National Journal of Biological Sciences, (2021), Volume 2, Issue I

Bio-Active Potential of Naturally Coloured Foods and Their Nutraceutical Significance

Misbah Arshad[1], Maimoona Ashfaq[1], Muniba Tariq[1], Ishrat Parveen[2], Sidra Khalid[1], Tallat Anwer Faridi[3], Sumbal Nazir[2]*

[1]*Institute of Diet and Nutritional Sciences, University of Lahore, Pakistan*
[2]*Department of Zoology, University of Central Punjab, Pakistan*
[3]*Department of Allied Health sciences University of Lahore, Pakistan*
**Corresponding author*: sumbalgcu@yahoo.com

Received: 20th January, 2021 / Revised: 17th March, 2021 / Accepted: 16th June, 2021 / Published: 25th June, 2021

Abstract

Bio-active components and a variety of nutrients in colored foods make them therapeutically rich. Worldwide availability and accessibility of these colored foods depend upon geographical and seasonal variations. Evidence based studies previously proved that colored foods have great influence on the prevention of various carcinogenic disorders and other nutritional deficiencies. Diseases like cardio vascular disease, diabetes and cancer which are more prevalent nowadays can be controlled with the help of these colored foods. Abundance of phytochemicals, vitamins and minerals make them active nutraceutical compounds. Each color identifies specific type of nutrients and these nutrients perform specific functions. For instance, yellow-colored foods are abundant in vitamin C, β-carotenoids and bioflavonoids which act as antioxidant and anticoagulant. Green colored foods are loaded with potassium and foliate to improve vision. Chlorophyll in green foods acts as antioxidant and prevents free radicals production which is the root cause of various diseases. Red colored foods are the good source of phytochemicals and lycopene that show anti-aging and antioxidant properties; on the other hand, white and brown foods also contain a large number of vitamins, minerals and many other active ingredients. These foods also contain a significant amount of fiber that helps to promote gastric functioning. Hence, colored foods help in the prevention of different diseases with the help of essential nutrients and phytochemicals.

Keywords: Bioflavonoids, Lycopene, Diabetes, Anti-aging, Colored foods

Introduction

Color is the prominent characteristic of a food and often decides our expectancy to eat that food. Color is used to identify a food and a way to judge the quality of a food. A diet with variety of colors provides optimal health benefits (**Rodriguez-Casado, 2016)**. Talking about colorful foods the healthiest foods that comes in mind are the beautiful colorful fruits and

vegetables. Universally fruits and vegetables are considered healthy (**Slavin & Lloyd, 2012**). They are low in fat, cholesterol or sodium and provide abundant amount of complex carbohydrates. They are rich source of essential dietary micronutrients such as vitamin C; vitamin A; vitamin E; and potassium; and antioxidants; fibers and are important source of phytochemicals (**Hornick & Weiss, 2011**).

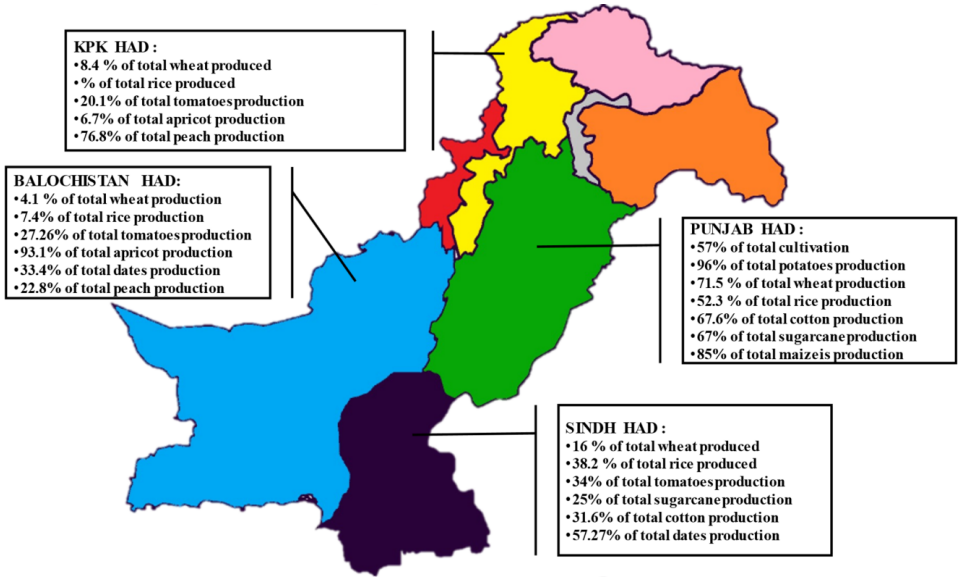
Phytochemicals are naturally occurring substances in plants and have potential to provide health benefits beyond basic nutrients. These substances also provide color, such as anthocyanin gives blue color to blueberries. Phytochemicals also act as antioxidants, phytoestrogens, and anti-inflammatory agents. These phytochemicals also help in the synthesis of other essential nutrients. These also work deactivate carcinogenic substances **(Fadaka *et al.*, 2019)**. Fruits and vegetables are also considered as functional foods. Functional foods provide a health benefit and also protect against many diseases (**Betoret *et al.*, 2011**). According to WHO; fruits and vegetables intake is 400g/day about 4-5 portions a day **(Nishida & Uauy, 2009)**. Antioxidants rich foods in the diet effects brain function; promote anti-aging; and prevent neurodegenerative disorders. Fruits and vegetables provide significant amount of dietary fiber. Fiber intake is directly associated with the reduction of cardiovascular diseases and other metabolic disorders **(Chikara *et al.*, 2018).**

Each fruits and vegetables serving contain 1–5 g of fiber. Except citrus fruits, majority of fruits and vegetables contain insoluble fiber (**Andrews *et al.*, 2002**). Soluble Fibers help to reduce blood lipids levels whereas insoluble fibers have digestive and laxative benefits **(Kranz *et al.*, 2012).** Increased consumption of fruit and vegetables protects from disease incidence (**Zurbau *et al.*, 2020**), and other metabolic disorders **(Wedick *et al.*, 2012).** Powerful nutrients in these fruits and vegetables make them desiring as they boost immune function, prevent skin from aging factors and also improve blood circulation. Phytochemicals in color foods also act as detoxifying agents and prevent body from contamination (**Actis-Goretta *et al.*, 2006**). Not a single vegetable or fruit will supply all essential nutrients for health, so it is necessary to consume a variety of color foods to get sufficient amount of nutrients. People who avoid foods and vegetables completely or consume very less amount are indeed at the risk of diseases (**Song *et al.*, 2010**). Unlike other meat products fruits and vegetables are alkaline which help to reduce acidic environment of body and maintain its pH (**Van Buren, 1979**).

Different phytochemical in food gives different color to that food and have different function as lycopene provides red color to foods and vitamin C act as anti-oxidants in orange (**Leontowicz *et al.*, 2002).** Yellow orange color is due to B-carotenoids; B flavonoids and zeaxanthin as in carrots and peaches (**Li *et al.*, 2000**). The white tan or brown color of is due to the presence of phytochemical Allicin & organosulphurs as in garlic onion and leechi (**Serdula *et al.*, 2004**). Green foods contain Vitamin C, β-carotenes, potassium and folate (**Dehghan *et al.*, 2011**). Blue and purple group offers phytochemical such as anthocyanin and phenolic as in blue berries and eggplant (**Kay *et al.*, 2002**). Studies suggested that maximizing immune system requires a variety of colored foods as colored foods in plate supplies more nutrients (**Fraga *et al.*, 2019**). There is an opposite association among fruits/vegetables consumption and chronic diseases including types of cancers,

CVD, neurodegenerative disorders and obesity (**González-Castejón *et al.*, 2011**). Fruits and vegetables are also beneficial due to their low energy density (**Rolls *et al.*, 2004**). Choosing foods from every color in the rainbow is the key to good health (**Carlson, 2015**). There is great emphasis on fruits and vegetables consumption in dietary guidance due to their nutritive density, phytochemicals concentration and fiber content (**Riboli & Norat, 2003**).

Agricultural Production in Pakistan



Source: (Nair & Schreinemachers, 2020, Rose ***et al.,*** 2019)

Table.1: Pakistan's most produced crops in 2019

Crops	Production quantity	Rating among other countries
Sugarcane	66.8 million ton	5th largest producer
Wheat	24.3 million ton	7th largest producer
Rice	11.1 million ton	10th largest producer
Maize	7.23 million ton	20th largest producer
Cotton	4.49 million ton	5th largest producer
Potato	4.86 million ton	18th largest producer
Mango	2.27 million ton	5th largest producer
Onion	2.07 million ton	6th largest producer
Orange	1.61 million ton	12th largest producer
Tomatoes	1601 thousand ton	37th largest producer
Tangerine	596 thousand ton	4th largest producer
Apple	499 thousand ton	24th largest producer
Watermelon	565 thousand ton	30th largest producer
Carrot	504 thousand ton	17th largest producer
Date	483 thousand ton	6th largest producer

Borrelli Robinson 2020, **Pakistan Wheat Production up in 2017-18**

Each color offers a different health benefit. Here are some colored foods and their health benefits:

Red

Carotenoid pigmented family provides a large number of antioxidants to red color fruits and vegetables. Phytochemicals such as anthocyanin, lycopene, b-carotenes, vitamin C, A are present in red foods (**Böhm, 2012**) pene makes tomatoes, bell peppers and water melon red. Pink color of grapefruit is also due to the presence of lycopene. These components also make foods incredibly healthy. Red colored foods act as antioxidative and anti-aging agents, help in maintaining brain function, cardiac health and also reduces the risks of certain cancers in human being (**Tan *et al.*, 2021**). Beet-roots, strawberries and kidney beans are rich in folic acid (**Ahouagi, *et al.*, 2021**) kidney beans are also abundant in iron, protein and fiber. All types of berries, grapefruit and bell peppers are good sources of Ascorbic acid (vitamin C). **Aubert, 2021** tell peppers are also loaded with Retino (vitamin A). Vitamin A is necessary component for skin and vision health. Cherries, eggplant and prunes are abundant in fiber (**Rao & Brenner, 2021**). Cranberries help to prevent urinary tract infections because these contain a large amount of proanthocyanidin. Proanthocyanidin prevents bacterial growth with the walls of bladder (**Gupta *et al.*, 2007**). Cherries and figs are richer sources of potassium—a mineral that lowers the risk of hypertension (**Ried & Fakler, 2011**). Tomato is enriched with vitamin A and lycopene with greater bioavailability after cooking and processing. Thus, it prevents body from cardiovascular diseases, osteoporosis, cognitive dysfunction and ultraviolet light-induced skin damage (**Burton-Freeman & Reimers 2011).**

Table.2: Red Food Items, Scientific Name along with Bioactive Components and their Nutraceutical Effects

Food items	Scientific name	Bioactive components	Nutraceutical effects	Reference
Indian coffee plum	*Flacaurtia jangomas*	Vitamin C, Tannins, Phenolic acids	Antioxidant activity, anti-inflammatory, neurodegenera-tive diseases like Alzheimer and works against aging	(Dubey *et al.*, 2013)
Watermelon	*Citrullus vulgaris*	Tannins, Potassium, Flavonoids, Phenolics	It balances the ionic concentration, anti-cancerous, antioxidant properties and controls blood pressure	(Hannah & Krishnakumari, 2015)
Pomegranate	*Punica garanatum*	Protein, Minerals (Ca, P, Mg, Cu, Fe, Cl and S), Vitamins (Thiamine, Nicotinic acid, Carotene, Riboflavin, Vit-C, Pectin	Showers the progression of Alzheimer's disease, suppresses the estrogen thus lower the chances of breast cancer cure gastrointestinal problems, anti-inflammatory, anti-oxidant prevent nausea and reduces hypertension. Prevent the infection of intestinal lining.	(Parmar & Kar, 2008) (Jurenka, 2008)

Indian date jujube	*Ziziphus Mauritiana* Lam.	VMinerals (K, Na, Mg, Ca), Ascorbic acid, Riboflavin, Total Phenolic compounds, Rutinosides, Flavonoids, Proanthocyanidins, Epicatechins	It purifies the blood and aids in digestion. Anti-oxidant, anti-microbial and antianemic activity. It helps in management of dyslipidemia, insulin resistance, wound healing and bowel movement. It is used in many formulated food products like JOSHANDA.	(Rashwan *et al.*, 2020), (Rathore *et al.*, 2012)
Beetroot	*Beta vulgaris* L.	Betalains, betacyanin, vulgaxanthin, flavonoids, alkaloids, saponins, terpenoids, cyanogenetic glycosides and tannins.	Beneficial against, cancer, oxidative stress, inflammatory process, hypertension, hepatic disorders, gout, obesity, constipation and tuberculosis.	(Nikan & Manayi, 2019) (Naqvi & Husnain, 2020)
Red Chili	*Capsicum annuum* L.	Capsaicinoids, capsorubin, flavonoids, phenols, lignan, capsanthin	Antioxidative property, analgesic, anti-microbial, anti-pyretic, anti-cancerous, anti-inflammatory, immunomodulatory, expectorant, stimulants, cardiotonic, carminative and gastroprotective effect.	(Maji, & Banerji, 2016). (Saleh *et al.*, 2018)
Tomato	*Solanum lycopersicum* L.	Beta-carotene, lycopene,	Protects from lungs cancer, cardiovascular diseases, arteriosclerosis and diabetes. Anti-bacterial, anti-mutagenic and anti-fungal property.	(Nasir *et al.*, 2015) (Viuda-Martos *et al.*, 2014)

Orange /Yellow

Yellow and orange colored fruits and vegetables contain β-carotenoids, ascorbic acid (vitamin C) and bioflavonoids. Beta carotene as precursor of vitamin A prevents free radicals production in body. Sweet potatoes, carrots, apricots, carrots, yams and mangoes are good sources of beta-carotene. Orange and yellow fruits and vegetables are also providing adequate amount of rich folic acid and potassium bromelain (**Kesh, & Palai, 2021**). Ranges are considered as the most ordinary fruit source of ascorbic acid (vitamin C). Other sources of vitamin C are Bell peppers, peaches, sweet potatoes, papaya, mangoes, and cantaloupe. Carrots, cantaloupe, summer squash, and corn are rich in folic acid. Pumpkin, sweet potatoes, and butternut squash contain high contents of potassium, which lowers blood pressure (**Jomov & Valko, 2013**). Bromelaine, an enzyme found in pineapple, helps in digestion. It is also responsible for reducing infection and swelling (**Pavan *et al.*, 2012**). The healing effect of their free radicals supports immune function, improves skin health, prevents night blindness, decreases risk of various cancers and heart diseases (**Kasperczyk *et al.*, 2014**).

Table 3: Orange-yellow food items, scientific name along with their bioactive ingredients and nutraceutical properties

Food items	Scientific name	Bioactive ingredients	Nutraceutical properties	References
Pineapple	*Ananas comosus*	Bromelin, magnesium, vitamin C and B6.	Emmenagogue, styptic, anthelmintic, diaphoretic, styptic, vermicide, unripe papaya improve digestion, uterine tonic fastens tissue repairing, it has also anti-diabetic, anti-oxidantive and lipid lowering properties.	(Hossain *et al.*, 2015), (Wali, 2019).
Banana	*Musa paradisiac* L.	Retinol, tannins and minerals (Mg, P, Ca, Cu and Fe).	Laxative, demulcent, helpful in diarrhea and intestinal lesion smooths stomach lining against ulcer and acidic reactions. Aids in dyspepsia.	(Singh *et al.*, 2016)
Orange	*Citrus reticulata*	1-Limonene, phenolic derivatives, beta carotene, flavonoids, tannins, β-phellandrene and r-terpinene.	Aphrodisiac, laxative, astringent and relieves vomiting	(Singh *et al.*, 2016), (Pons *et al.*, 2016)
Mango	*Mangifera indica* L.	Gallic acid, carotenoids, phenolic compound, folate, iron, vitamin A, C, B6 and E.	Anthelmintic, Laxative, tonics, and diuretic. laxative, diuretic, tonic, anthelmintic, iron present in it helps against anemia. Esters, terpenes and aldehydes increases appetite and aids in the digestion system. Higher amount of Vit-B6 helped in improving cognitive functioning. Beta-carotene helps to enhance the immunity	(Wall-Medrano *et al.*, 2020), (Swaroop *et al.*, 2018)
Papaya	*Carica papaya*	Papayotin or Papain, manganese Papayic acid, carposide and carpaine.	Acts as laxative, anthelmintic, diuretic, anti-bacterial, emmenagogue, anti-viral, anti-inflammatory and anti-pyretic. Fibrinolytic present in papaya helps in dissolving blood clots, gastrointestinal functioning. Due to high manganese content which also aid in preventing osteoarthritis and osteoporosis.	(Rashmi, 2019), (Prabhu *et al.*, 2017)
Carrot	*Daucas carota* L.	Oligosaccharide, carotenoids, tocopherol, phylloquinone, caffeic acid, Vitamin-A, chlorogenic acid, and anthocyanins.	Anti-oxidant, anti-cancer potential, artery protecting effect, immune-modulatory actions, fights against infection, relief constipation, helpful in reproductive potential and decreases cholesterol level. Good for vision.	(Prabhu *et al.*, 2017)
Sweet potato	*Ipomoea batatas*	Quercetin, fisetin, beta-carotene, lycopene, alpha-carotene, phenolic compounds, Merin, rich in minerals (Fe, Ca, P), vitamin A, B and C.	Act as antioxidant, antimicrobial, antiulcer, immune booster and antimutagenic. It is helpful in relieving diarrhea, wound healing and hypoglycemic effect.	(Jones and de Brauw 2015), (Mohanraj & Sivasankar 2014)

Green

Green color vegetables are rich in chlorophyll, an antioxidant with great health benefits. These vegetables also contain lutein, indole and zeaxanthin in a significant amount. Green fruits contain vitamin C, β-carotenes, potassium and folate, folate have the potential to promote vision health. These foods contents are enriched in sulfoxides and glucosinolates. These antioxidants are partially responsible for maintaining digestive process, detoxification of body (**Haghi *et al.*, 2017**), reducing the risk of cancer (**Aziz *et al.*, 2020**), boosting immune function and healing process (**Abdel-Aal *et al.*, 2013**). Zeaxanthin and Lutein are belonged to carotenoids family. These substances are responsible for improving vision health as shown in figure 1. These carotenoids also reduce the chance of age-related eye diseases by functioning as anti-inflammatory and anti-oxidative agents (**Rhone and Basu, 2008**). Other nutrients in green foods are copper, potassium, folate magnesium and pyridoxine. Cruciferous vegetables such as broccoli, cabbage and brussels sprouts are rich in Beta-carotene and vitamin C (**Ma and Lin 2010**).

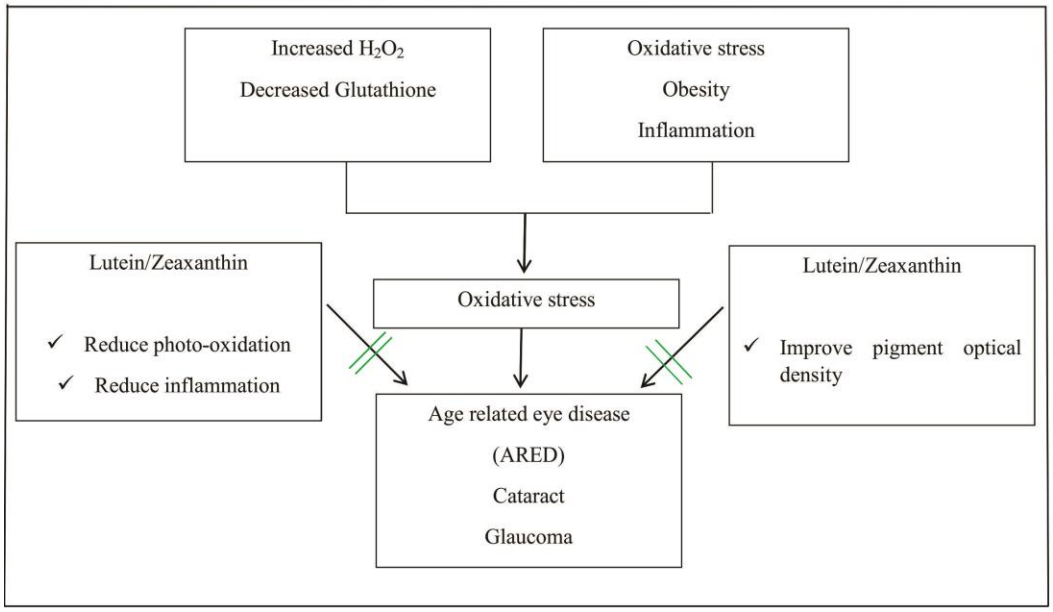


Figure 1: Effects of Lutein and Zeaxanthin for Vision protection.

Table. 4: Green Food Items, Scientific Name along with their Bioactive Ingredients and Nutraceutical Properties

Food items	Scientific name	Bioactive ingredients	Nutraceutical properties	References
Avocados	*Persea americana*	Vitamin A, Zeaxanthin, lutein, riboflavin, thiamin, niacin, folate and pantothenic acid. Minerals (Ca, Zn, K, P, Mg, Mn), beta-sitosterol, Vitamin B6, C, K and E.	Anti-inflammatory, anti-cancerous, neuroprotective effect, anti-aging, natural detoxifier, good for heart health, healthy for bones and anti-microbial.	(Dreher and Davenport 2013, Duarte *et al.*, 2016)
Indian gooseberry	*Phyllanthus emblica*	Essential oils, ascorbic acid, ellagitannins, flavonoids, gallic acid, emblic acid, tannins and phyllanthin	Laxative, Refrigerant, diuretic, loaded with vitamin C that is helpful in treatment of scurvy, it also perform anti-viral activity, antiallergic, antimutagenic and have antimicrobial properties.	(Ahmad *et al.*, 2021)
Guava	*Psidium guava*	Essential oil, minerals and Eugenol	Antioxidant, laxative, antimicrobial activity against organisms causing diarrhoea like *Salmonella, Bacillus, Shigella, Staphylococcus, E. coli, Pseudomonas and Clostridium.*	(Parvez *et al.*, 2018), (Alvarez-Suarez *et al.*, 2018)
Lady finger	*Abelmoschus esculentus* L.	Mucilage	Regulates blood glucose levels, It has anti-ulcerative property. It lowers blood lipids levels as it binds to bile acid and also prevents cancer as it bind to bile acid.	(Kaewsrichan *et al.*, 2020)
Cucumber	*Cucumis sativus* L.	Beta- carotene	Retinol improves vision health, helps in controlling fever due to its cooling effect, acidosis property, lowers high blood pressure, prevents constipation, obesity and rheumatism.	(Mukherjee *et al.*, 2013, Sharma *et al.*, 2020)
Pea	*Pisum sativum* L.	Phenolic acid, Primary compounds such as protein, starch and fiber. vitamin, Tannins and flavonoids	It prevents osteoporosis.. It has antioxidant, abortifacient and anticancer properties. Maintains metabolic function, gastrointestinal and cardiovascular health in humans. It has also insulin resistance property.	(Ge *et al.*, 2020)
Broccoli	*Brassica oleracea*	Polyphenol, chromium, glucosinulates, quercetin and sulphoraphane.	Potent antioxidant, immunomodulatory and prevent colon cancer. Lowers cholesterol levels, rich in chromium that regulates insulin.	(Vanduchova et al., 2019, Bessler and Djaldetti, 2018)

Blue and Purple

The blue/purple food groups have phytochemicals anthocyanins, flavonoids and phenolics. These are super antioxidants helps which aid in heart and brain function. Flavonoids and poly phenols improve cellular strength, reduce inflammation all over the body and prevent aging process. Anthocyanin is one of the best cancer preventative nutrients. It also helps to prevent inflammatory disorders (**Przybylska, 2020**). Anthocyanins as anti-oxidants fight against atherosclerosis and other cardiac diseases (**Yousuf *et al.*, 2016**). Anthocyanin is responsible for darker pigmentation in foods like eggplant and berries. Blueberries contribute to the reduction of disorders like Alzheimer's and Dementia (**Routray and Orsat, 2011**).

Table. 5: Blue-Purple food items, scientific name along with their bioactive ingredients and nutraceutical properties

Food items	Scientific name	Bioactive ingredients	Nutraceutical properties	Ref
Jamun	*Eugenia jambolana*	Ellagic acid and Jamboline, essential oil	Diuretic, anti-diabetic, hematinic, prevents constipation, hepatoprotective, flatulence, Stomachic and gastritis.	(Zahra *et al.*, 2019)
Plum	*Prunus domestica*	Amygdaline, emulsin, of selenium ion, boron and malic acid in small amount	Laxative, anti-oxidant, anti-cancer colon cancer, Coolant and emollient. Prevent hyper lipidemia and atherosclerosis. Rich in boron and selenium to improve bone density.	(Singh *et al.*, 2017)
Egg plant	*Solanum melongena* L.	Anthocyanin, phenol, rich in Minerals (Fe, Ca, P), glycoalkaloids (Solasodine) and vitamin-B complex,	Hypotensive effect and Anti-hemorrhoidal. lowers blood lipids.	(Gürbüz *et al.*, 2018)
Makoi	*Solanum nigrum* Linn.	Richest source of poly-phenols, saponins and flavonoids,	It has anti-convulsant and anti-inflammatory activity, treats, epilepsy, diabetes cardiovascular diseases, tuberculosis, cancer and cognitive disorders.	(Wang *et al.*, 2017)
Blueberry	*Vaccinium corymbosum*	Anthocyanins, flavonols, proanthocyanidins, hydroxycinnamic acid esters (especially chlorogenic acid)	Cardioprotective effect, antioxidant, anti-inflammatory, regulates immune function.	(McAnulty *et al.*, 2017)

White/Tan/Brown

White foods are loaded with allicin. Allicin ia a sulfur containing compound abundantly present in onions, garlic, leeks and scallions (**Falcón-Piñeiro *et al.*, 2021**). It has a potential to prevent bacterial and fungal growth (**Zainal *et al.*, 2021**). It helps to prevent vascular inflammatory damage (**Sorlozano-Puerto *et al.*, 2021**). Rice bran also contain anthocyanin pigments which act as anti-oxidative agents (**Mahanta and Sikia, 2016**). There is direct correlation between wheat consumption and cell survival in humans (**Hole et al., 2012**). Mushrooms are also loaded with essential nutrients such as pyridoxine, cholecalceferol, zinc, copper and B-complexes. These all nutrients are required for proper functioning of immune system (**Jablonska and Vinceti, 2015**). Glutathione synthesis also requires all these nutrients. Glutathione is also known as power-house antioxidant with ability to fight against cancer. White cauliflower is a good source of cancer preventing nutrients such as sulforaphanes and Indole-3-Carbonyl (**Hubbard *et al.*, 2015**). Onion and garlic contain organosulphurs, photochemicals fight against tumour and cancer (**Wang and Huang 2015**). Bananas, leechi, coconuts, potatoes help in maintaining blood pressure (**Pereira and Maraschin 2015**). White vegetables are also rich in dietary fiber (**Cui *et al.*, 2019**), and resistant starch. These resistant starch and fiber contents are generally protective against weight gain and diabetes mellitus. Potatoes are also rich source of fiber and resistant starch (**King and Slavin, 2013**).

Table. 6: White-Brown-Tan Food Items, Scientific Name along with their Bioactive Ingredients and Nutraceutical Properties

Food items	Scientific name	Bioactive ingredients	Nutraceutical properties	References
Mulberry	*Morus alba* L.	kaempferol glucuronide, gallic acid, Morroles B-F, quercetin and galloctechin,	Antioxidants, anti-atherosclerotic, anti-diabetic, hepatoprotective activity and anti-obesity.	(Yuan and Zhao, 2017)
Lychee	*Litchi chinensis*	Saponin, Epicatechin, and procyanidin A2	Rich in antioxidants	(Zhao *et al.*, 2020)
Radish	*Raphanus sativus* L.	Methyl mercaptan. and Raphanin	Antiviral, anti-microbial, secretolytic property. Helpful in Bronchitis, piles, urinary complaints and hyperlipidemia	(Kumakura *et al.*, 2017)
Potato	*Solanum tuberosum* L.	Potassium, Glycoalkaloids, solanine and alpha-chaconine	Rich in potassium and prevent stroke.	(Dupuis and Liu 2019)
Coconut	*Cocos nucifera* L.	Peroxidas, Phytoharmones and Polymerases	Antibacterial, Estrogenic effect, Antiviral properties , antioxidant effect, antithrombotic effect.	(Reddy *et al.*, 2018)

Garlic	*Allium sativum* L.	Allicin, allyl propyl, ajoene, S-allyl marcaptocystein, sally cysteine, diallyl tri sulphide and vinyl dithine	Antibacterial, Antipyretic, anticancer, antiviral, immunomodulating and also helps in reducing migraine and blood pressure.	(Zhang *et al.*, 2020)
Wheat	*Triticum aestivum L.*	Tocopherols, benzoxazinoids, lignans, Carotenoids, phytosterols and alkylresorcinols	Reduces the risk of colon cancer, Antioxidant, lower the low-density lipoproteins, anti-inflammatory, immunological functioning, cholesterol levels and anti-oxidant	(Luthria *et al.*, 2015)

Thus, different colors of fruits and vegetables possessing various phytochemicals have the following therapeutic effects as listed below:

Colors of fruits and vegetables	**Phytochemicals**	**Therapeutic impacts on human health**
Green	Glucosinolates, Folate, Vitamin C, Catechins, Carotene, Chlorophyll, Chlorogenic acid, Epigallocatechin, flavonoids, gallate, Isoflavones, Folates, Nitrates, Isothiocyanates, Oleocanthal,L-theanine, Oleuropein, Sulforaphane, Phytosterols, Tannins, Silymarin, Vitexin and tyrosol.	1. Antioxidant 2. Improve blood circulation 3. Help in Methylation
Orange-Yellow	Lutein, Beta-carotene, Curcuminoids, Alpha-carotene, Bioflavonoids, Beta-cryptoxanthin, Nobiletin, xanthopehyll, Bromelain, Prebiotic fibers, Rutin, Zeaxanthanthin, Gingerol and Potassium ions.	1. Enzymatic activity 2. Antioxidant 3. Reduce glycemic impact 4. Gastric motility and regulation 5. Maintain healthy microbiome 6. Role in ovulation and fertility processes 7. Antioxidants prevent lipid-peroxidation 8. Improve endocrine function
Red	Ellagic acid, Lycopene, Hespiridin, Quercetin, Lutein, anthocyanins, vit-c, zeaxanthin, Ellagitannins, Carotenoids, Phloretin and Fistin flavones	1. Antioxidant activity 2. Anti-inflammatory 3. Immune modulation
Blue-purple	Resveratrol, Pterostilbene, Phenolic acid, pro-anthocyanidins, flavonoids and anthocyanidins	1. Cognitive support 2. Role in neuronal health 3. Antioxidant 4. Healthy mood balance
White-Brown-Tan	Dietary fiber and flavonoids	1. Antioxidant 2. Antimicrobial 3. Anti-inflammatory

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