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Novel Function of Polyphenols in Human Health: A Review

[1]Tanu Srivastava and [2]Sunil Kumar Mishra
[1]SHEAT College of Pharmacy, Varanasi, Uttar Pradesh, India
[2]Department of Pharmaceutics, Indian Institutes of Technology, Banaras Hindu University, Varanasi, 221005, Uttar Pradesh, India

Corresponding Author: Tanu Srivastava, SHEAT College of Pharmacy, Varanasi, Uttar Pradesh Technical University, Lucknow, India

ABSTRACT

With the accelerated pace of modern life people are becoming increasingly stressed. As a result, depression is becoming an epidemic that seriously impacts human life. Although, the antidepressant effect of flavonoids/polyphenols has been demonstrated and drawn considerable attention the mechanism needs further investigation because it is complex and involves different neurotransmitters. Continuing research highlights the dynamic capacity of natural polyphenolic compounds to exhibit their antioxidant effect by a number of potential mechanisms. The free radical scavenging, in which the polyphenols can break the free radical chain reaction, as well as suppression of the free radical formation by regulation of enzyme activity or chelating metal ions involved in free radical production. Thus, the antioxidant properties certainly contribute to their neuroprotective effect. Polyphenols have gained much interest recently due to its antioxidant capacity and possible benefits to human health such as anti-carcinogenic, anti-atherogenic, anti-ulcer, antithrombotic, anti-inflammatory, immune modulating, anti-microbial, vasodilatory and analgesic effects.

Key words: Antioxidants, human health, polyphenols, anti-cariogenic

INTRODUCTION

The term polyphenol appears to have been in use since 1894 (Nonaka, 1989). The term "polyphenol" should be used to define compounds exclusively derived from the shikimate/phenylpropanoid and/or the polyketide pathway, featuring more than one phenolic unit and deprived of nitrogen-based functions.

Polyphenols always have heteroatom substituents other than hydroxyl groups; ether and ester linkages are common, as are various carboxylic acid derivatives. Ester linkages are common in the hydrolyzable tannins. Polyphenols (Quideau *et al*., 2011) also known as Polyhydroxyphenols are a structural class of mainly natural but also synthetic or semisynthetic, organic chemicals characterized by the presence of large multiples of phenol structural units. The number and characteristics of these phenol structures underlie the unique physical, chemical and biological (metabolic, toxic, therapeutic, etc.) properties of particular members of the class. Examples include tannic acid and ellagitannin (Quideau *et al*., 2011; Chuang *et al*., 2013).

Polyphenols are naturally occurring compounds found largely in the fruits, vegetables, cereals and beverages. Fruits like grapes, apple, pear, cherries and berries contains up to 200-300 mg polyphenols per 100 g fresh weight. The products manufactured from these fruits, also contain polyphenols in significant amounts. Typically a glass of red wine or a cup of tea or coffee contains about 100 mg polyphenols. Cereals, dry legumes and chocolate also contribute to the polyphenolic intake.

Polyphenol compounds (sources and general health benefits of polyphenols)

Sources of polyphenols: Cranberry, apple, red grape, strawberry, pineapple, banana, peach, lemon, orange, pea grape fruit, broccoli, spinach, yellow onion, red pepper, carrot, cabbage, potato, lettuce, celery, cucumber, aloe, fennel, basil, ginger, pomegranate, red chilli, tea, red grapes and others.

Health benefits of polyphenols consumption on human beings: Polyphenols in particular has long been valued by human beings throughout the world for its medicinal properties. A good number of animal and clinical studies suggest that chemical constituents in polyphenols play an important role in contributing overall human health. The health benefits derived through the consumption of polyphenols is summarized below.

Acts as antioxidant: Neurons and microglial cells provided strong evidence for antioxidative and anti-inflammatory effects of Hon and Mag and underscore the important role of NADPH oxidase in mediating oxidative stress in neurons and microglial cells and has unveiled the role of IFNγ in stimulating the MAPK/ERK1/2 signaling pathway for activation of NADPH oxidase in microglial cells. Hon and Mag offer anti-oxidative or anti-inflammatory effects, at least in part, through suppressing IFNγ induced p-ERK1/2 and its downstream pathway (Chuang *et al*., 2013).

Studies from the seven medicinal plants of the family Asclepiadaceae were characterized for their free radical scavenging activity, total polyphenol and flavonoid contents. Antioxidant activity was determined by DPPH (1, 1-diphenyl-2-picryl- hydrazyl) assay method. The DPPH assay is quick, reliable and reproducible method widely used to test the ability of compounds as free radical scavengers or hydrogen donors and to evaluate the antioxidative activity of plant extracts (Mosquera *et al*., 2007). In the present study, it was observed that the antioxidant activities more or less had direct correlation with quantities of total polyphenols thus agreeing with the earlier reports (Zhu *et al*., 2004). The strong correlation coefficient (R^2) value 0.8337 suggests that flavonoid compounds present in these plants contribute well to the antioxidant capacity. The results (Table 1 and 2) obtained in the present study indicates that the leaves of these medicinal plants have great importance as therapeutic agents in preventing oxidative stress related degenerative diseases. However, conformation of its activity *in vivo* models should be carried out. Such could replace synthetic toxic antioxidant (Irimpan *et al*., 2012).

Antioxidant assay and HPLC analysis of polyphenol-enriched extracts from industrial apple pomace. Six fractions of apple polyphenols, API to APVI, were acquired through extraction and purification using absorbent macroporous resin. Fraction APIII, eluted by 40% aqueous ethanol, had the highest content of total phenolics (1.48±0.03 g gallic acid equivalents g^{-1} dry apple pomace), which consisted of chlorogenic acid, caffeic acid, syrigin, procyanidin B2, (-); Epicatechin, cinnamic acid, coumaric acid and quercetin. Antioxidant assays showed that APIII had the strongest antioxidant activity of DPPH radical scavenging rate (90.96±10.23%), ABTS radical inhibition rate (89.78±6.54%) and the strongest reducing power (8.30±0.71 μmol Trolox equivalents kg^{-1} dry apple pomace). It also indicated that procyanidin B2, chlorogenic acid, (-): Epicatechin and quercetin had stronger antioxidant capacity than other phenols (Bai *et al*., 2013).

Table 1: Total polyphenol and flavonoid content of the seven plants under study

Plants	Total polyphenolic content (%) (Mean±SD)	Total flavonoids conc. (Mean±SD)
Asclepias curassavica L.	0.75800±0.03	2.73±0.18
Calotropis gigantea (L.) R.Br.	0.13000±0.02	2.19±0.13
Gymnema sylvestre (Retz) R.Br.	0.93100±0.12	2.19±0.13
*Holostemma ada.*kodien Schult.	0.95757±0.08	2.94±0.16
Pergularia doemia (Forsk.) Chiov.	1.52400±0.14	4.41±1.02
Tylophora indica (Burm f.) Merrill.	1.03000±0.12	3.21±1.03
Wattakaka volubilis (L.f.) Hasskarl	0.44000±0.02	2.42±0.05

Table 2: Antioxidant value of seven plants under study

Plants	IC_{50} values (μg mL^{-1})
Asclepias curassavica L.	170.600
Calotropis gigantea (L.) R.Br	486.400
Gymnema sylvestre (Retz) R.Br.	199.526
Holostemma ada.kodien Schult.	158.490
Pergularia doemia (Forsk.) Chiov.	147.700
Tylophora indica (Burm f.) Merrill	181.970
Wattakaka volubilis (L.f.) Hasskarl	179.640

IC_{50} values of Ascorbic acid is 8.91 (μg mL^{-1})

Antioxidant activities in hot and cold aqueous extracts extracted from fresh leaf of Ficus deltoidea using 2,2-diphenyl-1-picrylhydrazil (DPPH) free radical scavenging activity and Ferric Reducing Antioxidant Power (FRAP) assays. Phenolic compounds were measured using total polyphenol, phenolic acid and flavonoid content. Different extraction conditions significantly affected the total antioxidant activities, polyphenol, phenolic acid and flavonoid content of the extracts. The decreasing order of antioxidant activities using DPPH method in hot aqueous extracts were as follows: var *kunstleri*>var *trengganuensis*>var *angustifolia*, while cold aqueous extracts: var *kunstleri*>var *angustifolia*>var *trengganuensis*. The total antioxidant content using FRAP method showed the highest activity in hot aqueous extracts of F2 with 2.13 mg Trolox equivalent per gram fresh weight (TE/g FW). Hot aqueous extract for F2 and F11 contained the highest total polyphenol content with 0.88 mg gallic acid equivalent (GAE)/g FW, while the lowest in cold aqueous of M6 contained total polyphenol content with 0.47 mg GAE/g FW. Total phenolic acid ranged from 0.54-2.19 mg GAE/g FW in hot aqueous extracts, while 0.59-1.96 mg GAE/g FW for cold aqueous extract. Total flavonoid content ranged from 0.17-0.66 and 0.18-0.51 mg Catechin Equivalents (CE)/g FW in hot and cold aqueous extracts, respectively (Hakiman *et al*., 2012).

Role for polyphenols in the prevention of degenerative diseases, particularly cardiovascular diseases and cancers. The antioxidant properties of polyphenols have been widely studied but it has become clear that the mechanisms of action of polyphenols go beyond the modulation of oxidative stress. This supplemental issue of The American Journal of Clinical Nutrition, published on the occasion of the 1st International Conference on Polyphenols and Health, offers an overview of the experimental, clinical and epidemiologic evidence of the effects of polyphenols on health (Scalbert *et al*., 2005).

Studies on antioxidants should focus on their bioavailability (absorption, metabolism and cellular and tissue distribution), establishing whether the *in vitro* effects are applicable to the situation *in vivo*. Human trials should focus on specific populations with low intake of these substances. Antioxidants may act as pro-oxidants under certain circumstances (McKevith *et al*., 2003; Yordi *et al*., 2012).

Cocoa (*Theobroma cacao* L.) is a rich source of polyphenols and reported having high antioxidant activity than teas and red wines. Cocoa and its derived products (cocoa powder, cocoa liquor and chocolates) contain varied polyphenol contents and possess different levels of antioxidant potentials. The polyphenols in cocoa beans contribute to about 12-18% of the dry weight of the whole bean. Three main groups of cocoa polyphenols can be distinguished namely the catechins (37%), anthocyanins (4%) and proanthocyanidins (58%). The main catechin is (-): Epicatechin with up to 35% of polyphenol content as shown in Table 3 (Hii *et al*., 2009).

Flavonols isolated from green, black and red tea leaves possess very strong antioxidant proprieties (Table 4) (Gramza *et al*., 2005).

Polyphenol extracts from PFDCB (PE-PFDCB) and UFDCB (PE-UFDCB). Antioxidant activity of PE-PFDCB and PE-UFDCB showed IC_{50} value of 1.1604 and 0.2500 mg mL^{-1}, respectively (Prayoga *et al*., 2013).

Oxaliplatin induced painful peripheral neuropathy in mice, an effect that was prevented by rutin and quercetin. The mechanism of action of oxaliplatin appears to be, at least, partially oxidative stress-induced damage in dorsal horn neurons, with the involvement of lipid peroxidation and protein nitrosylation (Azevedo *et al*., 2013).

Fights against variable forms of cancer: Green tea polyphenolics can interact directly with some promutagens or inhibit them on the way of the cytochrome P-450-dependent bioactivation (Gramza *et al*., 2005).

Anticancerogenic properties of green tea are related to the presence of many flavonoids from the group of catechins, especially of EGCG (Ahmad *et al*., 1997). Green tea shows a beneficial effect to reduce cancer risk (Table 5) (Kim and Masuda,1997).

Use of *Allium Sativum* (Bulb) Polyphenolic Compound activity on MCF-7, A549 and PA-1 cancer cell line (breast, lung and ovary cancer, respectively). Hydro alcoholic (1:1) sample of *Allium sativum* (Bulb) were prepared and tested for their cytotoxic activities against cancer cell lines (MCF-7, A-549 and PA-1) with standard Doxorubicin. From IC_{50} values of MTT assay of

Table 3: Total polyphenols content in cocoa beans

Geographical origin	Variety	Total polyphenol content (mg GAE g^{-1})
Ivory coast	Forastero	81.5
Columbia	Amazon	81.4
Guinea Ecutorial	Amazon Forastero	72.4
Ecuador	Amazon hybrid	84.2
Venezuala	Trinitario	64.3
Peru	Criollo	50.0
Dominican Republic	Criollo	40.0
Malaysia	Unknown	71.42-82.68
Cameroon	Unknown	86.6-143.6 mg epicatechin equivalent g^{-1}

Table 4: Antioxidant activity of green tea polyphenols

Material tested	Aim /Models/Method
Aqueous extracts of rooibos, green,oolong and black teas	DPPH+scavenging and α-carotene bleaching
123 batches of tea (most of them from green tea)	Principal Component Regression (PCR) was used to model the relation between the total antioxidant capacity and the NIR spectra of green tea
Catechins	The antioxidative mechanism of catechins were studied by investigation products generated by AAPH-induced radical oxidation

Table 5: Green tea polyphenols as anticarcinogenic compounds in animal models

Compound tested	Organ/Chemicals used for tumorogenesis/animals
Green tea infusion (2% oral administration)	Esophageal: N-nitrosomethylbenzylamine(NMBzA): rats
Green tea infusion (1.2% oral administration)	Forestomach: benzo(a)pyrene(BP): mice
EGCG(0.05% solution)	Glandular stomach: N-methyl_N'-nitro-nitrosoguanidine (MNNG): rats

Allium sativum (Bulb) for MCF7, A549 and PA1 cancer cell lines, from this it may conclude that *Allium sativum* (Bulb) shows efficient cytotoxicity on MCF-7 (6±1 µg) than PA-1(15±1 µg) and A459 (28±1 µg) cancer cell line (Nema *et al*., 2014).

Portulaca quadrifida (Portulacaceae) is traditionally used for the treatment against various ailments in tropical and subtropical parts of India without any scientific knowledge and results confirm that both extracts exhibited significant effect against HT-29 cell lines and are found less effective against normal L-6 cell lines indicating the cancer specific effect of *Portulaca quadrifida* (Mulla and Swamy, 2012).

Reduces risk of cardiovascular diseases: Tea may display a protective role against cardiovascular diseases via a number of different mechanisms, one of which are its antioxidative properties. As a result of LDL cholestereol oxidation, monocytes are recruited to the arterial wall and monocyte-derived macrophages accumulate the excessive amount of oxidised LDL and become lipidladen foam cell (Tijburg *et al*., 1997).

Antibacterial and anti viral activity: There are numerous studies on the antimicrobial activity of tea extracts, catechins and other polyphenols (Table 4). The ECG reduced oxacillin resistance in Methicillin-Resistant *Staphylococcus aureus* (MRSA) at concentrations below the MIC. Substitution of the gallate group of ECG with 3-O-acyl chains of varying lengths C4-C18 led to enhanced anti-staphylococcal activity with chain lengths of C8 and C18. 3-O-octanoyl catechin was bactericidal against MRSA as a result of membrane damage. The ECG was found also as an agent to combat beta-lactam resistance in *S. aureus* (Table 6) (Ahmad *et al*., 1997).

Allium cepa L. (onion) showed antibacterial activity against multidrug resistant *Pseudomonas aeruginosa, Salmonella typhi* and *E. coli*, while *Zingiber officinale* (ginger) did not show antibacterial activity against the organisms. White onion showed more antibacterial activity than red onion against the organisms (Adeshina *et al*., 2011).

Antibacterial activity of PE-PFDCB and PE-UFDCB was effective at inhibiting the growth of *Staphylococcus aureus* and *Salmonella typhimurium* at 25,000-100,000 ppm, respectively (Prayoga *et al*., 2013).

Burns fat: Obesity is a metabolic disorder resulting from imbalance between energy intake and energy expenditure. It is known to be a strong risk factor for lifestyle-related diseases (Murase *et al*., 2006).

Investigations into thermogenic tea properties showed synergistic action of caffeine and catechins, possibly stimulating the thermogenesis. It was stated that individuals, consuming tea

Table 6: Antimicrobial activity of green tea polyphenols

Compounds	Species	Effects
Green tea catechins	*Helicobacter pylori*	Weak inhibition of *Helicobacter pylori* growth
EGCG	*Legionella pneumophila*	EGCG enhanced the *in vitro* resistance of alveolar macrophages to *Legionella pneumophila* infection by selective immunomodulatory effects on cytokine formation
EGC	*Staphylococcus aureus*	EGC showed a weak activity against *Staphylococcus aureus*: substitution of the gallate group og ECG with 3-O-acyl chains of varying lengths led to enhanced antistaphylococcal activity.
EGCG	*S. aureus*, *S. epidemides*, *S. hominis*, *S. haemolyticus*	Minimum inhibitory concentration (MIC): 50-100
Lung chen tea, ECG, EC	*Helicobacter pylori*	MIC 50 for lung chen was 0.25-0.5% (w/w) and these of ECG and EC were 50-100 and 800-1600, respectively

extract containing 90 mg EGCG, three times daily, burned 266 kcal day^{-1} more than the group without the addition of catechins. It enabled the presumption that this property might be helpful in overweight and obesity control (Dulloo *et al.*, 2000).

Green tea catechins can influence the endocrine system (Kao *et al.*, 2000). EGCG considerably lowered food consumption level, body mass, estradiol, testosterone and leptine levels in the rats studied. It was also found that catechins can modulate steroid hormones concentration in the body, which is possibly an essential element in anticancerogenic prophylaxis (Strom *et al.*, 1999). Black tea polyphenols-theaflavins-also show beneficial influence on living organism. They are strong antioxidants protecting healthy cells of rat liver against oxidative stress and preventing DNA damages (Feng *et al.*, 2002).

Gives a boost to immunity: The EGCG enhanced the *in vitro* resistance of alveolar macrophages to *Legionella pneumophila* infection by selective immunomodulatory effects on cytokine formation. Furthermore, the tobacco smoking-induced impairment of alveolar macrophages regarding antibacterial as well as immune activity was also recovered by EGCG treatment. These results indicate that EGCG may be a potential immunotherapeutic agent against respiratory infections in immunocompromised patients, such as heavy smokers (Yamamoto *et al.,* 2004).

Improves oral health/anti-cariogenic effect: Green tea polyphenols are known to prevent dental caries. The effects of these compounds on cariogenicity were observed *in vitro* tests. Catechins inhibited the growth of cariogenic bacteria *Streptococcus mutans* and *S. sabrinus* chewing gums containing tea polyphenols was found effective in decreasing dental plaque formation in humans (Sakanaka *et al.*, 1989).

Polyphenols occurring in cocoa, coffee and tea can have a role in the prevention of cariogenic processes, due to their antibacterial action Studies carried out on green, oolong and black tea indicate that tea polyphenols exert an anti-caries effect via an antimicrobial mode-of-action and galloyl esters of (-): Epicatechin, (-): Epigallocatechin and (-): Gallocatechin show increasing antibacterial activities. The anti-cariogenic effects against α-haemolytic streptococci showed by polyphenols from cocoa, coffee and tea suggest further studies to a possible application of these beverages in the prevention of pathogenesis of dental caries (Ferrazzano *et al.*, 2009).

Acts as anti-inflammatory and anti-arthritic: Type-A procyanidine polyphenols (TAPP) are reported to have immunomodulatory and anti-inflammatory potential in vitro. The objective of present work is to evaluate potential of TAPP extracted from Cinnamon (*Cinnamomum zeylanicum*) bark in animal models of inflammation and rheumatoid arthritis in rats. The TAPP showed disease-modifying potential in animal models of inflammation and arthritis in rats (Vetal *et al.*, 2013).

Anti-inflammatory effects of epigallocatechin gallate (EGCG), the major polyphenol component of green tea, in human corneal epithelial cells (HCEpiC). Treatment of HCEpiC with 1 ng mL^{-1} IL-1β for 18 h significantly increased release of the cytokines/chemokines Granulocyte Colony-Stimulating Factor (G-CSF), granulocyte-macrophage colony-stimulating factor (GM-CSF), interleukin-6 (IL-6), interleukin-8 (IL-8) and Monocyte Chemotactic Protein-1 (MCP-1), while hyperosmolarity-induced release of IL-6 and MCP-1. EGCG acts as an anti-inflammatory agent in HCEpiC and therefore may have therapeutic potential for ocular inflammatory conditions such as dry eye (Cavet *et al.*, 2011).

Table 7: Antibacterial test results PBR in disc diffusion assay

Microorganisms	Strain	Polyphenol concentration (mg disc^{-1})					
		15	7.5	3.75	1.875	0.9375	0.46875
Staphylococcus aureus (MRSA)	CAU 11001	16*	14	12	ND*	ND	ND
	CAU 11002	20	18	17	12	ND	ND
	CAU 11003	22	20	17	13	ND	ND
	CAU 11004	20	17	14	11	ND	ND
	CAU 11005	16	14	14	ND	ND	ND
Carbapenem resistant *Acinetobacter boumannii* (CRAB)	CAU 10201	16	14	12	ND	ND	ND
	CAU 10202	16	15	11	ND	ND	ND
	CAU 10203	16	14	11	ND	ND	ND
	CAU 10204	15	12	12	ND	ND	ND
Bacillus anthracis	ATCC 14578*	18	16	14	13	11	ND

PBR: Polyphenol of black raspberry root, ND: Not detected *: Inhibition zones including of the paper disc (10 mm)

Anti-Inflammatory and anti-Superbacterial Activity of Polyphenols Isolated from Black Raspberry root polyphenols showed stronger anti-inflammatory activity than fruit polyphenols. Root polyphenols showed lethal activity against Methicillin-Resistant *Staphylococcus aureus* (MRSA), Carbapenem-Resistant *Acinetobacter boumannii* (CRAB) and *Bacillus anthracis*. In contrast, the black raspberry fruit did not demonstrate these properties. These data provide the first demonstration that black raspberry root has potential anti-inflammatory and antisuperbacterial properties that can be exploited as alternatives for use in the food and cosmetic industries and/or as pharmaceuticals (Table 7) (Kim *et al*., 2013).

Use of polyphenols in periodontal inflammation Quercetin and luteolin are generally safe. Infact quercetin was effective in a clinical trial for the inflammatory bladder disease interstitial cystitis as well as to reduce contact dermatitis in humans. Further preclinical animal and human clinical studies are required to show in what combination sand formulations flavonoids may best reduce periodontal inflammation (Palaska *et al*., 2013).

Anti-inflammatory effect of epigallocatechin gallate (EGCG), the major polyphenol component of green tea in Human Corneal Epithelial Cells (HCEpiC). data demonstrate EGCG acts as an anti-inflammatory and anti-oxidant agent in HCEpiC challenged with either the pro-inflammatory cytokine IL-1β or hyperosmolarity. Therefore, EGCG has potential therapeutic application for the treatment of ocular disorders with an inflammatory component, including dry eye (Cavet *et al*., 2011).

Anti-psychotics activity: Curcumin neuro-protective and anti-cancer properties but is rapidly eliminated from the body. By optimizing the HPLC method for analysis of curcumin, this study evaluates how the ability of curcumin to penetrate organs and different regions of the brain is affected by nanoparticulation to increase curcumin circulation time in the body (Tsai *et al*., 2011).

Prevents diabetes: Animal studies revealed that green tea may have properties to prevent development of Type 1 diabetes and slow the progression once it has developed (Sharangi, 2009).

Tea polyphenols lower the serum glucose by inhibiting the activity of the starch digesting enzyme, amylase. Tea inhibits both salivary and intestinal amylase. As a result, the starch is broken down more slowly and the sudden rise in serum glucose is minimized. The inhibition of a-amylase from human saliva by polyphenolic components of tea and its specificity was investigated *in vitro* (Hara and Honda, 1990).

Type 2 diabetes mellitus is a common disease that interfereswith the body's ability to store energy from food. Risk factors for type 2 diabetes mellitus include being overweight, lack of exercise and family history of the disease (Iso *et al*., 2006) opined from a study that people who were frequent drinkers of green tea (>6 cups per day) were less likely to develop this diabetes than those who drank less than one cup of these beverages per week.

Corrects skin disorder: Polyphenols specially Tea is used as an age-old home remedy for burns, wounds and swelling. Green tea constituents may be useful topically for promoting skin regeneration, wound healing or treatment of certain epithelial conditions such as aphthous ulcers, psoriasis, rosaceae and actinic keratosis. At certain concentrations, EGCG or a mixture of the major green tea polyphenols stimulated aged keratinocytes to generate biological energy and to synthesize DNA, possibly for renewed cell division (Hsu *et al*., 2003).

Keeps away from liver disease: Green tea protects the liver from alcohol and other harmful chemicals. Alcohol metabolism results in the production of damaging free radicals that can overwhelm the liver's supply of antioxidants, resulting in liver injury (Sharangi, 2009). In a study published in the January, 2004 issue of alcohol in which rats were chronically intoxicated with alcohol for four weeks, green tea prevented damage to their livers (Ostrowska *et al*., 2004).

Treat respiratory diseases: Polyphenol in which theophylline present in tea is used to prevent respiratory diseases like wheezing, shortness of breath and difficulty breathing caused by asthma, chronic bronchitis, emphysema and other lung diseases (Sharangi, 2009). It relaxes and opens air passages in the lungs, making it easier to breathe (Huerta *et al*., 2005) conducted a case-control study in the UK to evaluate the association between respiratory drugs and the occurrence of rhythm disorders among patients with asthma and those with chronic obstructive pulmonary disease.

CONCLUSIONS

Cranberry, apple, red grape, strawberry, pineapple, banana, peach, lemon, orange, pea grape fruit, broccoli, spinach, yellow onion, red pepper, carrot, cabbage, potato, lettuce, celery, cucumber, aloe, fennel, basil, ginger, pomegranate, red chilli, tea, red grapes and others. Cocoa (*Theobroma cacao* L.) is a rich source of polyphenols. It acts as antioxidant, fights against variable forms of cancer, reduces risk of cardiovascular diseases, antibacterial and anti viral activity, gives a boost to immunity, improves oral health/ Anti-cariogenic effect, acts as anti-inflammatory and anti-arthritic, antipsychotics activity , Prevents diabetes, corrects skin disorder, keeps away from liver disease, treat respiratory diseases. The healthy effects of polyphenols depend both on their intake and bioavailability. The concept of bioavailability integrates several variables, such as intestinal absorption, metabolism by the microflora, intestinal and hepatic metabolism, nature of circulating metabolites, binding to albumin, cellular uptake, accumulation in tissues and biliary and urinary excretion. The main difficulty is to integrate all the informations and relating the variables to health effects at the organ level. Since the evidence of therapeutic effects of dietary polyphenols continues to accumulate, it is becoming more and more important to understand the nature of absorption and metabolism *in vivo*. Moreover the identification and measurement of the physiologic polyphenol metabolites represent a key prerequisite for the understanding of the role of dietary polyphenols in human health. Recent studies have examined and demonstrated the potential cancer chemopreventive, antiangiogenic and other benefits of berry extracts especially freeze-dried berries including blueberry, bilberry, strawberry and black raspberries. Although, more human studies are warranted to establish the broad spectrum of health benefits of polyphenols, the currently available data and recent findings are very encouraging.

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