and smoking.<sup>1,2</sup> Free radicals are also known as reactive

oxygen species. If the body is not able remove them efficiently, oxidative stress can result. Oxidative stress is associated with the development of numerous non communicable diseases such as diabetes, cancer, cataract, coronary heart disease and age related macular degeneration.<sup>3,4</sup>

Antioxidants are known to neutralize free radicals in our bodies and thus contribute to boost overall health. A diet rich in natural antioxidants can significantly increase reactive antioxidant potential of the body, hence decreasing the risk of diseases having free radical origin. It has been documented that diets rich in antioxidants increases defensive abilities of the cells.<sup>5,6</sup> Several food components are loaded with antioxidant properties. Fruits and vegetables provide us with vitamins and minerals, but along with these important micronutrients they are best sources of antioxidants. Fruits and vegetables differ in the amount of antioxidants present in them. Insufficient intake of fruits and vegetables can be a risk factor several degenerative diseases.<sup>7</sup> The protective effect of fruits and vegetables are mainly attributed to the antioxidants present in them such as

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vitamin A, C and E.<sup>8</sup> Other antioxidants include polyphenols, terpenoids, organo-sulphurs and alkaloids which assist in reducing the oxidative damage by neutralizing the free radicals. These bioactive compounds vary in their biological and pharmacological properties. They possess antioxidant, anti-inflammatory, antimutagenic and anti-carcinogenic properties. In combined foods like salads, mixtures of fresh fruits and vegetables there is synergistic interaction among some of these compounds. In addition, whole cereals and legumes contains polyphenols which has beneficial effects in the body like antioxidant, anti-inflammatory and anticancer activities that can protect our body from free radicals. Animal derived food products contain amino acids, peptides and proteins which are important antioxidants. Also, group of products like beverages and herbs and spices can supply high amounts of antioxidants. This review highlights antioxidants present in commonly consumed foods and their role in prevention of diseases.

## 2. NEED FOR ANTIOXIDANTS

Our body cells are facing constant threat from free radicals, which in high number can harm the cells and genetic material. Free radicals can alter the instructions coded on DNA strands. They can modify cell membrane permeability thus changing the flow of substances crossing it. Our body has defensive mechanism to fight against these free radicals. In addition, consumption of diet rich in antioxidants will certainly protect our body against the damage done by free radicals. By stabilizing these free radicals, antioxidants can also help our immune system to function more efficiently and mitigate chronic inflammation, which is thought to be a causative factor for many health problems, like diabetes, cardiovascular disease and cancer. Antioxidants exists in enzymatic and non-enzymatic forms in the extracellular and intracellular environment. Body protects itself from reactive oxygen species (ROS) by enzymatic antioxidant mechanisms. The antioxidants enzymes like super oxide dismutase (SOD) reduce the levels of  $H_2O_2$ , thus help in maintaining integrity of cell membranes. SOD catalytically convert the  $O_2$  free radicals to oxygen in the presence of cofactors like copper, zinc or manganese.<sup>9</sup> The nonenzymatic antioxidants can be natural or synthetic.

### 2.1 Antioxidative properties of fruits and vegetables

Fruits and vegetables are good sources of vitamins, minerals and dietary fibre for humans. However, there is remarkable difference in their nutritional content as well as antioxidant potential. The antioxidants found in fruits and vegetables are in category of non-enzymatic natural antioxidants. There are four main types of antioxidants - vitamins, carotenoids, polyphenols and minerals (Figure 1). Polyphenols are further classified into flavonoids and phenolic acids.

#### 2.1.1 Vitamins

##### Vitamins A

Vitamins are micronutrients involved in various metabolic processes in the human body. Vitamins A, C and E are the prominent vitamins found in fruits and vegetables. Vitamin A includes several compounds, including the alcohol form (retinol), the aldehyde-based compound (retinal), an oxidation form of

retinol **1** (retinoic acid), and the provitamin A carotenoids (most notably beta-carotene **2**). Carotenoids, require conversion to the retinol form of vitamin A during the digestion process in order to be absorbed by the human body. However, the most effective form of vitamin A in terms of antioxidant functions is in the form of retinol due to its most reactive structure. Vitamin A is an efficient free radical scavenger and chain-breaking molecule in the peroxy radical reaction.<sup>10</sup> It acts as a physiological antioxidant thus preventing numerous chronic diseases such as coronary heart disease and cancer. Vitamin A has vital antioxidant contribution in protecting human LDL against copper stimulated oxidation.<sup>11</sup>

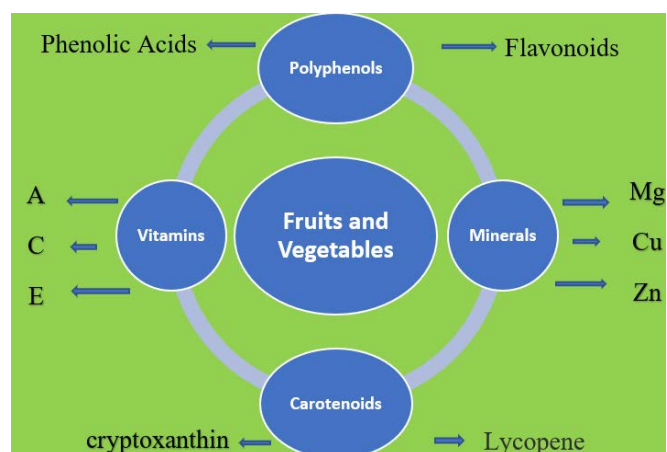
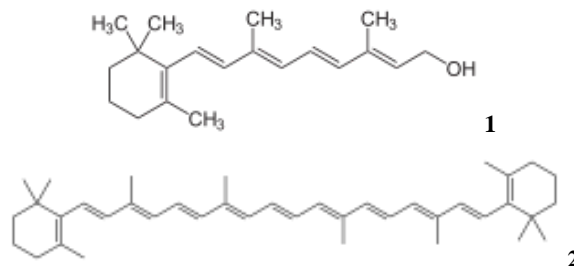


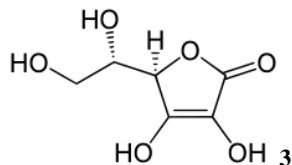
Figure 1: Antioxidants present in fruits and vegetables



##### Vitamin C

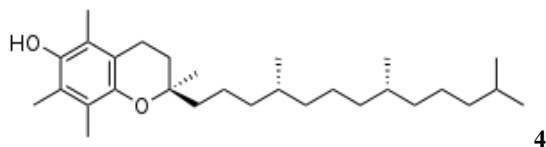
Vitamin C, also known as ascorbic acid, is a potent water-soluble anti-oxidant. It has greater functionality as an antioxidant compared to that of vitamin A. In addition, another important advantage of this vitamin is its ability to regenerate the antioxidant form of vitamin E. This allows greater availability of essential compounds within the metabolic functions of the human body, thus promoting good health.<sup>12</sup> Ascorbic acid also acts as a cofactor for different enzymes in the synthesis of many hormones and neurotransmitters, immune system, cell regulation and regeneration. It has ability to neutralize both ROS and nitrogen oxide species by donating a hydrogen atom. In the process, an ascorbic radical (dehydroascorbic acid) is formed which could be again converted to vitamin C. Being water soluble vitamin C can act both on the intracellular and extracellular side<sup>12,13</sup>. Thus, vitamin C is considered an antioxidant with immense potential to prevent the development of oxidative reactions of lipids and macromolecules. It is commonly found in citrus fruits and

vegetables such as oranges, lemons and tomatoes. Fruits and vegetables having high content of vitamin C should be consumed in small doses as vitamin C is absorbed less when given in large quantities.



### Vitamin E

Vitamin E is fat soluble and belongs to tocopherol family of antioxidant. It is lipid soluble antioxidant which acts as a chain breaker during lipid peroxidation in cell membranes. Among them, alpha-tocopherol **4** has important role due to its ability to prevent the development of lipid oxidative reactions leading to cell membrane damage.<sup>14,13</sup> The mechanism of action involves donation of a hydrogen atom from the phenolic group present in the ring of the vitamin E structure.<sup>15</sup> Oxidized form of alpha-tocopherol could revert its initial antioxidant active form through a reduction reaction with other antioxidants, such as vitamin C.<sup>14</sup> Vitamin E is involved in the immune system by giving protection from bacterial infections, inhibiting formation of mutagenic compounds and promoting cell repair. This role of vitamin E in the immune system has led to consider it as an essential compound to reduce the incidence of cancer cell and tumour development.<sup>13</sup> It is found naturally in lipid rich fruits and vegetables, such as olives, avocado, sunflower, nuts.

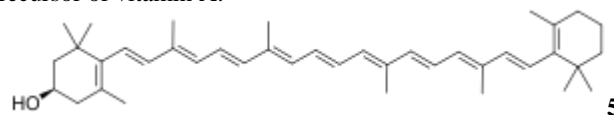


### Carotenoids

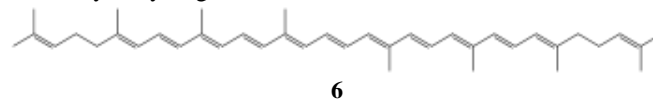
Carotenoids comprise over 700 naturally occurring pigments produced by plants, animals, and microbes for the purpose of their vital physiological actions. They can be either acyclic molecules, as is the case of lycopene, or a 40-carbon chain with six-carbon rings at its ends, as is the case of  $\alpha$ -carotene and  $\beta$ -carotene.<sup>16</sup> The biological activity and benefits on human health provided by these compounds is constantly increasing. Carotenoids have the ability to reduce free radicals, to act as reactive scavengers of oxygen species and as chemical inhibitors. They are powerful antioxidant substances as they reduce oxidative stress associated with various chronic disorders.<sup>17</sup> Along with their antioxidant properties, they are also precursors of vitamin A.<sup>18</sup> Health benefits like lower cardiovascular risk, lower macular degeneration, increased immune response and reduced cell proliferation have been associated with the consumption of carotene-rich foods.<sup>19,20,21</sup>

$\beta$ -Cryptoxanthin (BCX) **5** is a prominent dietary pro-vitamin A carotenoid, present mainly in fruits and vegetables such as orange, papaya, paprika, and carrot.<sup>22</sup> It provides several benefits for human health, such as reducing the risk of metabolic syndrome,<sup>23</sup> osteoporosis,<sup>24,25</sup> inflammatory disorders<sup>26</sup> and

certain types of cancer.<sup>27,28</sup>  $\beta$ -Cryptoxanthin is the most important precursor of vitamin A.



Lycopene **6**, a natural carotenoid pigment present in high concentration in fruits and vegetables such as tomato, guava, watermelon, spinach, carrot, beetroot, and red grapefruit. It possesses the high potential to scavenge free radicals. This is due to high reactivity derived from its molecular structure.<sup>29</sup> Lycopene is beneficial for human health in various ways. For example, it protects lipids, proteins and DNA from oxidative damage; modulates cell growth as well as acts as intermediate in immune and inflammatory processes. A beneficial response by lycopene will depend on the cellular and extracellular environment.<sup>30</sup> Antioxidant capacity of lycopene is not adversely affected by the sterilization and cooking steps performed during food processing. On the other hand, at high temperatures it has higher antioxidant potential.<sup>31</sup> Another important property of lycopene is that it is able to regenerate non-enzymatic antioxidants, such as vitamins E.<sup>30</sup> It acts as an antioxidant by radical addition, electron transfer or the formation of an allylic hydrogen.<sup>30,32</sup>



### 2.1.2 Polyphenols

#### Phenolic Acids

Phenolic acids naturally present in fruits and vegetables possess high antioxidant potential.<sup>33</sup> They are important constituents of food, contributing to taste, colour and nutritional value. They are secondary metabolites that are formed by replacing hydrogen atoms on benzene rings by carboxylic acids and at least one hydroxyl groups.<sup>34</sup> As they exist in free form they are absorbed in the digestive tract with ease. Phenolic acids such as benzoic, phenylacetic, and cinnamic acids have high bioavailability and are more soluble.<sup>34</sup> They are considered to be excellent antioxidants as they quench excessive free radicals through the formation of stable compounds.<sup>35,36</sup> They have potential to reduce free hydroxyl radicals, superoxides and peroxy radicals, and also act against other non-radical compounds involved in oxidative stress and cell damage, such as hydrogen peroxide and hypochlorous. Moreover, phenolic acids contribute towards the regulation of the immune response of the human body.<sup>36,37</sup>

#### Flavonoids

Flavonoids, is a subclass of polyphenols present abundantly in fruits and vegetables, such as potatoes, onion, grapes, tomatoes and red berries. Flavonoids are secondary metabolites having linear carbon chain with two phenolic rings synthesized in fruit and vegetables in response to microbial infection.<sup>38</sup> They are responsible for the colour, fragrance, and different flavours. In plants, they help in various functions like regulating cell growth, attracting insects for pollination, and protection against biotic and

abiotic stresses.<sup>39</sup> These antioxidant compounds present in fruit and vegetables comprises of six subgroups: flavones, flavanols, flavanones, catechins, anthocyanidins and isoflavones based on the degree of the phenolic ring saturation in relation to the heterocyclic ring.<sup>39</sup> These compounds have wide range of biological attributes due to their bioactive properties, such as anticancer, anti-aging, cardio-protective, neuroprotective, antidiabetic, antibacterial, antiparasitic, and antiviral properties.<sup>40,41</sup> They are also involved in amelioration of cardiovascular diseases, improvement in blood lipid profile, maintenance of oxidoreductive balance and brain as well as gut health.<sup>42,43</sup> Flavonoids reduce the risk of heart disease by reducing low-density lipoproteins from oxidation and ability of the platelets in the blood to clot, and by improving coronary vasodilatation.<sup>44</sup> In addition flavonoids also provide impact on various metabolic processes involving enzymes.<sup>45</sup> Flavonoids act as antioxidant by removing reactive oxygen species, inciting endogenous mechanism using gene expression or inhibiting the formation of reactive oxygen species.<sup>46,39,47</sup>

### Minerals

Minerals present in fruits and vegetables help to preserve water balance in cell membranes and also act as cofactors for enzymes. The common minerals found in fruits and vegetables are selenium, magnesium, selenium, zinc and copper. Selenium is present in glutathione peroxidase, an antioxidant enzyme responsible for reduction reactions of hydrogen peroxide and peroxide radicals. Selenium is also involved in formation of selenoprotein compounds which have antioxidant properties.<sup>48</sup> There are at least 25 selenoproteins that have been identified in humans.<sup>49</sup> Selenium has several health benefits, including cellular protection, hormone biosynthesis, and atherosclerosis and cancer prevention, and reduction of cardiovascular and coronary risks.<sup>50,51</sup>

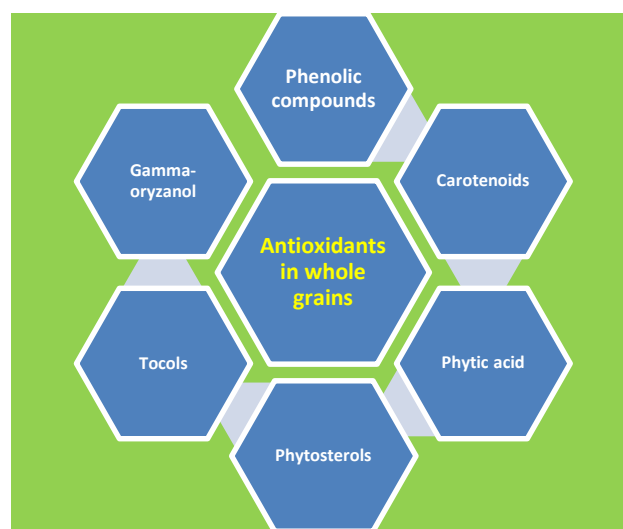
Magnesium, participates in a multitude of enzymatic reactions and has essential role in the maintenance of the antioxidant system.<sup>52</sup> Magnesium is involved in energy metabolism in the form of ATP-Mg and it is also a cofactor of several antioxidant enzymes, including superoxide dismutase (SOD).<sup>53</sup>

Zinc is an essential trace element and a cofactor for more than 300 enzymes.<sup>54</sup> It plays an important role in growth and development, acting as a signalling factor.<sup>55</sup> It has important role in antioxidant processes, protection of biomolecules from oxidation and fostering the activation of enzymes. It helps to reduce oxidation reaction activities of nitric acid synthase, lipid peroxidation products and NADPH oxidase.<sup>56</sup> Also, Zn has ability to inhibit reactive nitrogen and oxygen species, such as hydrogen peroxide, hydroxyl radicals and superoxide anions. On the other hand, it could also act directly as an antioxidant, when used in thiol groups.<sup>57</sup> Zinc plays a substantial role in the prevention of metabolic syndrome, including hyperglycaemia, insulinemia, and elevated blood pressure through the inhibition of proinflammatory cytokine expression, which helps to suppresses ROS production, thus protecting against oxidative stress damage.<sup>57</sup> In addition, it should also be noted that both excess and deficiency of Zn could lead to oxidative stress, so

maintaining an adequate level of Zn is essential to ensure human health.<sup>58</sup>

Copper is also as an essential trace element, as its deficiency may lead to cellular oxidative damage. It is necessary as it can act as a cofactor for different oxidation processes that neutralise ROS into water.<sup>59</sup> Also, copper is essential for several metabolic processes related not only to antioxidant role, but also for immune activities, molecule synthesis, enzyme activation, and iron metabolism.<sup>60</sup>

## 2.2 ANTIOXIDANT PROPERTIES OF CEREALS



**Figure 2:** Antioxidants in whole grains

Cereals are defined as edible seeds of the grass family. The major cereals grown all over the world are wheat, rice, maize, barley and oats. Apart from their nutritional value, these cereals contribute to various health promoting components.<sup>61</sup> Cereals contain wide range of substances having health promoting effects, which are often referred to as plant bioactive substances (Figure 2). The majority of bioactive compounds of whole-grains are present in the bran and germ portion of cereals. These bioactive compounds in whole grains have not received much attention. Some of these bioactive compounds possess antioxidant properties and help in reducing the risk of chronic diseases. Studies have shown that consumption of whole grains on regular basis decreases risks of several types of chronic diseases such as coronary heart diseases,<sup>62</sup> diabetes<sup>63</sup> and cancers.<sup>64</sup> Whole-grains contain unique antioxidant compounds that complement those in fruits and vegetables when consumed together. The major antioxidant compounds in whole-grain cereals are:

### 2.2.1 Polyphenols

Polyphenols possess one or more aromatic rings with one or more hydroxyl groups and are generally categorized as phenolic acids, flavonoids, stilbenes, coumarins and tannins.<sup>65</sup> In addition to their role in plants, these phenolic compounds in our diet provide numerous health benefits. Phenolic compounds have antioxidant properties and provide protection against chronic degenerative diseases like coronary heart diseases and cancer in

which reactive oxygen species are involved<sup>66</sup> (Figure 3). It is reported that polyphenols may have far more important effect in vivo such as improving endothelial function and anti-inflammatory properties.<sup>67</sup> The common polyphenols found in wholegrain cereals include:

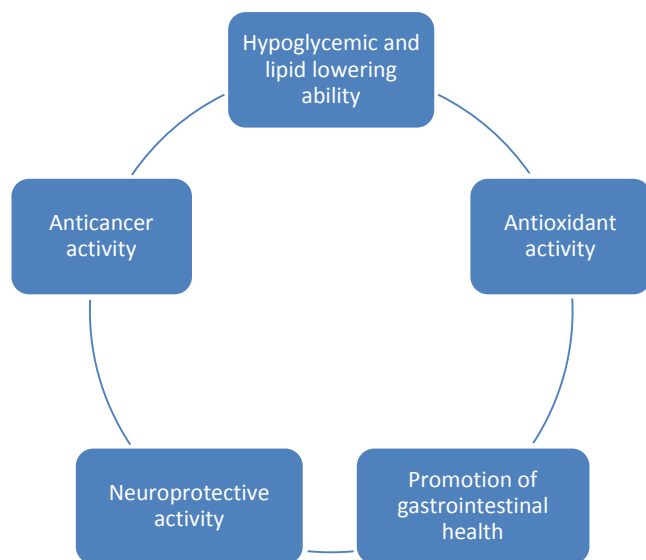
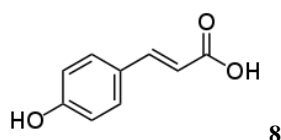
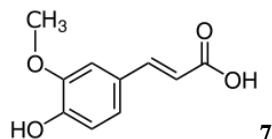


Figure 3: Beneficial effect of Polyphenols

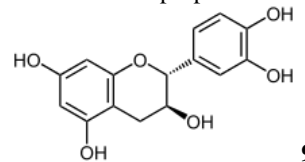
### Phenolic acid

Phenolic acids are known to be derivatives of benzoic and cinnamic acids and are present in all cereals. The major phenolic acids present in cereals are ferulic acids and p-coumaric acid.<sup>68</sup> Ferulic acid **7** is the main polyphenol present in cereals in which it is esterified to the arabinoxylans of the grain cell wall. Wheat bran is the good source of ferulic acid and it has antioxidant properties to combat destructive free radicals.<sup>69</sup> Ferulic acid can exist in free, soluble, conjugated and bound form in whole-grains. Ferulic acid is beneficial to health due to its antioxidant properties. Coumaric acids are hydroxyl derivatives of cinnamic acid. There are three types of coumaric acids, depending on position of the hydroxyl substitution of the phenolic group: p-coumaric acid, o-coumaric acid and m-coumaric acid. Coumaric acids are known to have antioxidant effect and studies indicate that they possess free radical scavenging property in p-coumaric acid **8**.<sup>70</sup> Coumaric acid also has been suggested to have anti-tumour activity against human malignant tumors.<sup>70</sup>



### Flavonoids

Flavonoids include anthocyanins, flavanols, flavones, flavanone and flavonols. Flavonoids are present in the pericarp of all cereals. Sorghum has many varieties of flavonoids. Cereals have less amount of flavonoids, except barley which contain measurable amounts of catechin **9**. Flavonoids are reported to have antioxidant and anticancer properties.<sup>71</sup>



### Avenanthramides

Avenanthramides are specific polyphenols from oats. Avenanthramide are bioavailable and they have anti-inflammatory, antiatherogenic and anti-oxidant properties.<sup>72</sup>

### Lignans

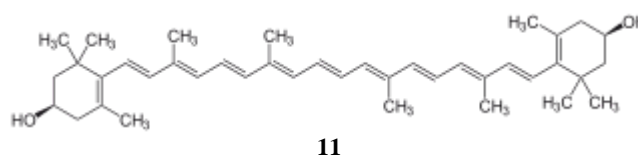
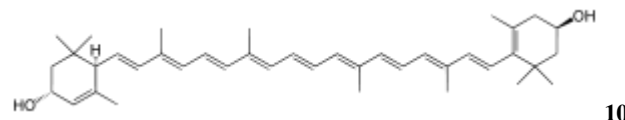
Lignans are polyphenolic compounds that are found in variety of plant foods including flax seeds, corn, oats, wheat and rye. Lignans have strong antioxidant activity that may account for their health benefits<sup>73</sup> and makes them unique in promoting health and combating various chronic diseases.

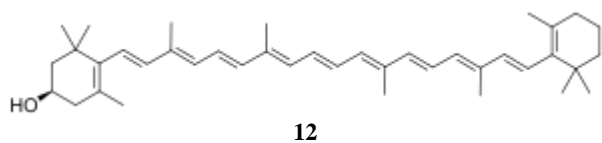
### Alkylresorcinols

Alkylresorcinols are plant derived phenolic lipids, found especially in whole-grain cereals. Rye contains very high amount of alkylresorcinols, which is almost the double that of wheat.<sup>74</sup> Alkylresorcinols possess anti-bacterial, anti-fungal and anti-oxidant property in vitro.<sup>75</sup> Several studies indicate that alkylresorcinols are antioxidants but their antioxidant activity is negligible as compared to tocopherols and catechol.<sup>76</sup>

### 2.2.2 Carotenoids

Carotenoids are the most common pigments in nature with yellow, orange and red colours and have also received attention because of their role as pro-vitamins and antioxidants. Carotenoids are divided into hydrocarbons (carotenes) and their oxygenated derivatives (xanthophylls). More than 600 different carotenoids have been identified in plants, microorganisms and animals. Carotenoids commonly present in whole-grain cereals include lutein **10**, zeaxanthin **11**, beta-cryptoxanthin **12**, beta carotene **2** and alpha carotene.<sup>77</sup> Lutein is present in highest concentration in wheat followed by zeaxanthin and then beta cryptoxanthin **5**.<sup>78</sup> Rice bran has both lutein and zeaxanthin. Carotenoids act as antioxidants in lipid medium of many biological systems. They are able to react with free radicals and convert them into less reactive radicals.

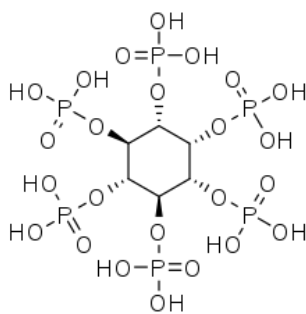




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### 2.2.3 Phytic acid

Phytic acid **13** is bioactive compound also known as Inositol hexaphosphate (IP6). IP6 in salt form, is known as phytate. Phytic acid is mostly present in the bran of whole-grain cereals. Phytic acid from whole-grain cereals has negative impact on mineral absorption since it binds minerals such as Zn, Fe, Ca and /or Mg, thus reducing their intestinal bioavailability.<sup>79</sup> However, phytic acid acts as strong antioxidant in vitro and it may also be a potent antioxidant in vivo, by reducing lipid peroxidation.<sup>80,81</sup> Phytic acid also decreases the colonic cancer incidence by suppressing the oxidative damage caused to the gut epithelium, especially in the colon where bacteria produces oxygenated radicals.<sup>82</sup>



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### 2.2.4 Phytosterols

Phytosterols are a collective term for plant sterols, which have similar structure as cholesterol. In cereals, plant sterols occur in many forms like free sterols, steryl esters with fatty acids, steryl glycosides, and acylated steryl glycosides. Plant sterols are bioactive components that have been reported to decrease serum cholesterol levels and are also beneficial in preventing colon cancer.<sup>83</sup>

### 2.2.5 Tocols

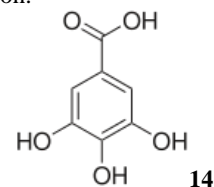
Tocols which include tocopherols and tocotrienols are natural antioxidants found in food of plant origin including cereals. These tocols occur in eight forms and are well recognized for their bioactivity.<sup>84</sup> Though the main source of tocols are vegetable oils, but substantial amounts of these bioactive compounds are reported in most cereal grains like barley, oats, wheat, rye, rice.<sup>85</sup> Recent studies have proved that tocotrienols have a protective effect by lowering LDL-cholesterol by inhibiting cholesterol biosynthesis.<sup>86</sup> It is reported that the high intake of  $\alpha$ -tocopherols decrease lipid peroxidation and platelet aggregation, and also function as a potent anti-inflammatory agent.<sup>87</sup>

### 2.2.6 Gamma-oryzanol

$\gamma$ -Oryzanol is a component of rice-bran oil and it was found to have antioxidant activity. Earlier it was presumed to be a single compound but later it was reported to be a mixture of sterols and ferulic acid. It helps to decrease plasma cholesterol and platelet aggregation.<sup>88</sup>

## 2.3 ANTIOXIDANTS PROPERTIES OF MARINE FOODS

Seaweeds and sponges are reported to be the richest source of bioactive compounds having the antioxidant activities.<sup>39</sup> They have been found to possess numerous disease prevention effects due to presence of phenolic compounds, polysaccharides, and useful organic acids.<sup>89</sup> The common phenolic compounds include flavonoids, benzoic acid, cinnamic acid, gallic acid **14**, and phlorotannin.<sup>90</sup> These provide protection against environmental pollutants and radiation.<sup>91</sup>



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Algae grow in extremes climatic conditions such as light, temperature, and salinity due to which there is production of reactive oxygen species (ROS) in large number. To cope with increased ROS, algae produce various secondary metabolites that possesses antioxidant activities such as polyphenols, carotenoids, and vitamins.<sup>92</sup> The composition of these seaweeds varies according to their species, geographical distribution, temperature, and season, but the overall nutritional value remains almost the same. Several compounds from marine algae possess anticancer activity, as they are rich source of antioxidants.<sup>93</sup> Majority of the secondary metabolites produced by marine organisms contain chloride and bromide ions. Marine halogenated compounds become part of other useful compounds such as indoles, peptides, terpenes, and phenols which possess antioxidant properties like free radical scavengers, hydrogen-donating compounds, and metal ion chelators.

Fish protein hydrolysate (FPH), prepared from various marine organisms has also been reported to have antioxidant activity.<sup>94</sup> Several peptides are obtained from fish muscle, bone, skin, and other tissues. All of these amino acids have free radical scavenging property, but amino acids who can easily donate hydrogen atoms are most powerful antioxidants. A pigment obtained from blue-green algae, phycocyanin can scavenge  $\text{OH}^\cdot$  and  $\text{RO}^\cdot$ . Algal antioxidants are also used in the cosmeceutical industries as antiaging agents.<sup>95</sup>

## 2.4 ANTIOXIDANT PROPERTIES OF MEDICINAL PLANTS AND SPICES

### 2.4.1 Garlic (Allium Sativum)

Garlic, a herb has strong antioxidant properties due to the presence of phenolic compounds.<sup>96</sup> It decrease reactive oxygen species, which are increased due to chronic inflammation, thus preventing the endothelial dysfunction which is early marker of atherosclerosis.<sup>97</sup> The antioxidant properties of garlic have been associated with several beneficial therapeutic effects, including cancer prevention, antithrombotic effects, cardiovascular protection and anti-aging effects.<sup>98</sup> The antioxidant potential of garlic increases with aging of the plant.<sup>99</sup>

### 2.4.2 Red Pepper (Capsicum annum)

Red pepper contains a wide range of phytochemicals with their radical scavenging properties. This spice contains carotenoids,

flavonoids, tocopherols, ascorbic acids and organic acids. The richness in bioactive compounds and the related antioxidant capacities greatly depend variety and on the fruits' maturation stage.<sup>100</sup> On ripening hot dried peppers have more content of bioactive substances that show free radical scavenging properties.<sup>101</sup> Several free and bound phenolic compounds have been detected and quantified in peppers.

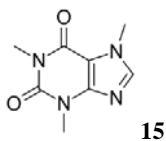
#### 2.4.3 Turmeric (*Curcuma longa*)

Turmeric is well known spice used as flavour enhancer in common dishes. Curcumin, a polyphenol, has multiple health benefits like antioxidant, anti-inflammatory,<sup>102</sup> antimutagenic, antimicrobial,<sup>103</sup> and anticancer properties.<sup>104</sup> Curcumin has been reported to improve systemic markers of oxidative stress.<sup>105</sup> Also it helps to increase serum activities of antioxidants such as superoxide dismutase (SOD).<sup>106</sup> As curcumin is a lipophilic compound, it is an efficient scavenger of peroxy radicals, hence, curcumin is also considered as a chain-breaking antioxidant like vitamin E.<sup>107</sup>

## 2.5 ANTIOXIDANTS PRESENT IN BEVERAGES

### 2.5.1 Tea

Phenolics in tea contribute towards its antioxidant activity. Major antioxidants of tea include polyphenolic compounds and caffeine **15**. The pure catechins and phenolic acids found in tea are more powerful antioxidants. Green tea is a gently processed tea on which the catechin profile is close to the original present in the leaves at the time of harvest. Black tea is a more processed product. Tea has been shown to have several health benefits, such as antioxidative, anticarcinogenic, anti-inflammatory, anti-obesity, anti-hypertensive and hypocholesterolaemia properties.<sup>108</sup>



### 2.5.2 Coffee

Phenolics are responsible for formation of coffee flavour. Catechol is the predominant phenolic compound found in coffee aroma. Coffee is rich in several antioxidants, including hydroxycinnamic acids and polyphenols. Hydroxycinnamic acids neutralizes free radicals and helps in preventing oxidative stress.<sup>109</sup>

### 2.5.3 Cocoa

Cocoa bean and its products are rich in antioxidants like polyphenols and tocopherols. These antioxidants can inhibit cellular damage either by quenching free radicals or through chelation of transition metal ions. Also, cocoa antioxidants could provide beneficial effects against risk factors of heart diseases, cancer, and neurodegenerative disorders.<sup>110</sup>

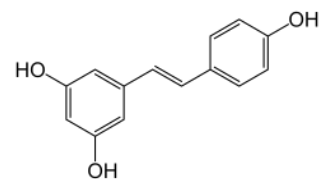
### 2.5.4 Beer

Beer is a beverage brewed from natural ingredients and contain appreciable amounts of antioxidants, which are associated with health effects. Polyphenols and melanoidins are the major antioxidants in beer. The amount of phenolic compounds and melanoidins in beer is largely influenced by its

raw materials and hence by the environmental factors in which they grow and it is also influenced by brewing factors.<sup>111</sup> Polyphenols are capable of reducing reactive oxygen species. Some researchers have shown that melanoidins have antioxidant, antimicrobial, antihypertensive, antiallergenic, and prebiotic properties.<sup>112</sup>

### 2.5.5 Wine

Wine is consumed worldwide for many centuries. According to many studies a certain amount of everyday wine consumption may prevent various chronic diseases. This is due to the presence of important antioxidants like resveratrol, anthocyanins, and catechins in red wine.<sup>113</sup> Resveratrol **16** prevents cardiovascular diseases by neutralizing free oxygen radicals and reactive nitrogenous radicals.<sup>114,115</sup> It also reduces platelet aggregation and so prevents the formation of blood clots or thrombi.

**16**

## SUMMARY

Several antioxidants are present in varied natural food components. They play vital role in our body. They control the autoxidation by inhibiting the formation of free radicals and subsequently reduce oxidative stress, and increase healthy longevity. It is important to consume these in our daily diet so that there is protection against deleterious effects of free radicals.

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