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Phytonutrients: Add Colors To Diet For Better Health

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ABSTRACT

Fruits and vegetables are major constituents of our daily diet. They are important sources of carbohydrates, proteins, lipids, vitamins and minerals. Other than these ingredients they also contain bioactive substances called as phytonutrients or phytochemicals. Phytonutrients are also called as phytopigments as they provide color to the fruits and vegetables. The darker the fruit or vegetable,higher would be the Phytonutrients content. They can be classified in to five different color groups Red, Green, White, Orange/Yellow and Purple/ Blue. Unlike vitamins and minerals phytonutrients are not essential to life for development, but they have antioxidant property which protects against cell damage, improves immunity against bacterial and viral infections and decreases the development of chronic conditions such as diabetes, hypertension, cardiovascular diseases. They also have anticancer property which protects against cancers. They are used therapeutically in the treatment of certain medical illness. They do not have adverse effects when compared to allopathic drugs. They are also cost effective and hence reduce the health care cost. It is important to encourage people to consume adequate amount of phytonutrients in their daily diet. Pharmaceutical industries should also try to extract phytonutrients and make it available to people for consumption at reasonable cost .The present article is framed to give information regarding important phytonutrients, their sources and uses.

Key-words: Phytonutrients, Phytochemicals, Phytopigments, Antioxidants

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Introduction:

The word phytonutrients derived from Greek word "Phyto" which means plant[1]. Phytonutrients are bioactive ingredients of plants products such as fruits, vegetables, legumes and nuts[2]. Phytonutrients are also called as the phytopigments as they provide vibrant color to the fruits and vegetables. Plants produce these substances to protect themself against viruses and bacteria. They also provide aroma and flavor to fruits and vegetables. It is estimated that >5000 individual phytochemicals have been identified in fruits, vegetables, legumes and nuts[3]. Phytonutrients are not essential for life, but when consumed they provide optimal health and longetivity. Phytonutrients function as antioxidants, enhance immune function, enhance cell to cell communication, repair DNA damage and detoxify carcinogens through activation of cytochrome P450 and Phase II enzyme systems. These properties of phytonutrients help in decreasing damage to cells, aging and development of chronic diseases like hypertension, diabetes mellitus, stroke and cancers[4]. Deeper the color of the fruit or vegetable more powerful will be the antioxidant property of the phytonutrient. Depending upon the color they provide, they can be broadly classified into Red, Green, White, Blue/Purple, and Orange/Yellow[5].

Classification Based On Colors:

Color	Phytonutrients/Phytochemicals/ Phytopigments
Red	Lycopenes, Ellagic Acid
Green	Isoflavones, Isothiocyanate, Lutein, Zeaxanthin
White	Allicin , Quercetin
Purple/Blue	Anthocyanidins , Resveratrol
Orange/Yellow	Alpha-carotene, Beta-carotene , Hesperitin , Beta cryptoxanthin

Red color Phytonutrients

Lycopene:

Lycopene, member of carotenoid family is a lipid soluble antioxidant synthesized by many plants. Lycopene is one of the nutrients which provides red color to fruits and vegetables. The important sources of lycopene are tomato, watermelon and red grape fruit.[6]

Lycopene is a highly unsaturated straight chain hydrocarbon with total of 13 double bonds, 11 of which are conjugated. This unique nature of the lycopene molecule makes it a very potent antioxidant. Lycopene is twice potent as β-carotene and ten times that of α-tocopherol as an antioxidant.[7] Lycopene absorption is significantly higher in the thermally processed tomato products compared to raw tomatoes. The processed products contain higher levels of cis-isomers of lycopene and hence cis-isomerization enhances its absorption.

Reactive oxygen species (ROS) are highly reactive oxidant molecules that are generated endogenously in the body through normal metabolic processes, life style activity and the diet. ROS is associated with increased incidence of chronic diseases such as cancer, coronary heart disease (CHD) and osteoporosis.

Lycopene has significant role in both prevention and treatment of prostate cancer. Epidemiological studies have shown an inverse relationship between the consumption of tomatoes and decreased risk of prostate cancer. Reduction in risk of prostate cancer has often been assigned to its antioxidant property. Cytotoxic and anti proliferative effects of lycopene on cancerous cells also have role in prevention and treatment in prostate cancer. Elevated insulin-like growth factor (IGF-1) levels are thought to be correlated with an increased lifetime risk of developing prostate cancer. Suppression of IGF-I by lycopene adds on to the efficacy against prostate cancer. Increased consumption of tomatoes also offers protection against digestive tract cancers. Animal studies have shown the protective effect of dietary lycopene against development of colon, lung and breast cancers.

ROS is recognized as an important etiological factor of coronary heart disease. Oxidation of the circulating low-density lipoprotein (LDL) to oxidized LDL (LDLox) leads to pathogenesis of the coronary heart disease. Lycopene protect native LDL from oxidation and also inhibit cholesterol synthesis hence decrease the development of coronary heart disease.

ROS also contribute to the pathogenesis of osteoporosis, the most prevalent 'metabolic bone disease'. Lycopene has a stimulatory effect on cell proliferation and the differentiation marker alkaline phosphatase of osteoblasts as well as inhibitory effects on osteoclasts formation and resorption of bone. There have been results of a possible decrease in bone turnover and oxidative stress markers and increase in antioxidant status in postmenopausal women taking tomato juice or lycopene capsules. Lycopene plays important role in bone health and provides dietary alternative to drug therapy for individuals who are at risk of osteoporosis.[8]

Ellagic Acid:

Ellagic acid is the dilactone of hexahydroxydiphenic acid, derived from the hydrolysis of ellagatannins.[9] Ellagic acid is present in many red fruits , berries like raspberries, strawberries, blackberries, cranberries, pomegranate and some nuts including pecans and walnuts. The highest levels of ellagic acid are found in raspberries[9] Ellagic acid has antioxidant, anti-mutagen , anti-cancer, antiviral and antibacterial properties. Studies have shown the anti-cancer activity on cancer cells of the breast, esophagus, skin, colon, prostate and pancreas. Several mechanisms by which ellagic acid can prevent carcinogenesis have been identified. Potential mechanisms include the inhibition of Phase I enzymes; modification of carcinogen detoxification through Phase II pathways; antioxidation activities, including scavenging DNA reactive agents; suppressing abnormal proliferation of early preneoplastic lesions; and inhibiting certain properties of the cancer cell. Ellagic acid also shows chemo protective effect against various chemically induced cancers[10].

Green Color Phytonutrients

Isoflavones

Isoflavones are polyphenolic compounds most commonly found in soy beans and other legumes. They are phytoestrogens, effectively modulate estrogen levels in humans and are therefore often of clinical value.[11] Isoflavones have other biological functions, such as antioxidant , inhibitory on cancer cell proliferation, anti-inflammatory and prevention of coronary

heart disease and osteoporosis[12]. Isoflavone intake exerts a protective effect against postmenopausal breast cancer. Two major subtypes of estrogen receptors are reported in humans, *viz*. estrogen receptor–alpha (ERα) and estrogen receptor-beta (ERβ). Agonists of ERα generally causes cell proliferation (for example, in breast cells), while ERβ agonists causes cell cycle arrest (for example, in prostate cells) and apoptosis. isoflavones, are therefore reported to be correlated to lower incidences of cancers, such as prostate cancer, in populations which consumes regular quantities of isoflavone-rich food .

Postmenopausal women experience a sharp decrease in estrogen concentration, leading to an increased rate of bone remodeling, which is associated with decreased bone mineral density and increased risk of fractures. Meta-analysis reported that consumption of isoflavones significantly increased the bone mineral density by 54% and decreased the bone resorption marker urinary deoxypyridinoline by 23% compared to baseline in women. Isoflavone use also increases the cognition performance in postmenopausal women. Over the counter tablet preparations isoflavones extracted from soy and other plants are widespread around the world. These OTC medicines are often used for postmenopausal treatment, like Hormone Replacement Therapy.[13]

Isothiocyanates:

Isothiocyanates are sulphur-containing phytochemicals Isothiocyanates with the stongest anticancer effects are phenylethylisothiocyanate, benzylisothiocyanate and 3-phenylpropylisothiocyanate[14]. Isothiocyanates occur naturally as glucosinolate conjugates in cruciferous vegetables. Isothiocyanates are also responsible for the typical flavor of these vegetables. Isothiocyanates can be found in cruciferous vegetables such as broccoli, cauliflower, kale, turnips, collards, Brussels sprouts, cabbage, radish, turnip and watercress[15]. Glucosinolates are precursors of isothiocyanates. When the raw vegetables are chewed the plant cells are broken and an enzyme (myrosinase) hydrolyses the glucosinolates into isothiocyanates. Isothiocyanates combat carcinogens by neutralizing them. Isothiocyanates act by inhibition of cell proliferation and induction of apoptosis. The isothiocyanates with the strongest anticancer effects are phenylethylisothiocyanate, benzylisothiocyanate and 3-phenylpropylisothiocyanate. Studies have shown that isothiocyanates help to prevent lung cancer and esophageal cancer. Isothiocyanates can also lower the risk of other cancers, including gastrointestinal cancer[16].

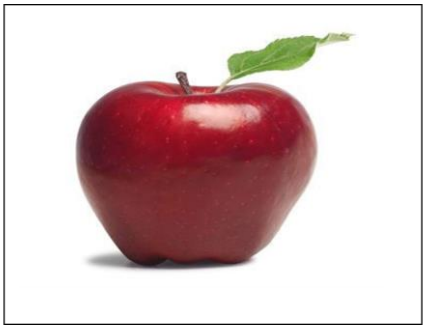
White color phytonutrients

Allicin:

Allicin is the major biologically active component of garlic .It is the key ingredient responsible for the broad-spectrum anti-bacterial activity in garlic. It is responsible for lipid-lowering, anti-blood coagulation, anti-hypertension, anti-cancer and antioxidant effects.[17] Allicin is garlic's defence mechanism against attacks by pests. When the garlic plant is attacked or injured it produces allicin by an enzymatic reaction. The enzyme alliinase, converts the chemical alliin to allicin, which is toxic to insects and microorganisms. Allicin extracted from garlic loses its beneficial properties within hours as it turns into other sulphur containing compound. Allicin responsible for the typical and offensive odor of garlic. Allicin has cardioprotective effect by decreasing the LDL cholesterol levels, preventing platelet aggregation and decreasing the blood pressure. The antimicrobial effect of allicin is due to its chemical reaction with thiol groups of

various enzymes. The phytochemical inhibits bacteria and viruses and also yeasts such as candida. Allicin may be an effective therapeutic candidate to promote ulcer healing by its antimicrobial activity. In vitro studies show that allicin inhibits the invasion and metastasis of human colon carcinoma cells. The allicin also exhibits antigenotoxic action.[18]

Quercetin:



Quercetin is the most abundant of the flavonoids. Quercetin belongs to the flavonoids family and consist of 3 rings and 5 hydroxyl groups. Quercetin is also a building block for other flavonoids. Only a small percentage of the ingested quercetin will get absorbed in the blood.[19] It is found in many common foods including apple, tea, onion, nuts, berries, cauliflower and cabbage.[20]

Quercetin has anti-inflammatory, anti-allergic and antitoxic effects. Most of these properties are linked to its strong antioxidant action of quercetin . It also modulates the expression of specific enzymes. It induces apoptosis and influences protein and lipid kinase signaling pathways. Quercetin is a candidate for preventing obesity-related diseases. Exerts many beneficial health effects like improvement of cardiovascular health, reducing risk for cancer, protection against osteoporosis. Quercetin may help to reduce symptoms of diabetes patients. Studies have shown quercetin reduces blood glucose level and improved plasma insulin levels in streptozotocin-induced diabetic rats. Quercetin also inhibits the release of histamine by basophils and mast cells. Studies have shown improved lung function and lower risk of certain respiratory diseases among people with high apple intake. Quercetin protect against myocardial infarction and stroke. It inhibits oxidation of LDL cholesterol, lowers blood pressure and reduces the risk of heart disease. Quercetin reduces cancer risk of prostate, ovary, breast, gastric and colon cells.[21]

Purple/Blue Color Phytonutrients

Anthocyanins:

Anthocyanins are water-soluble phytochemicals with a typical red to blue color. Anthocyanin belong to the group of flavonoids, polyphenolic molecules containing 15 carbon atoms and which can be visualized as two benzene rings joined together with a short three carbon chain.[22] They can be found in tissues of plants, including leaves, stems, roots, flowers and fruits. Anthocyanin occur mainly as glycosides of anthocyanidins such as cyanidin, delphinidin, peonidin, pelargonidin, petunidin and malvidin.[23] Anthocyanin protect the plant cells against damage caused by UV radiation.

It is found in numerous plants, but high levels are present in acai, blackcurrant, blueberry, bilberry, cherry, red grape and purple corn. Anthocyanins are powerful antioxidants. In vitro, their biological activity will be low because of their low stability and poor absorption. The beneficial biological effects of anthocyanin on cardiovascular health is due to their antioxidant activity. Anthocyanin can act on different cells involved in the development of arthrosclerosis. Anthocyanin may also act as anti-cancer agents by inhibiting promotion and progression of tumor cells by stopping the growth of pre-malignant cells, increasing the apoptosis of cancer cells and inhibiting the growth of new blood vessels that nourish tumors. The anti-inflammatory action of anthocyanin may be attributed to its direct and strong antioxidant action but also its regulatory effect on the expression of genes involved in the inflammatory response.[24]

Resveratrol

Resveratrol is a flavonol belonging to the group of flavonoids. It is produced by the plant as a defense against diseases. Resveratrol is present in many plants and fruits like red grapes, eucalyptus, spruce, blueberries, mulberries, peanuts, giant knotweed. Also red wine contains a lot of it. The longer the grape juice is fermented with the skin, the higher the resveratrol content will be.[25] Resveratrol is an antioxidant but its antioxidant properties is weak when compared to quercetin and epicatechin. In vitro studies have shown that resveratrol inhibits the oxidative damage caused by the heavy metal cadmium. The antioxidant activity of resveratrol reduces damage to endothelial cells exposed to nitrite radicals and protects skin cells against damage caused by UV radiation. The antioxidant action of resveratrol helps to prevent damage to DNA but it also influences the transcriptions of genes responsible for redox metabolism and inhibits proliferation of cancer cells. Resveratrol appears to decrease tumor promotion activity by inhibiting the enzyme cyclooxygenase-1, which converts arachidonic acid to substances that promote tumor growth. In vitro experiments provide support for resveratrol to serve as a candidate preventive agent against prostate cancer, but in vivo effects of resveratrol and the mechanisms of action of resveratrol on prostate cancer prevention remain largely unknown. Administration of resveratrol may protect against oxidative damage caused by high glucose levels. It also reduces diabetic neuropathic pain. Resveratrol protects heart and blood vessels by directly scavenging oxidants which causes oxidation of lipids and by preventing apoptosis of endothelial cells. Reduced platelet aggregation has been attributes to resveratrol, thereby reducing the risk of atherosclerosis. Resveratrol explains partly the French Paradox "the low incidence of heart disease among French people, who eat relatively a lot of unhealthy fat but drink resveratrol containing red wine studies on animals have shown antitoxic effects of resveratrol". Resveratrol was able to reverse damages caused by the administration of the chemotherapeutic drug bleomycin. Resveratrol also helped to reduce brain damage and oxidative damage of the liver during ethanol intoxication. It also reduced kidney damage of rats treated with the antibiotic gentamicin.[26]

Orange/Yellow Color Phytonutrients

Beta-Carotene:

Beta-carotene is the most common form of carotene and belongs to the group of terpenoids. Beta-Carotene is a yellow pigment naturally occurring in fruits and vegetables. It also known as a provitamin because it can be converted in our body into vitamin A after oxidative cleavage by *beta-carotene 15, 150-dioxygenase*.[27] In plants, beta-carotene, acts as an anti-oxidant and neutralizes singlet oxygen radicals formed during photosynthesis. Cooking improves the availability of carotenoids in foods. However, prolonged cooking should be avoided to prevent the formation of change of beta-carotene into the cis-configuration . Beta-carotene occurs in colored fruits and vegetables such as mango, apricot, sweet potatoes, carrots, kale, broccoli, spinach, turnip greens, winter squash and collard greens.[28] Beta-carotene is a powerful antioxidant, protecting the cells of the body from damage caused by free radicals. Studies indicate that diets low in beta-carotene can increase the body's susceptibility to damage from free radicals, resulting in an increased risk of chronic diseases like heart disease and cancers. Beta-carotene acts as an anti-cancer agent through its antioxidant property but it also seems to stimulate cell to cell communication. Poor communication between cells may eventually lead to cancer. Beta-carotene is also used for skin protection as it reduces UV-induced redness of the skin and improves melasma. Beta-carotene is often use in supplements or topical creams to protect our skin. Too much intake of beta-carotene can result in carotenodermia , a condition that shows a

yellowish discoloration of the skin but it is reversible and harmless. Beta-carotene may improve our heart health by decreasing blood pressure. Beta-carotene may also help to prevent atherosclerosis by inhibiting the oxidation of lipids.

Conclusion:

As the phytonutrients have many actions with less side effects these should be effectively used in day to day diet in preventing the chronic diseases. Appropriate education should be given to the public regarding these phytonutrients which are easily available and cost effective. Pharmaceutical industries must take appropriate step to extract these phytonutrients and make the available commercially at reasonable rates.

References:

1) Hall JN, Moore S, Harper SB, Lynch JW. Global variability in fruit and vegetable consumption. Am J Prev Med. 2009; 36(5):402–409.

2) Ogbonna Jdn , Kenechukwu1 F C, Attama Aa1, Chime S A. Different Approaches To Formulation Of Herbal Extracts /Phytopharmaceuticals/Bioactive Phytoconstituents - A Review. Int. J. Pharm. Sci. Rev. Res. 2012; 16(1):1-8.

3) Ramaswamy L , Kanmani M G. Phytonutrient Profile, Health Benefits and Culinary Applications of Selected Edible Foliages . International journal of ayurvedic & herbal medicine. 2012; 2(3): 469 – 76.

4) Liu R.H. Health Benefits of Fruits and Vegetables are from Additive and Synergistic Combination of Phytochemicals. American Journal of Clinical Nutrition. 2003; Vol. Pp 517-27.

5) America's Phytonutrient Report: Quantifying the Gap. Available via: http://www.amway.com/en/nutritionwellness/nutriliteexperience#/section/phytonutrients/modal/content_list/id/phytonutrients_report .(Accessed 20 February 2015)

6) Chasse GA, Mak ML, Deretey E, Farkas I, Torday LL, Papp JG, D Sarma DSR, Agarwal A, Chakravarthi S, Agarwal S, and Rao AV. J Mol Struc . 2001; 571 27.

7) A.V. Rao, L.G. Rao. Carotenoids and human health . Invited review. Pharmacological Research 55 (2007) 207–16.

8) Gerster H. The potential role of lycopene for human health. J Am Coll Nutr. 1997;16:109–26.

9) Sepúlveda L, Ascacio A, Herrera R R, Carbó A A , Aguilar C A. Ellagic acid: Biological properties and biotechnologicaldevelopment for production processes. African Journal of Biotechnology . , 2011; 10(22): 4518-23.

10) Jurenka J. Therapeutic Applications of Pomegranate (Punica granatum L.):A Review. Alternative Medicine Review . 2008;13(2):128-44.

11) Campos M D G, Matos M P. Bioactivity Of Isoflavones: Assessment Through A Theoretical Model As A Way To Obtain A "Theoretical Efficacy Related To Estradiol (Tere)". Int. J. Mol. Sci. 2010(11):480-91.

12) Fizpatrick L.A. Soy isoflavones: Hope or Hype. Int. J. Mol. Sci. 2003;44(11):21–29.

13) Nahas E.P, Neto J.N, Luca L, Traiman P, Pontes A, Dalben I. Benefits of soy germ isoflavones in postmenopausal women with contraindication for conventional hormone replacement therapy. Maturitas 2004; 48: 372–80.

14) Vargas L FM. Mechanism of action of isothiocyanates. A review. Agronomía Colombiana. 2013; 31(1): 68-75.

15) Singh SV, Singh K. Cancer chemoprevention with dietary isothiocyanates mature for clinical translational research. Carcinogenesis 2012; 33:1833–42.

16) Borlinghaus J , Albrecht F, Gruhlke M C. H , Nwachukwu I D , Slusarenko A J. Allicin: Chemistry and Biological Properties. Molecules. 2014;(19): 12591-618.

17) Neeraj S,Sushila K,Neeraj D,Milind P,Minakshi P.Garlic: A pungent wonder from the nature.Int.Res.J.Pharm.2014;5(7):523-29.

18) Ogita A, Nagao Y, Fujita K, Tanaka T. Amplification of vacuole-targeting fungicidal activity of antibacterial antibiotic polymyxin B by allicin, an allyl sulfur compound from garlic. J. Antibiot.**2007;**(60):511–18.

19) Lakhanpal P , Rai D . Quercetin: A Versatile Flavonoid. Internet Journal of Medical Update. 2007; 2(2):22-37.

20) Middleton EJ. Effect of plant flavonoids on immune and inflammatory cell functions. Adv Exp Med Biol 1998;439: 175-82.

21) Havsteen B. Flavonoids: A class of natural products of high pharmacological potency. Biochem Pharmacol.1983;(32):1141-48.

22) Raghvendra , Sharma V, Shakya A, Hedaytullah, Arya G S, Mishra A. Chemical And Potential Aspects Of Anthocyanins – A Water-Soluble Vacuolar Flavonoid Pigments: A Review. 2011;6(1):28-33.

23) Ghosh D, Konishi T. Anthocyanins and anthocyanin-rich extracts: role in diabetes and eye function. Asia Pac J Clin Nutr 2007;16 (2):200-08.

24) Skibola C, Smith M. Potential health impacts of excessive flavonoid intake. Free Radic Biol Med. 2000; 29(3-4): 375–83.

25) Smoliga J M , Blanchard O. Enhancing the Delivery of Resveratrol in Humans:If Low Bioavailability is the Problem, What is the Solution. Molecules. 2014;(19): 17154-72.

26) Smoliga J M, Baur J A , Hausenblas HA. Resveratrol and health – A comprehensive review of human clinical trials. Mol. Nutr. Food Res. 2011, 55, 1129–41.

27) Lyn Patrick. Beta-Carotene: The Controversy Continues. Alternative Medicine Review 2000;5(6) :530-45.

28) Faure H, Fayol V, Galabert C, et al. Carotenoids: 1. Metabolism and physiology. Ann Biol Clin. 1999(57):169-83.

29) Wang XD, Russell RM. Procarcinogenic and anticarcinogenic effects of beta-carotene. Nutr Rev 1999(57):263-72.