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Functional Foods and Nutraceuticals

Bioactive Components, Formulations
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Chapter 14

Fruits and Vegetables and its Nutritional Benefits



Jyothi Kaparapu, Prayaga Murthy Pragada,
and Mohana Narasimha Rao Geddada

14.1 Introduction

An increase in the consumption of fruits and vegetables has been observed in recent years due to increase in knowledge of its beneficial properties. A high amount of plant-based food consumption, at least 400 g of fruits and vegetables is recommended in dietary guidelines (Agudo 2005). Epidemiological surveys indicated a positive correlation towards a diet rich in fruits and vegetables and minimized the occurrence of degenerative diseases including certain types of cancer, cardiovascular diseases, macular degeneration, aging and others (Michels et al. 2000; Trichopoulou et al. 2003; Willcox et al. 2003; Dauchet et al. 2006; Ordovas et al. 2007; Liu 2013).

Fruits and vegetables contain a wide range of micronutrients and non-nutrient bioactive compounds such as dietary fiber, minerals (potassium, calcium, and magnesium) vitamins (A, C and E), phytochemicals (poly phenolic compounds and carotenoids, glucosinolates, organosulphur compounds, sesquiterpene lactones). Approximately there are more than 5000 individual phytochemicals have been noticed in fruits, vegetables but a large proportion of them remains unknown (Liu 2013). Bioactive compounds are the secondary metabolites of the plants, which have pharmacological and poisonous manifestations in man and animals (Bernhoft 2010). They generate important functions in the living cell such as defense against

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free radicals and prevention of disease as a result of oxidative stress and act as anti-oxidants (Bernhoft 2010; Kaur and Kapoor 2001). The bioactive compound biosynthesis is encouraged by light; hence they assemble in the skin and leaves of the fruits and vegetables (Bernhoft 2010). The levels of the bioactive compounds in fruits and vegetables differs based on genetic factors, environmental conditions such as light, maturity and postharvest treatments (Deepa et al. 2007; Vallejo et al. 2003). The Vitamins, minerals and bioactive compounds of fruits and vegetables are in the liquid form which makes them more bioavailable in the human diet (Yildiz and Gültekin 2006).

The advantages from the intake of fruits and vegetables, seems to be related to additive interactions between the phytochemicals that could affect different pathways such as changes in cholesterol and hormone metabolism, enhances immune response, modulation of steroid hormone concentration and detoxifying enzymes, reduction of blood pressure, stimulates antibacterial, antiviral and antioxidant activity, lowers inflammatory processes, anti-carcinogenic properties and delay of cardiovascular diseases (Yu and Ahmedna 2013). It is a fact that fruits and vegetables can be processed for economical and logistical reasons to improve their commercial shelf-life and digestibility following the consumer habits of each country or to facilitate the consumption by special groups (children, pregnant women, older adults and patients with certain pathologies).

Foods that convey a specific, documented health promoting and disease preventing property beyond the basic function of supplying nutrients are termed 'functional foods.' Functional foods are an emerging science area. Currently, the functional food industry is encountering rapid growth due to the innovation of new products, and associated marketing, based upon the bioactivity of polyphenolic compounds. These products report the wellness trend and the needs of health-conscious consumers across infinite health areas (Gibson et al. 2000; Kathleen 1999). Another aspect of the success of functional foods is that they taste great and be convenient. Fruits have more health halo than vegetables and with their intrinsic sweetness, generally good taste, texture and convenience in portability; they are much more attractive to consumers. Our aim is the provision of appropriate information to plant breeding teams, to select for scientifically proven health-promoting fruits and vegetables as whole fresh functional foods.

Fruits and vegetables producing crops are classified based on their climatic adaptability (Table 14.1). They are tropical, subtropical, temperate and arctic fruits and vegetables. Tropical crops survive in the region between tropic of Cancer (23° 27"N latitude) and tropic of Capricorn (23° 27"S latitude), need a moist warm climate, resist dry weather and are evergreen. Sub-tropical fruits grow between temperate and tropical climatic conditions (either evergreen or deciduous). They are adapted to low temperatures. Temperate crops are those which survive in extreme cold. They are deciduous and become dormant in winter. The Arctic is a cold temperature region, a few crops thrive in such extreme frost conditions.

Table 14.1 Classification of Fruits and Vegetables based on climate

Type of Fruit	Fruits Examples	Vegetables Examples
Tropical	Mangosteen, jackfruit, Olive rambutan, Syzygium , Mango, banana, plantain, papaya, guava, pineapple passion fruit etc. (Ayala-Zavala et al. 2011)	Arugula, Asian Greens, Beans, Bell Peppers, Cabbage, Capsicum (that's the Australian name for peppers), Cassava, Chard (silverbeet, similar to spinach), Chinese Cabbages, Chilli Peppers, Cucumbers, Eggplant, Endive, Lettuce, Okra, Peppers, Pumpkins, Radish, Rocket Squash, Sweet Corn etc. (Wani et al. 2017; Litz et al. 1986; Tindall 1983)
Subtropical	Grapes, pomegranate, Pineapples, Papaya, Banana, Avocado, Litchie, Kiwi Mangoes, Guavas, Citrus fruit (sweet orange, mandarin, tangerine) (Galan Sauco et al. 2014; Litz et al. 1986)	Cherry tomato, Pumpkin, lablab bean, Choko, Ethiopian or Kenyan Cabbage, Sweet potato, Luffa (<i>Luffa cylindrica</i>) etc. (Wani et al. 2017; Litz et al. 1986)
Temperate	peach, pear, strawberry, cranberry, blackberry, blueberry, Apple, pear, stone fruits etc. (Kole 2011)	Endive, Escarole, Mustard, Black mustard, Kale, collards, Cabbage, Savoy cabbage, Garden cress, Watercress, Chard, Swiss chard, Spinach, lettuce, Sorrel, Asparagus, lettuce, Celery, Parsley, Rubharb etc. (Martin 1982)
Arctic	Almond and trifoliate orange, arctic rasp berries etc. (Molau 1997)	Herbs, Braccoli (Ganong 1977)

14.2 Functional Properties of Fruits and Vegetables

Fruits and Vegetables are composed of several macro and micronutrients. Macronutrients are required in larger amounts and are mainly carbohydrates, proteins, and fats. Micronutrients are only needed in smaller quantities. Common micronutrients are vitamins and minerals. Vitamins devote the maintenance of healthy vision, immune function, bone health; cell integrity helps regulate calcium and phosphorus. Fruits are rich in vitamin C, A and E. Minerals may reduce the risk of high blood pressure and stroke. Copper and manganese are cofactors of the anti-oxidant enzyme, superoxide dismutase. Copper is required for the production of red blood cells. Vitamin composition of some fruits and vegetables are tabulated below (Tables 14.2 and 14.3).

14.3 Functional Bioactive Compounds and Their Properties

The list of major bioactive components of fruits and vegetables that have beneficial effects in the human body has been summarized in Table 14.4.

Table 14.2 Vitamin content of some major Fruits

Fruit	Vitamins									
	A (IU)	B1 (mg)	B2 (mg)	B3 (mg)	B6 (mg)	B9 (µg)	C (mg)	D (IU)	E (mg)	K (µg)
Grapes	67	15	–	0.00006	0.000016	0.00009	6.5	–	–	–
Plantain	1127	0.052	0.05	0.69	0.29	22	18.4	0.7	0.14	0.7
Pineapple	58	0.08	0.03	0.5	0.11	18	47.8	0	0.02	0.7
Apple	54	0.02	0.03	0.09	0.04	3	4.6	0	0.18	2.2
Orange	225	0.09	0.04	0.28	0.06	30	53.3	0	0.18	0
Banana	64	0.03	0.07	0.67	0.37	20	8.7	0	0.1	0.5
Mango	1082	0.03	0.04	0.67	0.12	43	36.4	0	0.9	4.2
Peach	326	0.02	0.03	0.81	0.03	4	6.6	0	0.73	2.6
Papaya	950	0.02	0.02	0.35	0.03	37	60.9	0	0.3	2.6
Pear	25	0.01	0.03	0.17	0.03	7	4.3	0	0.12	4.4
Guava	624	0.06	0.04	1.08	0.11	49	228.3	0	0.7	2.6

Source: (Saini and Keum [2016](#); Dasgupta and Klein [2014](#); Płonka et al. [2012](#); Chun et al. [2006](#); Benvenuti et al. [2004](#); Belitz et al. [2004](#))

Table 14.3 Vitamin content of some major Vegetables

Vegetable	Vitamins					
	A (IU)	B1 (mg)	B2 (mg)	B6 (mg)	B9 (µg)	C (mg)
Pumpkin	0.02	0.04	0.04	0.02	0.007	16.00
Broccoli	0.2	0.1	0.3	0.21		110.00
Brussels sprouts	0.03	0.1	0.12	0.23	0.087	66.00
Cabbage	0.01	0.1	0.15	0.2	0.069	80.000
Carrot	0.6	0.01	0.01	0.03	0.016	1000
Cauliflower	0.001	0.05	0.07	0.2	0.044	80.000
Cucumber	0.034	0.03	0.01	0.03	0.005	10.000
Onion	0.001	0.03	0.01	0.17	0.01	10.000
Peas	0.3	0.06	0.05	0.05	0.022	1000
Potato	0	0.12	0.04	0.3	0.023	14.000
Radish	0.002	0.05	0.03	0.08	0.028	20.000

Source: (Saini and Keum [2016](#); Dasgupta and Klein [2014](#); Chun et al. [2006](#); Benvenuti et al. [2004](#); McCarthy and Matthews [1994](#); Saleh et al. [1977](#))

Polyphenols Polyphenols are dietary antioxidant that exists usually in fruits and vegetables. They consist of flavonoids (flavonols, flavones, isoflavones, flavonols, flavanones and anthocyanins) and non-flavonoid polyphenols (phenolic acids, lignans and stilbenes).

Flavonoids Flavonoids neutralize free radicals that damage cells and increases cellular antioxidant protection. Isoflavones- are structurally similar to estrogen but are not steroids.

Table 14.4 Bioactive compounds of Fruits and Vegetables

Functional compounds		Mechanism of action	Fruit source	Vegetable source
Flavonoids	Flavanones	Hesperidin Hesperetin	Oranges (Gattuso et al. 2007)	Lettuce Onion Tomato (Sanchez-Moreno et al. 2000); parsley, celery (Tomas-Barberan and Clifford 2000; Mouly et al. 1994)
		Naringenin	Citrus fruits (Gorinstein et al. 2001; Wang et al. 2008; Harborne and Williams 2000)	
	Flavonols	Eriocitrin		
		Neohesperidin		
		Naringin	Oranges (Chadha 2001)	
		Narirutin		

(continued)

Table 14.4 (continued)

Functional compounds		Mechanism of action	Fruit source	Vegetable source
Flavonols	Kaempferol	Anti-inflammatory and antioxidant	Grapes, plantain, apple (Yu and Ahmedna 2013; Pan et al. 2001; Shahidi and Nacz 1995; Radha and Mathew 2007)	Onion (Benitez et al. 2011, 2012; Gonzalez-Pena et al. 2013); Beets
	Myricetin	Reduce atherosclerosis	Grapes, apple, plantain, pineapple, straw berry, mulberry (Sultana and Anwar 2008)	Cherry tomato, broccoli, (Ninfali and Angelino 2013); Cabbage, carrot, cauliflower, spinach, turnip, onion, garlic, ginger (Sultana and Anwar 2008)
	Quercetin	Anticarcinogenic, diarrhea, allergies, prevent atherosclerosis, asthma, Hay fever, hypertension, interstitial cystitis prostatitis diabetes Rheumatoid Arthritis (RA) athletic endurance	Grapes, apricot, plantain, apple, peaches, Berries (Mariaa et al. 2002; Radha and Mathew 2007)	
	Isorhamnetin	Reduce the risk of cancer, improve heart health and ease diabetes complications	Plantain, grapes, apple (Eberhardt et al. 2000)	
	Laricitrin	Prevents cardio vascular diseases, anticarcinogenic	Red grapes, apple (Castillo-Munoz et al. 2007)	
Anthocyanidins	Syringetin	Stimulates osteoblast differentiation	Red grapes (Castillo-Munoz et al. 2007)	
	Malvidin	Anti-inflammatory and anticarcinogenic activity, cardiovascular disease prevention, obesity control	Oranges Guava, Berries, grapes (Wang and Lin 2000)	Aubergine, red cabbage, Lettuce (Koponen et al. 2007; Wu et al. 2006)
	Peonidin			
	Delphinidin			
	Peltunidin			
	Cyanidin			

Leucoanthocyanidins	Leucocyanidin	Protection against ulcer	Plantain (Loganayaki et al. 2010)	beans, Broccoli, tomato, spinach, Kale (Appari et al. 2014; Pathak et al. 2018)
Flavan-3-ols	Catechin	Anticarcinogen in lungs, stomach, esophagus, duodenum, liver, pancreas, mammary gland	cherry, apple apricot, Grapes, pineapple, Kiwi peaches, goose berry, peaches, blackberries, black grapes, strawberries, blueberries and raspberries (Zanwar et al. 2014; Mariaa et al. 2002)	
	Epicatechin	Reduction of diabetes, heart health	Grapes, pineapple, apple, peaches (Mariaa et al. 2002; Jose et al. 1997)	
Flavones	Gallocatechin epigallocatechin	Improve brain function, fat loss, anti-cancerous.	Banana, Grapes, apple, pear (Pathak et al. 2018)	
	Apigenin	Treatment of HIV, inflammatory bowel disease, prostate cancer and cervical cancer	Plantain (Loganayaki et al. 2010), Citrus, kiwi (Hostetler et al. 2017)	Peas, Parseley, Capsicum, onion Pepper, Lettuce (Justesen et al. 1998; Crozier et al. 1997)
	Luteolin	Antimutagenic, antitumorogenic, antioxidant, anti-inflammatory properties		
	Tangeretin	Prevents breast cancer, cholesterol lowering and in neuroprotection	Tangerines (Hung et al. 2010; Berhow et al. 1998)	

(continued)

Table 14.4 (continued)

Functional compounds		Mechanism of action	Fruit source	Vegetable source
Carotenoids	α – Carotene β – Carotene lycopene β – Cryptoxanthin Lutein Zeaxanthin Astaxanthin	Prevents cancer in endometrium, breast, lungs, liver and colon; cornea protection against UV-induced erythema	Orange, passion fruit, jackfruit, Tangerines, pineapple, Apricot, peaches, pear, guava, banana, apple, grapes, mango, Acerola (Saini et al. 2015; Lokesh et al. 2014; Divya and Pandey 2014; Chan Jr 1980)	Tomato (Sanchez-Moreno et al. 2000); Carrot (Sun et al. 2009) sweet potato, pumpkin, green beans, spinach and broccoli (Khoo et al. 2011); Broccoli, Brussels, cauliflower, Chicory, drumstick, Kale, Lettuce, Pumpkin, Squash (Saini et al. 2015).
Phenolic acids				
Hydroxybenzoic acid	Gallic acid p-hydroxybenzoic acid Gentisic acid	Reduce hypertension, atherosclerosis and dyslipidemia	Grapes, guava, pineapple, Plantain Grapes (Pan et al. 2001), pomogranate, Berries, onion, blackberry, raspberry, strawberry	Lettuce, Tomato (Sanchez-Moreno et al. 2000); Artichoke (Femenia et al. 1998; Larrosa et al. 2002); Carrot, Potato (Mattila and Hellstrom 2007).
Hydroxycinnamic acid	Caffeic acid	Chemo protective agent in oral cancer, helps in cardiac health and antihyperglycemic	Plantain, grapes (Loganayaki et al. 2010)	Beets (Canadianovic-Brunet et al. 2011; Ninfali and Angelino 2013)
	Chlorogenic acid	Reduce colon cancer, prevents hardening of arteries	Pineapple, peaches, grapes, Kiwi, cherry, plum, apple, pear (Alam et al. 2016)	
	Ferulic acid	Protect against cancer, bone degeneration, menopausal symptoms	Pineapple, grapes, apple, orange	

Stilbenoids	Resveratrol	Anti-aging, anticancer factor against colon and prostate cancers, against coronary heart disease, alleviates the risk of stroke, chemopreventive agent against melanoma, preventing Alzheimer disease and viral/fungal infections	Grapes (Niles et al. 2003; Nazar et al. 2006)	
Phytoestrogens	Glycetin	Relief from menopausal symptoms and lower risk of osteoporosis, heart disease and breast cancer	Plantain, grapes (Loganayaki et al. 2010; Cornwell et al. 2004)	
Tannins	Proanthocyanidins Procyanidin B2	Fight against tooth cavities, diarrhea, protect heart diseases and cancer	Pineapple, peaches, grapes, apple, orange (Montes-Avila et al. 2017)	Indian squash (Montes-Avila et al. 2017)
Dietary fibres	Cellulose, Hemicelluloses Galactooligosaccharides, Lignin, Pectin	Maintain bowel health, lowers cholesterol levels, helps to control blood sugar levels	Grapes (Niles et al. 2003; Nazar et al. 2006)	Tomato (Sanchez-Moreno et al. 2000); artichoke (Femenia et al. 1998; Larrosa et al. 2002); Carrot (Chau et al. 2004); Onion (Benitez et al. 2012; Gonzalez-Pena et al. 2013; Colina-Coca et al. 2013, 2014)
Prebiotics	Fructooligosaccharides	Increases the growth intestinal bacteria, Resists gastric acidity	Banana, watermelon, custard apple, Gapes (Wuyts et al. 2006)	Chikory, Jerusalem artichoke, onions, savoy cabbage (Allsopp and Rowland 2009)
Others	Oleoresins, Shogaol, Gingerol, Astilbin	Reduces blood cholesterol, Suppresses arthritis	Plantain (Loganayaki et al. 2010)	Capsicum, Pepper, celery (Moyler 1991)

Flavanones These are flavonoids that are glycosylated at the seventh position to give flavanones. A variety of flavanones are present in fruits and vegetables. Hesperetin- regenerates vitamin C. It inhibits the proliferation of cancer cells, replication of viruses like polio, herpes, and flu (Divya and Pandey 2014). They have chemopreventive effects. They are used in treating hemorrhoids, varicose veins, and lymphedema Naringenin acts as antioxidant, anti-inflammatory, anti-allergic, hypolipidemic and vasoprotective (Gardana et al. 2007). Narirutin used in the treatment of bronchial asthma (Funaguchi et al. 2007).

Flavonols They occur in un-glycosylated forms. It includes catechins and proanthocyanidins. Catechins (Flavan-3-ols) It acts as an anticarcinogen in the lungs, stomach, esophagus, duodenum, liver, pancreas, mammary gland. It also prevents chronic inflammation associated with carcinogenesis and cardiovascular disease (Cheynier et al. 2000). Quercetins effective in protecting Low Density Lipoprotein from oxidation, followed by myricetin and kaempferol. It inhibits oxidation of LDL thus reducing atherosclerosis and cardiovascular diseases; inhibit colon cancer (David et al. 2016). Kaempferol It has anti-inflammatory and antioxidant properties. Proanthocyanidins. They are oligomers of catechin and epicatechin and their gallic acid esters. They form tannins.

Anthocyanins These are watersoluble plant pigments, responsible for the red, blue and purple colors of fruits (Rufino et al. 2010). Cyanidin, delphinidin, petunidin, peonidin and malvidin are the classes (Mazza and Miniati 1993). It has antioxidant properties. It enhances immune suppressive mechanisms, anti-allergic, anti-inflammatory, antimicrobial and anti-cancer (uterine carcinoma and colon adenocarcinoma) (Cheynier et al. 2000).

Flavones Apigenin, luteolin and tangeretin are important edible flavones. Apigenin- used in the treatment of HIV, inflammatory bowel disease and skin conditions (Duthie and Crozier 2000), prostate cancer and cervical cancer (Gupta et al. 2002). Luteolin exhibits anti mutagenic, anti tumorigenic, antioxidant and has anti-inflammatory properties (Kim et al. 1999). Tangeretin is a polymethoxylated flavone, stops cancer cell proliferation, breast cancer (Marc et al. 1999).

Carotenoids They inhibit the cell proliferation of human endometrium, mammary gland, and lungs. β - Carotene neutralizes free radicals, which may damage cells. β - Carotene and lutein are orange and yellow carotenoids. They minimize liver cancer and lung cancer (Pueyo and Polo 1992). B Carotene boosts the activity of natural killer immune cells. It gives cornea protection against UV light. Zeaxanthin grants to the preservation of healthy vision. Lutein may protect against colon cancer. Lycopene aids in the continuation of prostate health.

Phenolic Acids Separated into two classes- hydroxybenzoic acids and hydroxycinnamic acids.

Hydroxybenzoic acid-Gallic acid and p-hydroxybenzoic acid are common types.

Hydroxycinnamic acid- Phenols and hydroxycinnamic acid inhibit the formation of carcinogen metabolites. Chlorogenic acid prevents colon cancer, helps in the maintenance of cardiac health and prevents various tumors. It also possesses chemopreventive properties. Ferulic acid- inhibits carcinogen metabolites. Stilbenoids: They are glycosylated forms of stilbenes. Resveratrol in grapes acts as an antioxidant, anti-aging agent, reducing the oxidative damage in the DNA of neuronal cells (Nazar et al. 2006). It has an anticancer factor against colon and prostate cancers. It is beneficial in coronary heart disease by preventing vasodilation and platelet aggregation (Niles et al. 2003). It protects against age related macular degeneration (King et al. 2005). It has a role in preventing Alzheimer's disease and viral/fungal infections.

Dietary Fibers Insoluble fiber may accord to the perpetuation of a healthy digestive tract (Dreher 2018). Soluble fibre may reduce the risk of coronary heart disease and some types of cancer. Cellulose, hemicellulose and pectin are some examples.

Proteins Proteins in the form of enzymes play a significant role in free radical scavenging activities Polyphenol oxidases, peroxides, phenolase, phosphatase, proteases, pectin, Methyl esterase (PME), polygalacturonase etc. are enzymes present in the skin (Shahidi and Nacz 1995). Bromelain of the pineapple has significant anti-inflammatory effects in acute sinusitis, sore throat, arthritis and speeding recovery from injuries. Bromelain also used in the treatment of rheumatoid arthritis, diabetic ulcers, angina pectoris and general surgery. Pineapple is an excellent cerebral toner that combats loss of memory sadness and melancholy.

Prebiotics They are non-digestible carbohydrates that cannot be broken down by the body. They are food sources for probiotic organisms.

Some vegetables and fruits can be classified as super foods, referring to foods that provide utmost nutritional benefits for minimal calories. They are packed with vitamins, minerals, and antioxidants. The term "superfood" was used as a marketing tool for selling specific foods, dietary supplements, foods with selected food additives (Fitzgerald 2014). "Super food" products were sold at a greater price than similar foods without the label.

As there is no official scientific definition of a super food by regulatory authorities in major consumer markets, such as the United States Food and Drug Administration and Department of Agriculture or the European Food Safety Authority (Brown 2010), but it is generally accepted that super foods contain high levels of vitamins and minerals. They can be a source of antioxidants, substances that protect from cell damage, preventing cancer. They also possess healthy fats that prevent heart disease, fiber thought to ward off diabetes and digestive problems; and phytochemicals, responsible for deep colors and odors which have many health benefits. Super fruits are a subset of super foods (Srinivasan 2008). The designation of a fruit as a super fruit is entirely up to the product manufacturer, as the term is primarily used to create consumer demand (Starling 2008). Following are the list of some super foods.

14.4 Dark Green Leafy Vegetables

These are rich in folate, zinc, calcium, iron, magnesium, vitamin C and fiber. They minimize the probability of chronic illnesses including heart disease and type 2 diabetes (Blekkenhorst et al. 2008; Wang et al. 2016). They also contain high levels of carotenoids (anti-inflammatory compounds), protect against certain types of cancer (Xavier and Perez-Galvez 2016). Some well-known Dark green leafy vegetables considered as super foods include Kale, Swiss chard, Collard greens, Turnip greens, Spinach. **Kale** is a good source of minerals, antioxidants and vitamins A, C and K. It also contains antioxidants lutein and beta-carotene, which prevents the risk of diseases due to oxidative stress (Lien et al. 2008). **Collard greens** are reliable sources of calcium and vitamins A, B9 (folate), C and K (Weber 2001). **Spinach** is rich in manganese vitamin K and A. It's also packed with folate, which plays a key role in red blood cell production and the prevention of neural tube defects in pregnancy (Furness et al. 2013). **Swiss Chard** is rich in the minerals potassium, manganese and vitamins A, C, and K. Swiss chard also contains a unique flavonoid called syringic acid, a compound that may be beneficial for lowering blood sugar levels (Young-Hee Pyo et al. 2004). **Turnip greens** accommodate diverse antioxidants including glucotropaeolin, gluconasturtiin, quercetin, myricetin and beta-carotene, etc., effective in lowering stress you're the risk of heart disease, cancer and inflammation (Lin and Harnly 2010).

14.5 Green Leafy Vegetables

Green leafy vegetables contain folic acid (B vitamin) that prevent birth defects, heart disease, dementia, colon cancer, vision loss and protects skin and bones. Green leafy vegetables are a source of lutein which prevents macular degeneration (a cause of age-related vision loss), cataracts and protect skin from the adverse effects of sun exposure. Lutein preserves the fats in the top layer of skin, halting dehydration, roughness and even wrinkles. Green leafy vegetables are rich in vitamin K, necessary for bone development. Examples include: **Micro greens**-Microgreens are immature greens developed from the seeds of vegetables and herbs, measure 1–3 inches. Microgreens contain up to 40 times more nutrients compared to their mature counterparts including vitamins C, E and K (Xiao et al. 2012). **Cabbage** is formed of clusters of thick leaves that come in green, white and purple colors. Vegetables in *Brassica* family contain glucosinolates may have cancer-protective properties against lung and esophageal cancer (Johnson 2002). Cabbage can be fermented and turned into a sauerkraut, which improves digestion, boosts the immune system and aids weight loss (Gupta and Garg 2009). **Beet Greens** rich in potassium, calcium, riboflavin, fiber and vitamins A and K. fiber. They also contain the antioxidants beta-carotene and lutein, which inhibit the risk of eye disorders, such as macular degeneration and cataracts (Semba and Dagnelie 2003). **Watercress**

is an aquatic plant from the *Brassicaceae* family. Watercress extract is beneficial in targeting cancer stem cells and impairing cancer cell reproduction and invasion (Boyd et al. 2006). Romaine Lettuce is an excellent source of vitamins A and K which is important for good health (Nicolle et al. 2004). **Arugula** is a leafy green from the *Brassicaceae* family. It's also one of the best sources of dietary nitrates, may help increase blood flow and reduce blood pressure by widening your blood vessels (Kapil et al. 2015). **Endive** belongs to the *Cichorium* family, rich in vitamin K, A and folate. It's also a source of kaempferol, an antioxidant reduces inflammation and inhibits the growth of cancer cells in test-tube studies (Chen and Chen 2013). **Bok Choy** is a variety of Chinese cabbage. Bok Choy is popular in China and often used in soups and stir-fries. It contains the mineral selenium, which benefits brain health, immunity, cancer protection and thyroid health (Ventura et al. 2017).

14.6 Cruciferous Vegetables

Cruciferous vegetables (broccoli, cabbage and Brussels) possess sulforaphane an enzyme that detoxifies carcinogens before they damage cells. Cruciferous vegetables prevent the development of cancer cells in the breast, uterine lining (endometrium), lung, colon, liver and cervix. Isothiocyanates from cruciferous vegetables aids in the conversion of estrogen and other hormones into forms that are more easily excreted from the body. Diets rich in cruciferous and dark yellow veggies helps to defend against cardiovascular disease. Vitamin C, beta carotene and potassium are the other significant nutrients of cruciferous vegetables. **Sweet potato** is a root vegetable stuffed with a variety of nutrients, including potassium, fiber vitamins A and C, carotenoids of sweet potato inhibits the risk of cancer (Tanaka et al. 2012). Interestingly, they may improve blood sugar control in those with type 2 diabetes (Ooi and Loke 2013). The **Onions** family and related super foods including garlic and leeks have a wide range of nutritional and health benefits. Naturally controls blood sugar in diabetics, very good source of daily fiber and natural sugars (Morris 2012). Onions used as disinfectants (sulfur content), a diuretic, anti-emetic, stimulant, expectorant, and fight colds. Onions contain selenium, an important nutrient. Red onions are rich in anthocyanins, which are powerful plant pigments that may protect against heart disease, certain cancers and diabetes (Slimestad et al. 2007).

14.7 Orange Fruits and Vegetables

Beta carotene of orange vegetables and fruits such as sweet potatoes, squash, pumpkins, carrots, mangos, oranges and papayas possess beta carotene, an anti-oxidant that helps protect healthy skin cells and block sun damage (Schulz 2004). Beta

carotene is necessary for the lining of membranes in the mouth, throat, lungs, stomach, intestines, urinary tract and the reproductive tract. It also helps night vision. Manganese, copper, fiber, vitamin B-6, potassium and iron are the other nutrients in orange fruits and vegetables.

Berries Berries are boosted with vitamins, minerals, fiber and antioxidants. The strong antioxidant property of berries reduce threat of heart disease, cancer and other inflammatory conditions (Skrovankova et al. 2015; Manganaris et al. 2014). Berries are efficient in eliminating digestive and immune-related disorders (Govers et al. 2018). Some of the most common berries include: Raspberries, Strawberries, Blueberries, Blackberries, Cranberries. **Blueberries** are considered to improve memory, brain function, heart function; inhibits the risks of cancer, reduce cholesterol; act as an anti-inflammatory and have anti-aging benefits etc. Blueberries are a great add-in for smoothies, yogurt, salads or just to eat alone (Seeram 2008). **Canberries** are rich in high phenol content that help to lower the oxidation of the LDL cholesterol. Proanthocyanidins in Cranberries' can protect against urinary tract infections. The antioxidants and other nutrients in Cranberries enhance immune function, helps digestion, decrease the risk of heart-problems and possess anti-aging properties.

Pomegranates are an antioxidant rich fruit used for treating diarrhea, excessive perspiring, recurrent fevers, sore throats. It also used as an astringent. Bark, rind, and seeds of pomegranates are frequently used. Avocado is a good source of many nutrients, including fiber, vitamins, minerals and healthy fats, monounsaturated fats (Dreher and Davenport 2013). Oleic acid is the most predominant MUFA in avocado, which reduces inflammation in the body (Sales-Campos et al. 2013). Avocado may reduce the risk of heart disease, diabetes, metabolic syndrome and certain types of cancer (Fulgoni 3rd et al. 2013; Wang et al. 2015; Ding et al. 2007).

14.8 Conclusion

Food is a substance that we eat which provides nutrition to maintain growth and sustain life. Instead of having anything to consume, it will be good to take food which provides us both flavor and health. As the Father of Medicine, Hippocrates said more than 2000 years ago "Let food be thy medicine and medicine be thy food". Fruits and vegetables are a good source for obtaining phytochemicals with high antioxidant activity and other beneficial health properties. The utilization of these low-cost renewable resources could be prepared for the pharmaceutical, nutraceutical, and food industries with the opportunity of developing new nutraceutical and pharmaceutical products. Studies are to be focused on elucidating the possible mode of action of bioactive compounds. It is also aimed to prevent deteriorative reactions as well as identify their specific contribution to the total antioxidant capacity. Furthermore, encompassing the efforts of food technologists, nutritionists and

physicians will lead to the development of programs to raise awareness of the great health advantages that fruit and vegetable consumption offers.

References

- Agudo A (2005) Measuring intake of fruit and vegetables. In: Joint FAO/WHO workshop on fruit and vegetables for health, Kobe, Japan. WHO/FAO, Kobe
- Alam MA, Subhan N, Hossain H et al (2016) Hydroxycinnamic acid derivatives: a potential class of natural compounds for the management of lipid metabolism and obesity. *Nutr Metab (Lond)* 13:27
- Allsopp P, Rowland I (2009) Potential protective effects of probiotics and prebiotics against colorectal cancer. In: Charalampopoulos D, Rastall RA (eds) *Prebiotics and probiotics science and technology*. Springer, New York
- Appari M, Babu KR, Kaczorowski A, Gross W, Herr I (2014) Sulforaphane, quercetin and catechins complement each other in elimination of advanced pancreatic cancer by miR-let-7 induction and K-ras inhibition. *Int J Oncol* 45(4):1391–1400
- Ayala-Zavala JF, Vega-Vega V, Rosas-Domínguez C, Palafox-Carlos H, Villa-Rodriguez JA, Siddiqui Md Wasim, Dávila-Aviña JE, González-Aguilar GA (2011) Agro-industrial potential of exotic fruit byproducts as a source of food additives. *Food Res Int* 44(7):1866–1874
- Belitz HD, Grosch W, Schieberle P (2004) Vitamins. In: *Food chemistry*. Springer, Berlin/Heidelberg
- Benitez V, Molla E, Martín-Cabrejas MA, Aguilera Y, Lopez-Andreu FJ, Cools K, Terry LA, Esteban RM (2011) Characterization of industrial onion wastes (*Allium cepa* L.): dietary fibre and bioactive compounds. *Plant Food Hum Nutr* 66(1):48–57
- Benitez V, Molla E, Martín-Cabrejas MA, Aguilera Y, Lopez-Andreu FJ, Esteban RM (2012) Onion (*Allium cepa* L.) by-products as source of dietary fiber: physicochemical properties and effect on serum lipid levels in high-fat fed rats. *Eur Food Res Technol* 234(4):617–625
- Benvenuti S, Pellati F, Melegari M, Bertelli D (2004) Polyphenols, anthocyanins, ascorbic acid, and radical scavenging activity of *Rubus*, *Ribes*, and *Aronia*. *J Food Sci* 69(3):FCT164–FCT169
- Berhow M, Tisserat B, Kanes K, Vandercook C (1998) Survey of phenolic compounds produced in Citrus. *USDA ARS Tech Bull* 1998:1–154
- Bernhoft A (2010) A brief review on bioactive compounds in plants. In: Bernhoft A (ed) *Bioactive compounds in plants: benefits and risks for man and animals*. The Norwegian Academy of Science and Letters, Oslo
- Blekkenhorst LC, Sim M, Bondonno CP, Bondonno NP, Ward NC, Prince RL, Devine A, Lewis JR, Hodgson JM (2008) Cardiovascular health benefits of specific vegetable types: a narrative review. *Nutrients* 10(5)
- Boyd LA, McCann MJ, Hashim Y, Bennett RN, Gill CI, Rowland IR (2006) Assessment of the anti-genotoxic, anti-proliferative, and anti-metastatic potential of crude watercress extract in human colon cancer cells. *Nutr Cancer* 55(2):232–241
- Brown A (2010) *Understanding food: principles and preparation*. p 331. ISBN 978-0-538-73498-1
- Canadanovic-Brunet JM, Sabavic SS, Cetkovic GS, Vulic JJ, Djilas SM, Markov SL, Cvetkovic DD (2011) Antioxidant and antimicrobial activities of beet root pomace extracts. *Czech J Food Sci* 29(6):575–585
- Castillo-Munoz N, Gomez-Alonso S, Garcia-Romero E, Hermosin-Gutierrez I (2007) Flavonol profiles of *Vitis vinifera* red grapes and their single-cultivar wines. *J Agric Food Chem* 55(3):992–1002
- Chadha KL (2001) *Hand book of horticulture*. Indian Council of Agricultural Research, New Delhi, p 1031

- Chan HT Jr (1980) Passion fruit. In: Shaw PE, Chan HT Jr, Nagy S (eds) Tropical and subtropical fruits: composition, nutritive values, properties and uses. AVI Publishing Co., Westport, CT, pages 568
- Chen AY, Chen YC (2013) A review of the dietary flavonoid, kaempferol on human health and cancer chemoprevention. *Food Chem* 138(4):2099–2107
- Cheyrier V, Moutounet M, Sarni-Manchado P (2000) Los Compestos fenolicos. In: Flanzky C (coordonateur) *Enologia: Fundamentos Cientificos y Technologicos*. Ediciones MundiPrensa & A Madrid Vicente, Madrid, pp 114–136
- Chun J, Lee J, Ye L, Exler J, Eitenmiller RR (2006) Tocopherol and tocotrienol contents of raw and processed fruits and vegetables in the United States diet. *J Food Compos Anal* 19(2–3):196–204
- Colina-Coca C, De Ancos B, Sanchez-Moreno C (2014) Nutritional composition of p rocessed onion: S-Alk(en)yl-L-cysteine sulfoxides, organic acids, sugars, minerals, and vitamin C. *Food Bioprocess Technol* 7(1):289–298
- Crozier A, Lean ME, McDonald MS, Black C (1997) Quantitative analysis of the flavonoid content of commercial tomatoes, onions, lettuce, and celery. *J Agric Food Chem* 45(3):590–595
- Dasgupta A, Klein K (2014) Chapter 12 - fruits, vegetables, and nuts: good sources of antioxidants. In: Klein AD (ed) *Ntioxidants in food, vitamins and supplements*. Elsevier, San Diego, pp 209–235
- Dauchet L, Amouyel P, Hercberg S, Dallongeville J (2006) Fruit and vegetable consumption and risk of coronary heart disease: a meta-analysis of cohort studies. *J Nutr* 136(10):2588–2593
- David AVA, Arulmoli R, Parasuraman S (2016) Overviews of biological importance of quercetin: a bioactive flavonoid. *Pharmacogn Rev* 10(20):84–89
- Deepa N, Kaur C, George B, Singh B, Kapoor H (2007) Antioxidant constituents in some sweet pepper (*Capsicum annuum* L.) genotypes during maturity. *LWT- Food Sci Technol* 40(1):121–129
- Dew LJ, Boubli JP (eds) (2005) Tropical fruits and frugivores. The search for strong interactors. Springer, Cham, pp 237–250
- Ding H, Chin YW, Kinghorn AD, D'Ambrosio SM (2007, Oct) Chemopreventive characteristics of avocado fruit. *Semin Cancer Biol* 17(5):386–394
- Divya, Pandey V (2014) Natural antioxidants and phytochemicals in plant foods. Satish Serial Publishing House, Delhi, p 366
- Dreher ML (2018) Introduction to dietary fiber. In: Dietary fiber in health and disease, Nutrition and health. Humana Press, Cham
- Dreher ML, Davenport AJ (2013) Hass avocado composition and potential health effects. *Crit Rev Food Sci Nutr* 7(7):738–750
- Duthie G, Crozier A (2000) Plant-derived antioxidants. *Curr Opin Clin Nutr Metab Care* 3:447–445
- Eberhardt M, Lee C, Liu RH (2000) Antioxidant activity of fresh apples. *Nature* 2000(405):903904
- Femenia A, Robertson JA, Waldron KW, Sevendran RR (1998) Cauliflower (*Brassica oleracea* L.), globe artichoke (*Cyanara scolymus*) and chicory witloof (*Cichorium intybus*) processing byproducts as sources of dietary fibre. *J Sci Food Agric* 77(4):511–518
- Fitzgerald M (2014) It's a bird! It's a plane! It's superfood! The Surprising Fallacy at the Core of Nutrition Fads and a Guide to Healthy Eating for the Rest of US. Pegasus Books, Diet Cults. isbn:978-1-60598-560-2
- Fulgoni VL 3rd, Dreher M, Davenport AJ (2013) Avocado consumption is associated with better diet quality and nutrient intake, and lower metabolic syndrome risk in US adults: results from the National Health and nutrition examination survey (NHANES) 2001–2008. *Nutr J* 12:1
- Funaguchi N, Ohno Y, La BL, Asai T, Yuhgetsu H, Sawada M, Takemura G, Minatoguchi S, Fujiwara T, Fujiwara H (2007) Narirutin inhibits airway inflammation in an allergic mouse model. *Clin Exp Pharmacol Physiol* 34(8):766–770
- Furness D, Fenech M, Dekker G, Khong TY, Roberts C, Hague W (2013) Folate, vitamin B12, vitamin B6 and homocysteine: impact on pregnancy outcome. *Matern Child Nutr* 9(2):155–166
- Galan Sauco V, Herrero M, Hormaza JI (2014) Tropical and subtropical fruits. In: Dixon G, Aldous D (eds) *Horticulture: plants for people and places*, vol 1. Springer, Dordrecht
- Ganong WF (1977) Arctic operational information and forecasting systems. In: Amaria PJ, Bruneau AA, Lapp PA (eds) *Arctic systems*, Nato conference series, vol 2. Springer, Boston, MA

- Gardana C, Guarnieri S, Riso P, Simonetti P, Porrini M (2007) Flavanone plasma pharmacokinetics from blood orange juice in human subjects. *Br J Nutr* 98(1):165–172
- Gattuso G, Barreca D, Gargiulli C, Leuzzi U, Caristi C (2007) Flavonoid composition of Citrus juices. *Molecules* 12(8):1641–1673
- Gibson GR, Christine M, Williams CM (2000) Functional foods-concept to product. Wood head Publishing Limited/Abington Hall/CRC Press, Abington/Cambridge UK/Washington, DC. pages 374
- Gonzalez-Pena D, Colina-Coca C, Char CD, Cano MP, De Ancos B, Sanchez-Moreno C (2013) Hyaluronidase inhibiting activity and radical scavenging potential of flavonols in processed onion. *J Agric Food Chem* 61(20):4862–4872
- Govers C, Berkel Kasicki M, van der Sluis AA, Mes JJ (2018) Review of the health effects of berries and their phytochemicals on the digestive and immune systems. *Nutr Rev* 76(1):29–46
- Gupta V, Garg R (2009) Probiotics. *Indian J Med Microbiol* 27(3):202–209
- Gupta S, Afaq F, Mukhtar H (2002) Involvement of nuclear factor- κ B, Bax and Bcl-2 in induction of cell cycle arrest and apoptosis by apigenin in human prostate carcinoma cells. *Oncogene* 21:3727–3778
- Harborne JB, Williams CA (2000) Advances in flavonoid research since 1992. *Phytochemistry* 55(6):481–504
- Hostetler GL, Ralston RA, Schwartz SJ (2017, May) Flavones: food sources, bioavailability, metabolism, and bioactivity. *Adv Nutr* 8(3):423–435
- Hung JY, Hsu YL, Ko YC, Tsai YM, Yang CJ, Huang MS, Kuo PL (2010) Didymin, a dietary flavonoid glycoside from citrus fruits, induces Fas-mediated apoptotic pathway in human non-small-cell lung cancer cells in vitro and in vivo. *Lung Cancer* 68(3):366–374
- Johnson IT (2002) Glucosinolates: bioavailability and importance to health. *Int J Vitam Nutr Res* 72(1):26–31
- Jose AL, Ruperez P, Calixto FS (1997) Pineapple Shell as a source of dietary fibre with associated polyphenols. *J Agric Food Chem* 45(10):4028–4031
- Justesen U, Knuthsen P, Leth T (1998) Quantitative analysis of flavonols, flavones, and flavanones in fruits, vegetables and beverages by high-performance liquid chromatography with photodiode array and mass spectrometric detection. *J Chromatogr A* 799(1):101–110
- Kapil V, Khambata RS, Robertson A, Caulfield MJ, Ahluwalia PA (2015) Dietary nitrate provides sustained blood pressure lowering in hypertensive patients: a randomized, phase 2, double-blind, placebo-controlled study. *Hypertension* 65:320–327
- Kathleen K (1999) Phytochemicals and functional foods; super foods for optimal health. Rutgers cooperative research and extension, NJAES, Rutgers, The State University of New Jersey, page 1
- Kaur C, Kapoor HC (2001) Antioxidants in fruits and vegetables—the millennium’s health. *Int J Food Sci Technol* 36(7):703–725
- Khoo HE, Prasad KN, Kong KW, Jiang Y, Ismail A (2011) Carotenoids and their isomers: color pigments in fruits and vegetables. *Molecules* 16(2):1710–1738
- Kim HK, Cheon BS, Kim YH, Kim SY, Kim HP (1999) Effects of naturally occurring flavanoids on nitric oxide production in the macrophage cell line RAW 264.7 and their structureactivity relationships. *Biochem Pharmacol* 58:759–765
- King RE, Kent KD, Bomser JA (2005) Resveratrol reduces oxidation and proliferation of human retinal pigment epithelial cells via extracellular signal-regulated kinase inhibition. *Chemico-Biol Interact* 151:142–149
- Kole C (2011) Wild crop relatives: genomic and breeding resources, Temperate fruits. Springer, Berlin/Heidelberg
- Koponen JM, Happonen AM, Mattila PH, Torronen AR (2007) Contents of anthocyanins and ellagitannins in selected foods consumed in Finland. *J Agric Food Chem* 55(4):1612–1619
- Larrosa M, Llorach R, Espin JC, Tomas-Barberan FA (2002) Increase of antioxidant activity of tomato juice upon functionalisation with vegetable byproduct extracts. *LWT-Food Sci Technol* 35(6):532–542
- Lin LZ, Harnly JM (2010) Phenolic component profiles of mustard greens, yu choy, and 15 other brassica vegetables. *J Agric Food Chem* 58(11):6850–6857. <https://doi.org/10.1021/jf1004786>

- Litz RE, Jarret RL, Asokan MP (1986) Tropical and subtropical fruits and vegetables. In: Zimmerman RH, Griesbach RJ, Hammerschlag FA, Lawson RH (eds) Tissue culture as a plant production system for horticultural crops. Current plant science and biotechnology in agriculture, vol 2. Springer, Dordrecht
- Liu RH (2013) Dietary bioactive compounds and their health implications. *J Food Sci* 78(s1):A18–A25
- Loganayaki N, Rajendrakumaran D, Manian S (2010) Antioxidant capacity and phenolic content of different solvent extracts from banana (*Musa paradisica*) and Mustai (*Rivea hypocrateriformis*). *Food Sci Biotechnol* 19(5):1251–1258
- Lokesh V, Divya P, Puthusseri B, Manjunatha G, Neelwarne B (2014) Profiles of carotenoids during post-climacteric ripening of some important cultivars of banana and development of a dry product from a high carotenoid yielding variety. *LWT Food Sci Technol* 55(1):59–66
- Manganaris GA, Goulas V, Vicente AR, Terry LA (2014) Berry antioxidants: small fruits providing large benefits. *J Sci Food Agric* 94(5):825–833
- Marc EB, Herman TD, Tom B, Veerle L, Marck V, Kristl MV, Vanluchene E, Margareta N, Rudolphe S, Marc MM (1999) Influence of Tangeretin on Tamoxifen's therapeutic benefit in mammary cancer. *JNCI J Nat Cancer Inst* 91(4):354–359
- Maria IG, Francisco A, Tomá S-BN, Betty H-P, Adel AK (2002) Antioxidant capacities, phenolic compounds, carotenoids, and vitamin C contents of nectarine, peach, and plum cultivars from California. *J Agric Food Chem* 50:4976–4982
- Martin FW (1982) Okra, potential multiple-purpose crop for the temperate zones and tropics. *Econ Bot* 36:340. <https://doi.org/10.1007/BF02858558>
- Mattila P, Hellstrom J (2007) Phenolic acids in potatoes, vegetables, and some of their products. *J Food Compos Anal* 20(3–4):152–160
- Mazza G, Miniati E (1993) Anthocyanins in fruits, vegetables and grains. CRC Press, Boca Raton, FL, p 362
- McCarthy MA, Matthews RH (1994) Nutritional quality of fruits and vegetables subject to minimal processes. In: Wiley RC (ed) Minimally processed refrigerated fruits & vegetables. Springer, Boston, MA
- Michels KV, Giovannucci E, Jshipura KJ, Rosner BA, Stampfer MJ, Fuchs CS, Colditz GA, Speizer FE, Willett WC (2000) Prospective study of fruit and vegetable consumption and incidence of colon and rectal cancers. *J Natl Cancer Inst* 92(21):1740–1752
- Molau U (1997) Phenology and reproductive success in Arctic plants: susceptibility to climate change. In: Oechel WC et al (eds) Global change and arctic terrestrial ecosystems, Ecological studies (analysis and synthesis), vol 124. Springer, New York
- Montes-Avila J, Lopez-Angulo G, Delgado-Vargas F (2017) Tannins in fruits and vegetables: chemistry and biological functions. *Fruit Veg Phytochem*:221–268
- Morris MS (2012) The role of B vitamins in preventing and treating cognitive impairment and decline. *Adv Nutr* 3(6):801–812
- Mouly PP, Arzouyan CR, Gaydou EM, Estienne JM (1994) Differentiation of citrus juices by factorial discriminant analysis using liquid chromatography of flavanone glycosides. *J Agric Food Chem* 42(1):70–79
- Moyler DA (1991) Oleoresins, tinctures and extracts. In: Ashurst PR (ed) Food flavourings. Springer, Boston, MA
- Nazar L, Csiszar A, Veress G, Stef G, Pacer P, Oroszi G, Wu J, Ungvari Z (2006) Vascular dysfunction in aging: potential effects of resveratrol and anti-inflammatory phytoestrogen. *Curr Med Chem* 13(9):989–996
- Nicolle C, Cardinault N, Gueux E, Jaffrelo L, Rock E, Mazur A, Amouroux P, Rémésy C (2004) Health effect of vegetable-based diet: lettuce consumption improves cholesterol metabolism and antioxidant status in the rat. *Clin Nutr* 23(4):605–614
- Niles RM, McFarland M, Weimer MB, Redkar A, FuY M, Meadows GG (2003) Resveratrol is a potent inducer of apoptosis in human melanoma cells. *Cancer Lett* 190:157–163

- Ninfali P, Angelino D (2013) Nutritional and functional potential of *Beta vulgaris* cicla and rubra. *Fitoterapia* 89:188–199
- Ooi CP, Loke SC (2013) Sweet potato for type 2 diabetes mellitus. *Cochrane Database Syst Rev* 3(9):CD009128
- Ordovas JM, Kaput J, Corella D (2007) Nutrition in the genomics era: cardiovascular disease risk and the Mediterranean diet. *Mol Nutr Food Res* 51(10):1293–1299
- Pan W, Ikeda K, Takebe M, Yamori Y (2001) Genistein, daidzein and glycitein inhibit growth and DNA syntheses of aortic smooth muscle cells from stroke-prone spontaneously hypertensive rats. *J Nutr* 131(4):1154–1158
- Pathak S, Kesavan P, Banerjee A, Celep GS, Bissi L, Marotta F (2018) Chapter 25: Metabolism of dietary polyphenols by human gut microbiota and their health benefits. In: *Polyphenols: mechanism of action in human health and disease*, 2nd edn. Elsevier, London, pp 347–359
- Plonka J, Toczek A, Tomczyk V (2012) Multivitamin analysis of fruits, fruit–vegetable juices, and diet supplements. *Food Anal Methods* 5:1167–1176. <https://doi.org/10.1007/s12161-011-9349-3>
- Pueyo E, Polo MC (1992) Compesicion lipidica de lasuvas y el vino. *Alimentacion, equipos y tecnologia* 2:77–81
- Radha T, Mathew L (2007) Fruit crops. In: Peter KV (ed) *Horticulture science series* 3. New India Publishing Agency, New Delhi. 4, Page 29
- Rufino MDSM, Alves RE, De Brito ES, Perez-Jimenez J, Saura-Calixto F, Mancini-Filho J (2010) Bioactive compounds and antioxidant capacities of 18 non-traditional tropical fruits from Brazil. *Food Chem* 121(4):996–1002
- Saini RK, Keum Y-S (2016) Tocopherols and tocotrienols in plants and their products: a review on methods of extraction, chromatographic separation, and detection. *Food Res Int* 82:59–70
- Saini RK, Nile SH, Park SW (2015) Carotenoids from fruits and vegetables: chemistry, analysis, occurrence, bioavailability and biological activities. *Food Res Int* 76:735–750
- Saleh N, El-Hawary Z, El-Shobaki FA et al (1977) Vitamins content of fruits and vegetables in common use in Egypt. *Z Ernährungswiss* 16:158–162. <https://doi.org/10.1007/BF02024787>
- Sales-Campos H, Souza PR, Peghini BC, da Silva JS, Cardoso CR (2013) An overview of the modulatory effects of oleic acid in health and disease. *Mini Rev Med Chem* 13(2):201–210
- Sanchez-Moreno C, Jimenez-Escrig A, Saura-Calixto F (2000) Study of low-density lipoprotein oxidizability indexes to measure the antioxidant activity of dietary polyphenols. *Nutr Res* 20:941–953
- Schulz V (ed) (2004) *Rational phytotherapy: a reference guide for physicians and pharmacists*, 5th edn. Springer, Munich, pp 304–305. isbn:978-3-540-40832-1
- Seeram NP (2008) Berry fruits: compositional elements, biochemical activities, and the impact of their intake on human health, performance, and disease. *J Agric Food Chem* 56(3):627–629
- Semba RD, Dagnelie G (2003) Are lutein and zeaxanthin conditionally essential nutrients for eye health? *Med Hypotheses* 61(4):465–472
- Shahidi F, Naczki M (1995) *Food Phenolics. Sources, chemistry, effects, applications*. Technomic Publishing, Lancaster, PA, p 331
- Skrovankova S, Sumczynski D, Mlcek J, Jurikova T, Sochor J (2015) Bioactive compounds and antioxidant activity in different types of berries. *Int J Mol Sci* 16(10):24673–24706
- Slimestad R, Fossen T, Vagen IM (2007) Onions: a source of unique dietary flavonoids. *J Agric Food Chem* 55(25):10067–10080
- Srinivasan S (2008) Super fruits – bespoke for functionality or fad? *Frost & Sullivan Market Insight*
- Starling S (2008) Superfruit success not grown on trees, say authors. William Reed Business Media Ltd., Crawley, UK
- Sultana B, Anwar F (2008) Flavonols (kaempferol, quercetin, myricetin) contents of selected fruits, vegetables and medicinal plants. *Food Chem* 108:879–884
- Sun T, Simon PW, Tanumihardjo SA (2009) Antioxidant phytochemicals and antioxidant capacity of biofortified carrots (*Daucus carota* L.) of various colors. *J Agric Food Chem* 57(10):4142–4147

- Tanaka T, Shnimizu M, Moriwaki H (2012) Cancer chemoprevention by carotenoids. *Molecules* 17(3):3202–3242
- Tindall HD (1983) *Vegetables in the tropics*. Macmillan Education, London, pp 14–415
- Tomas-Barberan FA, Clifford MN (2000) Review: flavanones, chalcones and dihydrochalcones—nature, occurrence and dietary burden. *J Sci Food Agric* 80:1073–1080
- Trichopoulou A, Naska A, Antoniou A, Friel S, Trygg K, Turrini A (2003) Vegetable and fruit: the evidence in their favour and the public health perspective. *Int J Vitam Nutr Res* 73(2):63–69
- Vallejo F, Garcia-Viguera C, Tomas-Barberan FA (2003) Changes in broccoli (*Brassica oleracea* L. var. *italica*) health-promoting compounds with inflorescence development. *J Agric Food Chem* 51(13):3776–3782
- Ventura M, Melo M, Carrilho F (2017) Selenium and thyroid disease: from pathophysiology to treatment. *Int J Endocrinol* 2017:1297658
- Wang SY, Lin HS (2000) Antioxidant activity in fruits and leaves of blackberry, raspberry, and strawberry varies with cultivar and developmental stage. *J Agric Food Chem* 48(2):140–146
- Wang YC, Chuang YC, Hsu HW (2008) The flavonoid, carotenoid and pectin content in peels of citrus cultivated in Taiwan. *Food Chem* 106(1):277–284
- Wang L, Bordi PL, Fleming JA, Hill AM, Kris-Etherton PM (2015) Effect of a moderate fat diet with and without avocados on lipoprotein particle number, size and subclasses in overweight and obese adults: a randomized, controlled trial. *J Am Heart Assoc* 4(1):001355
- Wang PY, Fang JC, Gao ZH, Zhang C, Xie SY (2016) Higher intake of fruits, vegetables or their fiber reduces the risk of type 2 diabetes: a meta-analysis. *J Diab Investig* 7(1):56–69
- Wani SM et al (2017) Minimal processing of tropical and subtropical fruits, vegetables, nuts, and seeds. In: Yildiz F, Wiley R (eds) *Minimally processed refrigerated fruits and vegetables*, Food engineering series. Springer, Boston, MA
- Weber P (2001) Vitamin K and bone health. *Nutrition* 17(10):880–887
- Willcox JK, Catignani GL, Lazarus S (2003) Tomatoes and cardiovascular health. *Crit Rev Food Sci Nutr* 43(1):1–18
- Wu X, Beecher GR, Holden JM, Haytowitz DB, Gebhardt SE, Prior RL (2006) Concentrations of anthocyanins in common foods in the United States and estimation of normal consumption. *J Agric Food Chem* 54(11):4069–4075
- Wuyts N, De Waele D, Swennen R (2006) Extraction and partial characterization of polyphenol oxidase from banana (*Musa acuminate* grande naine). *Plant Physiol Biochem* 44:308–314
- Xavier AA, Perez-Galvez A (2016) Carotenoids as a source of antioxidants in the diet. *Subcell Biochem* 79:359–375
- Xiao Z, Lester GE, Luo Y, Wang Q (2012) Assessment of vitamin and carotenoid concentrations of emerging food products: edible microgreens. *J Agric Food Chem* 60(31):7644–7651
- Yildiz F, Gültekin E (2006) Introduction to phytoestrogen. In: Yildiz F (ed) *Phytoestrogen in functional foods*. CRC/Taylor and Francis Group, London/New York, pp 3–18
- Young-Hee Pyo, Tung-Ching Lee, Logendra L, Rosen RT (2004) Antioxidant activity and phenolic compounds of Swiss chard (*Beta vulgaris* subspecies *cycla*) extracts. *Food Chem* 85(1):19–26
- Yu J, Ahmedna M (2013) Functional components of grape pomace: their composition, biological properties and potential applications. *Int J Food Sci Technol* 48(2):221–237
- Zanwar AA, Badole SL, Shende PS, Hegde MV, Bodhankar SL (2014) Chapter 21: Antioxidant role of Catechin in health and disease. In: *Polyphenols in human health and disease*, vol 1. Academic Press, San Diego, CA, pp 267–271

Chapter 15

Cereals and Grains as Functional Food in Unani System of Medicine



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15.1 Introduction

Cereal-based food products have been the basis of human diet since ancient times (Borneo and Leon 2011). Whole grains, refined cereals, and legumes are important components of diet in many parts of the world. They are major source of energy, proteins, and other nutrients (Tayyem et al. 2016; Dias-Martins et al. 2018). The concept of functional food includes foods or food ingredients that exert a beneficial effect on health and/or reduce the risk of chronic diseases beyond basic nutritional functions. Increasing awareness of consumer health and interest in functional foods to achieve a healthy lifestyle has resulted in the need for food products with versatile health-benefiting properties. Cereal and cereal based food products offer opportunities to include probiotics, prebiotics, and fibres in the human diet (Das et al. 2012). Dietary guidelines has it that the high nutrient density of breakfast cereals (especially those that are whole grain or high in cereal fibre) makes them an important source of key nutrients in addition to providing an important source of vitamins and minerals. Breakfast cereals are also potentially important source of antioxidants and phytoestrogens and are one of the most important sources of whole grains (Williams 2014).

A whole grain is a grain of any cereal and pseudo cereal that contains the endosperm, germ, and bran, in contrast to refined grains, which retain only the endosperm (Aune et al. 2016). There are a lot of supportive evidence showing that the consumption of whole grains and whole-grain-based products are associated with the reduction of the risk of developing many diseases such as cardiovascular diseases,

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