REVIEW ARTICLE

Nutraceutical, pharmaceutical and therapeutic uses of *Allium cepa*: A review

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Abstract

Onion is a well-known traditional nutraceutical and medicinal plant that is cultivated and used around the world. Onions contain phenolics and flavonoids that have potential anti-inflammatory, anti-cholesterol, anticancer, and antioxidant properties. Onions contain 89% water, 1.5% protein, and vitamins B_1, B_2, and C, along with potassium and selenium. It also contains polysaccharides such as fructosans, saccharose, peptides, flavonoids (mostly quercetin), and essential oil. Onion contains numerous sulfur compounds including thiosulfinates and thiosulfonates; cepaenes; S-oxides; S, S-dioxides; mono, di, and tri-sulfides; and sulfoxides. Onion is highly nutritional and its dietary use improves digestion and mental health and lower down toxigenicity of oils. Onion has potential in treating cardiovascular disease, hyperglycemia, and stomach cancer. Onion contains an important antioxidative, i.e., quercetin that is derived from *Allium cepa* on aldehyde oxidase low-density lipoprotein which reduces hepatocytes apoptosis in streptozotocin-induced diabetic rat. Onion has great ethnomedicinal importance as native remedies used against diabetes, and related complications are from onion. *A. cepa* red and white varieties showed antimicrobial and antioxidant activities. These are used in traditional Indian spices and are of great health significance. These are curative for implications from and for food cultures for cardiovascular disease and provide longevity.

Key words: *Allium cepa*, nutraceuticals, onion bulb, pharmaceuticals, traditional medicine

INTRODUCTION

Onion is multipurpose food plant that is used as traditional Indian spices. It has great health significance and is consumed for its putative nutritional and health benefits for centuries.[1] Onion (*Allium cepa* L.) belongs to Family: Liliaceae (lilies) [Figure 1]. It is an easily digestible aromatic vegetable which is used throughout the world. In Hindi, it is known as Pyaj and is also recognized by other names such as Bulbus Allii Cepae, common onion, garden onion, white onion. It is the most widely cultivated species of the genus *Allium*. Both annual and biennial varieties of onion are cultivated for vegetable use. Plant attains to a height of 15-45 cm (6-18 inch) and bear yellowish-green leaves with flattened, fan-shaped swathe. The inflorescence of onion plant is globular umbel type and bear white flowers with parts in sixes. The seeds are glossy black and triangular in cross section.[2] Onions are cultivated and used around the world. Its two crops are grown, in India, and in other sub-tropical countries for vegetable use [Figure 1]. In the autumn, the foliage dies down and the outer layers of the bulb become dry and brittle. Both winter and post summer crops are harvested and dried, and the onions are ready for use or storage. As a foodstuff they are usually cooked, as a vegetable or part of a prepared savory dish, but can also be eaten raw or used to make pickles or chutneys. They are pungent when chopped and contain certain chemical substances which irritate the eyes. Onions contain phenolics and flavonoids that have potential anti-inflammatory, anti-cholesterol, anticancer, and antioxidant properties. *A. cepa* is an important crop plant and its cultivation is done in central and southeast Asia.[3] Other correlated species of onion which are grown include *Allium vavilovii* (Popov and Vved.) and *Allium asarense* (R.M. Fritsch and Matin) from Iran.[4] The genus *Allium* also contains a number of other species variously referred to as onions and cultivated for food, such as the Japanese bunching onion (*Allium fistulosum*), Egyptian

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Figure 1: Green onion (*Allium cepa*) and aged onion bulbs

onion (*Allium proliferum*), and Canada onion (*Allium canadense*).[5] Wild onion is applied to a number of *Allium* species, but *A. cepa* is exclusively known from cultivation and its ancestral wild original form is not known but it is grown in some regions.[6]

NUTRACEUTICAL DIETARY USES

Small chopped onion bulbs of green or dry onions are used as an ingredient in various hearty warm dishes. These are used in salads, soup, or onion chutney. Onions are very versatile and can be baked, boiled, braised, grilled, fried, roasted, sautéed, or eaten raw in salads.[7] Onions are a staple material in Indian cuisine, it is used as a thickening agent for curries and gravies. Onions pickled in vinegar are eaten as a snack. Both sliced fried, green chops, battered and deep fried, and onion rings are used in pubs and fish and chip shops.[8] Onions are used in a number of ways. These are eaten raw or cooked in a variety of foods. Full-flavored onions are of great choice among visitors who use onions in salads everyday [Table 1]. Both yellow and red onions are selected best for soup because of its sweet flavor. Spring onions are most likely used in making vegetable flavor and of a different taste. Pink and red pickler onions are often preserved in vinegar as a long-lasting relish.[8] Pearl and boiler onions may be cooked as a vegetable rather than as an ingredient and pickler onions. When applied to the scalp it is said to promote growth of hair and on the face to reduce freckling. Red onion is also used in grilling and char-broiling. White onions are the traditional onions that are used in classic Mexican cuisine [Table 1]. They give golden color and a sweet flavor when cooked.[9]

Nutritionally, an indigenous variety of *Allium* is best because it contains ecologically favoring phytochemicals and a good percentage of water, sugar, protein, fiber, vitamins, and fats. Most onion cultivars are about 89% water, 4% sugar, 1% protein, 2% fiber, and 0.1% fat [Table 2]. They contain vitamin C, vitamin B_6, folic acid, and numerous other nutrients in small amounts. *Allium* also contains vitamin K-containing food sources,[9] low in fats and in sodium, and with an energy value of 166 kJ (40 kcal) per 100 g (3.5 oz) serving. *Allium* they can contribute their flavor to savory dishes without raising caloric content appreciably.[9] When chopped onion buds flutter certain chemical substances which irritate the eyes and show pungent volatile smell. Onions contain phenolics and flavonoids that have potential anti-inflammatory, anti-cholesterol, anticancer, and antioxidant properties [Table 2]. *Allium* is highly nutritional and its use lower down toxigenicity of oils.[10] It shows chemopreventive effects and its use in vegetables lower down the risk of effect on gastric cancer.[11] *A. cepa* L. shows inhibitory effects on proliferation of cancer cells and adipocytes via inhibiting fatty acid synthase (FAS).[12] Onions check fast dehydration of body in hot summer and protect from excessive heat.[13] It is used white vegetables known as a forgotten source of nutrients.[14] It contains minerals and trace elements of high nutritive value and considered to be a healthy meal.[15] Its use in daily diet restore zinc deficiency.[16] It contains polyphenol content[17] that lower down ultraviolet B (UV-B) radiation impacts on shoot tissue pigment composition in *A. fistulosum* L. cultigens.[18] Onion peel extracts ameliorate hyperglycemia and insulin resistance in high-fat diet/streptozotocin-induced diabetic rats.[19] It is a miracle food.[20]

Onions are traditional Indian spices which have great health significance.[1] It is the miracle food.[20] Use of onion in salads in dietary intakes of onion lower down plasma low-density lipoprotein (LDL) cholesterol concentration because it contains flavonols, flavones, and isoflavones [Table 2].[21] Dietary intake of white vegetables mainly *Alliums* reduces the risk of spontaneous preterm delivery,[22] glycemia, and satiety.[23] Due to the presence of important trace metals, such as zink onions, are considered a healthy food material.[15] In reality, there is no such other miracle food.[20] Onion (*A. cepa* L.) extract shows Inhibitory effects on proliferation of cancer cells and adipocytes via inhibiting FAS.[12] Onion peel extracts ameliorate hyperglycemia and insulin resistance in high-fat diet/streptozotocin-induced diabetic rats.[19] It is antimicrobial in nature and kills enterotoxigenic bacteria.[24] Onions are best source of vitamin B6.[25] Nutritional intake of onions increases learning potential in students.[26] S-alk(en)yl-L-cysteine sulfoxide found in yellow onions (*A. cepa* L.)[25] and dimethyl sulfone as a dietary biomarker for onion intake [Table 2].[25] *Allium* vegetables are strong antioxidants capacity of vegetables[27,28] but it is lost after cooking. Retention of quality and nutritional value of white vegetables can be restored using low-dose radiation.[28] Onions are also used for vinegar production.[29] Water solution of onion crude powder inhibits RANKL-induced osteoclastogenesis through extracellular signal-regulated kinase, p38, and nuclear factor-kappa B (NF-κB) pathways.[30] The presence of flavonoids in onions prevent intestinal neoplasia.[31] High selenium contents and varietal differences are noticed in phenolic content and antioxidant and anti-proliferative activities of onions.[32,33] Onion is also a good nutrition for animals and other veterinarians. It

Table 1: Multiple uses of various plant parts of onion (*A. cepa*) for treatment of different diseases

Medicinal	Preparation/ailment	Treatment
Leaves	Cold water concoction	Diarrhea, gastroenteritis problems
Leaves	Green paste	Reduce serum total cholesterol and triglyceride levels
Bulbs green	Crushed paste	Reduce platelet aggregation, hyperlipidemia
Leaves	Oil	Blood-thinning
Bulb	Sticky juice	Adhesive in mending glass and porcelain
Bulb	Solvent extract (w/v)	Antiparasitic and show repellent effects against flies and mosquitoes
Folk medicine	Crushed bulbs and dry stem	Relieving pain, defense against malaria, flu, cold and sneezing deterring animals such as birds, insects, and worms from eating the plant
Leaves	Hot syrup	Used as expectorant for coughs and constipation
Bulb	Luke warm paste	Antiseptic to prevent gangrene
Onion+mint	Bulb and bark	Fish and meat preservative, and antimicrobial
Spiritual and religious	Total plant	Use for keep away bad air, demons and evils
Europe	Bulbs	Lighten the balance of the blood
Central European	Onion bulbs	Pay their rent with onions, and even give them as gifts
Muslims	Green onion	Good for prayer
Hinduism	Green and raw onion	Rubbed down with onions to firm up their muscles, prescribe onions to facilitate bowel movements and erections, and to relieve headaches, coughs, snakebite and hair loss
Jain	Green and raw onion	Religion avoid eating onions
Buddhist traditions	Green and raw onion	Increase drives to the detriment of meditation practice, to make into syrups, to form poultices and in the preparation of dyes

A. cepa: Allium cepa

Table 2: Nutritional value of onion (*A. cepa*) and its components

Garlic, raw	Nutritional value per 100 g (3.5 oz)	Metabolic functions
Nutrient	Types	Energy provider
Carbohydrates	9.34 g	Play key roles in the immune system, fertilization, preventing pathogenesis, blood clotting and development
Sugars	4.24 g	Sugar good for human health
Dietary fiber	1.7 g	Production of healthful compounds, increase bulk, soften stool, and shorten transit time through the intestinal tract
Fat	0.1 g	Membrane synthsis, tissue
Protein	1.1 g	Build body tissues
Vitamins (%)		
Thiamine B1	0.046 mg (4)	Synthesis of acetylcholine, carbohydrate metabolism
Riboflavin (B2)	0.027 mg (2)	Forms the coenzyme FAD
Niacin (B3)	0.116 mg (1)	Forms the coenzyme NAD
Pantothenic acid (B5)	0.123 mg (2)	Forms conezymes involved in amino acid metabolism
Vitamin B6	0.12 mg (9)	Coenzyme in many chemical reactions
Folate (B9)	19 µg (5)	Induce DNA synthesis
Vitamin C	31.2 mg (38)	Promotes protein synthesis
Trace metals		
Calcium	23 mg (2)	Matrix component of bone tissue, cofactors of coagulation enzyme
Iron	0.21 mg (2)	Constituent of hemoglobin

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Table 2: *(Continued...)*

Garlic, raw	Nutritional value per 100 g (3.5 oz)	Metabolic functions
Magnesium	10 mg (3)	Activates ATPase
Manganese	1.29 mg (6)	Cofactor of kinases and isocitric decarboxylase
Phosphorus	29 mg (4)	Constituent of lipids, proteins, nucleic acids, sugar phosphates
Potassium	46 mg (3)	Membrane transporter
Zinc	0.17 mg (2)	Co-factor of enzyme
Water	89.11	Solubilizer
Flouride	1.1 µg	Bones

Percentage of ingredients varies in different varieties

contains short-chain fructooligosaccharides which display high nutritive values.[34] *Allium* is highly useful in respiratory and allergic diseases.[35] Yellow onions contain good amount of dietary fibers and is a good choice of people [Table 2].[36,37] Dietary intakes of flavonols, flavones, isoflavones, and quercetin reduce plasma LDL cholesterol concentration.[21] Onion contains a good amount of antioxidants.[27,28] It also increases antioxidant plasma status in humans,[38] onion flesh and onion peel enhances antioxidant status in aged rats.[39] Onion contains natural dietary fiber yellow onions that protect from stomach infection [Table 2].[37]

THERAPEUTIC USES

Therapeutically onion has multiple anti-disease potentials against a number of diseases. It was traditionally used by ancient Greece, mainly by athletes; they ate large quantities of onion because it was believed to lighten the balance of the blood.[40] Roman gladiators were rubbed down with onions to firm up their muscles [Table 2].[40] In the middle ages, onions were such an important food that people would pay their rent with onions, and even give them as gifts.[40] Doctors were known to prescribe onions to facilitate bowel movements and erections, and to relieve headaches, coughs, snake bite, and hair loss.[16] The ancient Egyptians worshipped it, believing its spherical shape and concentric rings symbolized eternal life.[16] Onions were even used in Egyptian burials, as evidenced by onion traces being found in the eye sockets of Ramesses IV.[41] The pungent juice of onions has been used as a moth repellent and can be rubbed on the skin to prevent insect bites. These are also used to make into syrups, to form poultices and in the preparation of dyes [Table 2].

Onion is multipurpose food that is used as the traditional Indian spices and has a great health significance.[1] It is widely used in preparation of ayurvedic formulations for wound healing[42] and in treating cardiovascular diseases, hyperglycemia, and stomach cancer. Its topical preparations have been used for prevention of surgical scars. Clinically, on average daily doses of 50 g of fresh onion, 50 g of fresh onion juice, or 20 g of dried onion have been suggested good for health. Onion is prescribed to facilitate bowel movements, erections, relieve headaches, coughs, snakebite, and hair loss.[40] Topical onion extract gels are used in scarring and are generally applied 3 times daily. It is used for prevention of presternal hypertrophic scar protection.[43] Consumption of large amounts of *Allium* vegetables reduces risk for gastric[11] and prostate cancer.[44] *A. cepa* (dry bulbs) showed antimicrobial activity against Gram-positive and Gram-negative bacteria and fungi *in vitro* tests.[45] Onion aqueous extract shows antioxidant and hepatoprotective activity [Table 3].

Onion (*A. cepa* L.) is widely used in the food industry for its nutritional and aromatic properties. The inclusion of fresh green onions in the diet can influence the initiation and the progression of carcinogenesis as it acts on pathways implied in cell proliferation, apoptosis, and metastasis. Onion is main green food item which contains active components, which possess antioxidant, cytotoxic and pro-apoptotic properties. Food-derived flavonoid quercetin, widely distributed in onions is able to inhibit the growth of various cancer cells. It can be considered as a good candidate for anticancer therapy [Table 3]. It behaves as antioxidant and/or prooxidant as well as modulating different intracellular signaling cascades may all play a particular role.[46] Combining onion and grape resulted in a synergistic anti-proliferative effect (APE) against MCF-7 compared with either onion or grape treatment alone. In contrast, combining grape and adzuki bean resulted in an antagonistic interaction. In addition, four antioxidant assays (total phenolic contents, ferric reducing antioxidant power, 2,2-diphenyl-1-picrylhydrazyl, and oxygen radical absorbance).[47] *A. cepa* Linn. is commonly used as a supplementary folk remedy for cancer therapy. Polyphenols extracted from lyophilized *A. cepa* Linn. (PEAL) in human leukemia cells and their mechanisms. PEAL inhibited cancer cell growth by inducing caspase-dependent apoptosis.[48] *Allium* vegetables, especially garlic intake, are related to decreased risk of prostate cancer.[49] Major dietary factors now known to promote cancer development are polished grain foods and low intake of fresh vegetables, with general importance for an unhealthy lifestyle and obesity [Table 3].[50]

Table 3: Biological activity of chemical constituents isolated from onion (*A. cepa*) and its associating species

Onion components	Characteristics/attributes	Biological activity
	Chemo-preventive and anticancer	
Acetal (bulb)		No activities reported
Acetic acid (bulb)	Major contributors to the characteristic odor of onion, chemo-preventive	Biological activities include: acidulant, antibacterial, antiotitic, antisalmonella, antivaginitic, expectorant, fungicide, keratitigenic, mucolytic, osteolytic, perfumery, protisticide, spermicide, ulcerogenic and verrucolytic. *A. cepa* is number 18 on the plant species with the highest amount of this constituent
Allicin (bulb)	A sulfur-containing compound found in *Allium* generates hot sensation	Allergenic, anthelmintic, antiatherosclerotic, antibacterial, antibiotic, anticholinesterase, antidiabetic, antiflu, antiglaucomic, antihypertensive, anti-inflammatory, antioxidant, antiplatelet, anticeptic, anti-triglyceride, antitumor, antiviral, candidicide, fungicide, hypoglycemic, and immunostimulant
Allyl propyl-disulfide (bulb)	A sulfur-containing compound	Biological activities are hypoglycemic, insulin-sparing and occuloirritant. There are two species listed with this constituent. *A. cepa* is second after garlic
Catechol (bulb)	Chemopreventive	Allergenic, antioxidant, cancer-preventive, antiseptic
Proteins, minerals, saponins, flavonoids, enzymes, B vitamins	Non-sulfur compounds	Anticarcinogenic
Cholesterol (bulb)	A non-sulfur, with cyclopentaphenanthrene ring system	Antioxidant
Allicin	OSC	Growth inhibitors of cancer cells, Strong odor a stinking rose, repellent action
Allyl methyl sulfide	After food intake onion strong-smelling sulfur compounds are metabolized, forming allyl methyl sulfide	Abundant sulfur compounds in garlic responsible for turning garlic green or blue during pickling and cooking. Act as mosquito repellent
Cyanidin-diglucoside (bulb)		No activities reported
Diallyl sulfide	A onion derived OSC	Prevents tumor progression and promotes apoptosis in ectopic glioblastoma xenograft, prevent growth of pancreatic cancer cells
Dillyl-disulfide	A onion derived OSC	Anti-HIV, antibacterial, antioxidant, antitumor cancer-preventive, fungicide, hypocholesterolemic, hypoglycemic, immunostimulant among others
Dimethyl-disulfide (bulb)	A onion derived OSC	Antithyroid and perfumery activities
DATS	Cytotoxic to prostate cancer cells	Highly cytotoxic to prostate cancer cells, inhibits cell proliferation by triggering either cell cycle arrest or apoptosis, shows pro-apoptotic activity regulated by a caspase-dependent cascade through the activation of both intrinsic and extrinsic signaling pathways, or mediated through the blocking of PI3K/Akt and the activation of the JNK pathway

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Table 3: *(Continued...)*

Onion components	Characteristics/attributes	Biological activity
	Chemo-preventive and anticancer	
Diallylpolysulfides	OSC	Diallylpolysulfides induce growth arrest and apoptosis in cells
DATTS	OSC	Induce mitotic arrest to apoptosis
Gamma-glutamylcysteines, allylcysteine sulfoxide (alliin)	OSC	Generate hot odor
Allyl sulfides	OSC	Inhibit cell growth of skin cancer cells through induction of DNA damage mediated G2/M arrest and apoptosis
S-allylcysteine	OSC	Anticancer
S-allylmercaptocysteine	OSC	Induce cell cycle arrest and reduce the risk of various types of human cancer
S-alkenylmercaptocysteine	OSC	Induce apoptosis in pancreatic cells
Garlicnins B (1), C (1), and D	Sulfur containing compounds	Highly toxic to cancer cells
S-allylmercaptocysteine	active OSCs	Highly toxic to cancer cells
S-allylcysteine	active OSCs	Suppresses proliferation and induces apoptosis in human ovarian cancer cells *in vitro*. reduced the migration of A2780 cells and decreases the protein expression of Wnt5a, p-AKT and c-Jun proteins which are involved in proliferation and metastasis
Polysulfanes	Sulfur-containing compounds	Possess antimicrobial, chemopreventive and anticancer properties
Glycolic acid (bulb)	Chemopreventive	Cholesterolic, diuretic, hepatonic and irritant
Kaempferol (bulb)	Chemopreventive	Antiaggregant, antiallergic, antibacterial, anticancer, antihistaminic, antigingivitic, anti-inflammatory, antioxidant, antiplaque, antiulcer, antiviral, hepatoprotective and vasodilator
Methyl-propenyl-trisulfide (plant), methyl-propyl-disulfide (bulb), methyl propyl-trisulfide (bulb)	No action	No activities reported
Oleanoic acid (bulb)	Chemopreventive	Anti-HIV, antiallergic, antiatherosclerotioc, antibacterial, antigingivitic, anti-inflammatory, antioxidant, antiviral, antitumor and cardioprotective
Potassium (bulb)	Active ion	Antiarrhythmic, antidepressant, antifatigue, antihypertensive, antispasmodic, diuretic and vasodilator
Pyrocatechol (bulb)	Chemopreventive	Anticancer (breast), antihepatotoxic, antioxidant, antiseptic, CNS-stimulant, cardiovascular, dermatitigenic, dye, insectifuge, nematicide and quinone-reductase-reducer
Pyruvic acid (fruit)	Flavor activity	Dietary functions
Quercitin (bulb)	Chemopreventive	Analgesic, anti-Crohn's, anti-GTF, anti-HIV, anti-PMS, antiaggregant, antiaging, antiallergic, antialzheimeran, antiarthritic, antiasthmatic, antiatherosclerotic, antibacterial, anticataract, anticystitic, antidepressant, antidermatic, antiflu, antigastric, antihistaminic, anti-inflammatory, antimalarial, antioxidant, antipancreatic, antiplaque, antipolio, antispasmodic, antitumor, antiulcer

(Cond..)

Table 3: *(Continued...)*

Onion components	Characteristics/attributes	Biological activity
	Chemo-preventive and anticancer	
Quercetin-3-beta-D-glucoside (bulb)	Chemopreventive	Anti-inflammatory and cancer-preventive
Riboflavin	Chemopreventive	Anticataract and antimigraine
S-methyl-cysteine-sulfoxide (bulb)	Chemopreventive	Antidiabetic and antihypercholesterolemic activities
Succinic acid (bulb)	Chemopreventive	*Allium cepa* is number eight on the plant species list with the highest amount of this constituent
Vanillic acid	Chemopreventive	Anthelmintic, antibacterial, anticancer, antifatigue, anti-inflammatory, antiseptic, antitumor, cancer-preventive and laxative

DATS: Diallyl trisulfide, OSC: Organosulfur compounds, DATTS: Diallyl tetrasulfide, GTF: Glucosyltransferase, CNS: Central nervous system, PMS: Premenstrual syndrome

Quercetin is a member of the flavonoid family shows a variety of anticancer activities. It shows anti-proliferation, cell cycle arrest, and induction of apoptosis of cancer cells. Quercetin has also been shown to undergo oxidation.[51] Diallyl trisulfide (DATS) a natural product isolated from onion and garlic shows alteration in carcinogen-metabolizing enzymes, cell cycle arrest, induction of apoptotic cell death, suppression of oncogenic signal transduction pathways, and inhibition of neoangiogenesis.[52] Quercetin, found in onions is associated with the down-regulation of protein kinase C and RhoA by blocking mitogen-activated protein kinase and phosphatidylinositol 3-kinase (PI3K)/AKT signaling pathways and NF-κB and urokinase plasminogen activator, resulting in inhibition of matrix metalloproteinase-2 (MMP-2) and MMP-9 signaling.[51] It shows inhibition of migration and invasion of SAS cells. Dihydroquercetin (taxifolin) is a potent flavonoid found in onions, It does activation of the antioxidant response element (ARE) and detoxifying Phase II enzymes, and causes inhibition of cytochrome P(450) and FAS in carcinogenesis. It increases tumor necrosis factors-alpha and NF-κB dependent transcription in hepatitis C infections, the scavenging effect of myeloperoxidase-derived reactive nitrogen species and subsequent effects on cholesterol biosynthesis as well as the effects on apob/apoA-I, 3-hydroxy-3-methyl-glutaryl-CoA reductase and apoptosis and contains high therapeutic potential.[53] Ethyl acetate extract of onion (EEO) shows potent inhibitory effects on animal FAS, and could induce apoptosis in FAS over-expressing human breast cancer MDA-MB-231 cells [Table 3].[54]

PHARMACEUTICAL EFFECTS

Anti-diabetic

Onion is used to treat diabetes[12] and its other related complications.[55] It shows anti-obesity effects in Zucker diabetic fatty rats.[56] Regular use of raw red onion consumption dissolutes fat and cut downs overweight or obese women.[57] Onion soup is used for controlling Type 2 diabetes mellitus and other lifestyle diseases.[58] Its extract restores intestinal α-glucosidases activities, control spikes in postprandial blood glucose levels in Sprague-Dawley rat model[59] and cure diabetic neuropathy in mice.[60] It ameliorates hyperglycemia and insulin resistance in high-fat diet/streptozotocin-induced diabetic rats.[19] Red onion *A. cepa* shows hypoglycemic effects of *A. cepa* (red onion) in Types 1 and 2 diabetic patients.[61] It enhances glucose transport,[62] and makes blood glucose level normal, and cut down renal oxidative stress in diabetic rats (*A. cepa*. Linn).[63] Dietary *A. cepa* L. bulbs showed anti-diabetic effects[64,65] in a high-fat diet streptozotocin-induced diabetes rodent model.[66] Onion is a good medicinal herb that is used to cure diabetic patients.[67,68] Onion is a vital food among all anti-diabetic foods that can be used for management of diabetes mellitus.[69,70] *A. cepa* shows hypoglycemic effects[71] in alloxan-induced diabetic rats.[72] Dietary use of onions shows anti-hyperglycemic effect and subsides metabolic abnormalities in streptozotocin induced diabetes mellitus rats.[73-75] Allyl propyl disulfide increase glucose tolerance in alloxan diabetic rabbits[76] while S-methyl cysteine sulfoxide isolated from *A. cepa* Linn. shows anti-diabetic effects.[77] Onion contains an important anti-oxidative, i.e. quercetin that is derived from *A. cepa* on aldehyde oxidase LDL and hepatocytes apoptosis in streptozotocin-induced diabetic rat [Table 3].[78]

Wound Healing and Anti-scar

Onion is widely used in preparation of Ayurvedic formulations for wound healing.[42] It also shows biological efficacy for prevention median sternotomy wound in pediatric patients.[79,80] Its extract shows the therapeutic effect on human skin fibroblast cell line and is used for the treatment of keloids.[81] Onion peel extract shows biological efficacy for prevention of hypertrophic scar and keloid.[82] Onion extract

gel also shows presternal hypertrophic scar protection.[43] It is also used in topical modalities for treatment and prevention of postsurgical hypertrophic scars,[45,83] and surgical management of keloids.[84] Similarly, *A. cepa*-allantoin-pentaglycan gel cure skin hypertrophic scars[85] and is used to improve the cosmetic appearance of postsurgical scars.[86] and burn scars.[87] Onion extract, heparin, allantoin gel is used to remove tattoos.[88] Topical application of onion extract is used as a treatment for postsurgical scars.[89] Post-burn scars and keloids.[90] Onion-based ointments increase the elasticity of post-burn scars.[87] Cepan cream is used for the treatment of burn scars[87] and hypertrophic scarring in the rabbit ear model.[91] Onion extract and quercetin induce MMP-1 *in vitro* and *in vivo* [Table 3].[92]

Anticancer Activity

A. cepa contains organosulfur compounds, which suppress the proliferation of six various tumor cells.[93] *Allium* contains flavonoid quercetin that shows considered as a good anticancer activity. It is able to inhibit the growth of various cancer cells. *Allium* vegetables, especially garlic intake, are related to decreased risk of prostate cancer.[51] Quercetin, a principal flavanoid compound in onions, has been shown to possess a wide spectrum of pharmacological properties, including anticancer activities. Quercetin inhibits migration and invasion of SAS human oral cancer cells through inhibition of NF-κB and MMP-2/-9 signaling pathways.[94] Quercetin is a member of the flavonoid family and has been previously shown to have a variety of anticancer activities.[51,95] Quercetin shows antiproliferation, cell cycle arrest, and induction of apoptosis of cancer cells. It induces the apoptosis of certain malignant cells mainly on human malignant pleural mesothelioma.[96] Quercetin (3,5,7,3',4'-pentahydroxylflavone) induces apoptosis in human cancer cell lines, including human leukemia HL-60 cells.[95] Quercetin stimulates macrophage phagocytosis and promotes natural killer cell activity.[95] Dihydroquercetin (taxifolin) is a potent flavonoid found in onions, dihydroquercetin in major disease states such as cancer, cardiovascular disease and liver disease [Table 3]. It shows activation of the ARE and detoxifying phase II enzymes.[96]

EEO had potent inhibitory effects on animal FAS, and could induce apoptosis in FAS over-expressing human breast cancer MDA-MB-231 cells. Flavonoids, a family of naturally occurring polyphenolic compounds are ubiquitous in plants. Polyphenol based drugs are proved potential therapeutic agents against various diseases and disorders. Fisetin (3,7,3',4'-tetrahydroxyflavone) belongs to the flavonol subgroup of flavonoids together with quercetin, myricetin and kaempferol and is found in several fruits and vegetables including strawberries, apples, persimmons and onions. Fisetin is highly useful natural agent that shows potential inhibitory role against cancer in several *in vitro* and *in vivo* studies [Table 3].[54]

Onion and other *Allium* vegetables showed anticancer effects, because of the presence of DATS. DATS can offer protection against chemically-induced neoplasia as well as oncogene-driven spontaneous cancer development.[52] *A. cepa* shows the presence of quercetin-3'-O-beta-D-glucoside that display potent melanin biosynthesis inhibitory activity in B16 melanoma cells.[97] Onion possesses important natural products which cause alteration in carcinogen-metabolizing enzymes, cell cycle arrest, induction of apoptotic cell death, suppression of oncogenic signal transduction pathways, and inhibition of neoangiogenesis.[52] Its ethanolic extract is used in the management of breast tumors.[98] Apigenin, a flavonoid present in onions, possess anticarcinogenic effects.[99] It inhibits UV-B-induced cyclooxygenase-2 (COX-2) expression, which is a well-known key mediator of inflammation and cancer. It restores the upstream stimulatory factor level in JB6 P+ cells. Among such compounds has been fisetin (3,7,3',4'-tetrahydroxyflavone), a flavonol and a member of the flavonoid polyphenols that also include quercetin, myricetin, and kaempferol.[100] Fisetin in onions works effectively against melanoma and cancers of the prostate, pancreas and the lungs [Table 3].[100]

Consumption of *Allium* vegetables mainly onion consumption reduces the chances of stomach and colorectal cancers. It is good for controlling prostatic hypertrophy[44] and endometrial, breast and lung and gastrointestinal-related cancers.[11] Onion extract shows inhibition of mutagenesis/carcinogenesis,[101] modulation of enzyme and cell signaling pathways,[102] free-radical scavenging,[12,94,103] apoptosis, immunomodulatory;[104,105] and other effects on cell proliferation and tumor growth in *in-vitro* studies.[106] Dietary quercetin inhibits proliferation of lung carcinoma cells.[82] While fruit and vegetable intake stop prevalence of colorectal adenoma.[107] It also shows APE due to the presence of natural tetrasulfides in human breast cancer cells that is mediated through the inhibition of the cell division cycle 25 phosphatases.[96,93] Dietary flavonols contribute to false-positive elevation of homovanillic acid, a marker of catecholamine-secreting tumors.[108] Daily dietary consumption of onion check growth of invasive cervical cancer risk.[102] Quercetin-induced apoptotic cascade in cancer cells.[103] *Allium* vegetables are a good source of flavonoids[109] and its intake lower down endometrial cancer risk[110] and stop colorectal adenoma recurrence in the polyp.[109] Rutin inhibits nitric oxide and tumor necrosis factor-alpha production in lipopolysaccharide and concanavalin-stimulated macrophages.[111] Similarly, 2, 3-dihydro-3,5- dihydroxy-6-methyl-4H-pyranone shows anti-proliferative and proapoptotic effects through inactivation of NF-κB in human colon cancer cells [Table 3].[112]

Anti-genotoxic and Anti-mutagenic Effects

Onion is a miracle food[20] that shows inhibitory effects (*A. cepa* L.) on the proliferation of cancer cells and adipocytes

via inhibiting FAS.[12] *Allium* vegetables show antiproliferative activity against MCF-7 breast cancer cells[47] and lower down the risk of prostate cancer.[49] It is good food for cancer prevention in human beings.[51] *A. cepa* shows anti-genotoxic and anti-mutagenic[113] activity against gut carcinoma.[114] Exposure of *A. cepa* root cells to zidovudine or nevirapine induces cytogenotoxic changes.[114] Onion contains flavonoid quercetin that shows site-specific anticancer effects.[115] Polyphenols isolated from *A. cepa* L. induces apoptosis by suppressing inhibitor of apoptosis protein-1 through inhibiting PI3K/Akt signaling pathways in human leukemic cells.[116] Polyphenols do successful[65] chemoprevention of cancer.[117] Quercetin isolated from onion inhibits migration and invasion of SAS human oral cancer cells through inhibition of NF-κB and MMP-2/-9 signaling pathways.[94] Quercetin inhibits murine leukemia WEHI-3 cells *in vivo* and promoted immune response.[95] Quercetin-mediated inhibitory effects are established on human malignant pleural mesothelioma by interpreting role of transcription factor Sp1.[96] *Allium* reduces impact of ozonation on the genotoxic activity of tertiary treated municipal wastewater.[47] *A. cepa* dietary intake or its decoction is used for managing tumors.[103] and prevention of squamous cell carcinoma in the esophagus.[118] Quercetin glucosides from onions[119] show chemoprevention of prostate cancer [Table 3].[45]

Antimicrobial

Green onion extract mixed in ozonated water inactivates *Salmonella enterica typhimurium*.[120] It also does inactivation of internalized and surface contaminated enteric viruses[121] and stops growth of Gram-positive and Gram-negative bacteria and fungi *in vitro*.[45] Green onions are used for inactivation of internalized *S. typhimurium* with UV-C irradiation and chemical sanitizers.[122] Green onions and pulsed light (PL) and PL-surfactant-sanitizer treatment is done for decontamination of water from *Escherichia coli* O157:H7.[123] A mild heat and UV acidified sodium hypochlorite is used for decontamination of surface and infiltrated *E. coli* O157:H7 on green onions and baby spinach.[124] Onion powder and clove bud oil does concentration-dependent inhibition of *E. coli* O157:H7.[125] *A. cepa* red and white varieties showed chemotypic variations and display strong antimicrobial and antioxidant activities.[126] Fructan from Welsh onion *A. fistulosum* L. shows anti-influenza A virus effects.[118] Onion essential oil shows antimicrobial activity and inhibits *Aspergillus versicolor* growth and sterigmatocystin production.[127] Yellow onion *Allium flavum* contains phenolic and flavonoid compounds[128] which protect from oxidative damage and antioxidant response.[129] Flavonoids from onion showed blood-brain barrier permeation and neuroprotective effects.[130] Antifungal saponins isolated from bulbs of white onion, *A. cepa* L.[131] showed strong antifungal activity. The aqueous garlic, onion and leek extracts release.[132] nitric oxide from S-nitrosoglutathione and prolong relaxation of aortic rings.[133] Allyl isothiocyanate and DATS[134] cause cancer chemoprevention by targeting molecular mechanisms of cancer progression.[52] *A. cepa* fresh onion extract and cold water extract shows antibacterial activity against four isolates include: *E. coli, Staphylococcus aureus*, *Streptococcus pyogenes*, and *Streptococcus pneumonia*.[135] Fresh red and white *A. cepa* (onion) juices showed antibacterial activity against multidrug resistant bacteria *viz*.: *Pseudomonas aeruginosa*, *S. aureus*, *E. coli* and *Salmonella typhi*. All the bacteria except *S. aureus* were susceptible to the fresh red and white onion juices with the diameter of zones of inhibition ranging from 15 to 35 mm. Fermentation enhances the biological activity of *A. cepa* bulb extracts [Table 3].[136,137]

Antiparasitic

Administration of onion oils was found effective against experimental infection of mice with cryptosporidium parvum *Schistosoma mansoni*.[138] *A. cepa* oil is proved highly beneficial in worm infection.[139] The onion is found effective against eelworm (*Ditylenchus dipsaci*), a tiny parasitic soil-living nematode, cause swollen distorted foliage.

Antihyperlipidemic

Onion derived sulfur-compounds, including S-methyl cysteine sulfoxide and allylpropyl disulfide,[140] showed hypolipidemic effects. These are established in rats and rabbits, and lower down effects of diet-induced atherosclerosis, maintain hypolipidemic action, and inhibitory effects on platelet formation.[141] Raw onion contains these compounds in ample amount and antithrombotic effects.[141]

ANTIALLERGY/RESPIRATORY EFFECTS

Compounds derived from *A. cepa* (Family Liliaceae) showed anti-allergic and antihistamine effects *in vitro* and in animal models.[67,142] Anti-allergic profile of ALC-02 shows potential antihistaminic, anti-inflammatory, and antioxidant activities[67] in onion and garlic exposure patients synthesize sulfur compounds specific immunoglobulin E antibodies that indicate sensitization and allergenic potential of these food materials.[143] More specifically, garlic and onion dusts cause occupational rhinoconjunctivitis and bronchial asthma [Table 3].[144]

Anti-inflammatory

Red onion (*A. cepa* Linn.) scale extract shows immunomodulatory effect on experimentally induced atypical prostatic hyperplasia in Wistar rats.[145] Flavonols present in processed onion showed hyaluronidase inhibiting activity and radical scavenging potential.[108] A similar protective effect was seen in rutin against acute gastric mucosal lesions induced by ischemia-reperfusion.[146] Similarly, Welsh onion green leaves showed anti-inflammatory effects of an aqueous

extract of in mice. Onion apigenin reduces UV-B-induced skin inflammation.[99] *Allium ampeloprasum* var. porrum. bulbs contain a new steroidal saponin with anti-inflammatory and anti-ulcerogenic properties.[147] Quercetin-rich onion peel extracts influence adipokine expression in the visceral adipose tissue of rats.[61] Quercetin also lowers down allergy and inflammation.[148] while typheramide and alfrutamide found in *Allium* species effect COXs and lipoxygenases activity.[149] Flavonoid quercetin protects against swimming stress-induced changes in oxidative biomarkers in the hypothalamus of rats[149] while dimethyl sulfone is a dietary biomarker for onion intake.[27] Apigenin is used for cancer prevention.[150,151] Though quercetin shows *in vivo* genotoxicity[152,153] but its lower concentration play important role prevention of allergy and inflammation.[150] The steam distillate from freeze-dried onion sprout shows antioxidant/anti-inflammatory activities of (*A. cepa* L.).[154] Onion peel hydroalcoholic extract shows vasorelaxant and hypotensive effects in rat.[155] Onion does inhibition of chemotaxis of human polymorphonuclear leukocytes by thiosulfinates and cepaenes.[155] Onions showed antiasthmatic[156] and is used for arthritis treatment.[157] Flavonoids tricin, apigenin, and quercetin did differential modulation of COX-mediated prostaglandin production by the putative cancer chemoprevention.[158,159] Peroxidase-active cell-free extract from onion solid wastes showed biocatalytic properties and putative pathway of ferulic acid oxidation.[160] Ajoene, a natural product isolated from *Allium* shows anti-inflammatory properties [Table 3].[161]

Cardioprotective

Bioactive compounds found in onion play important role in the prevention of cardiovascular diseases and cancer.[162] Production of biologically active equine interleukin-12 (IL) through expression of p35, p40 and single chain IL-12 in mammalian and baculovirus expression systems suppress cancer production.[163] Onions contain flavonoids which are used for prevention and treatment of cardiovascular diseases[164] and stop heartburn.[165] Certain onion genotypes containing higher contents of sulfur in the bulb showed greater antiplatelet activity. Thiosulfinates dimethyl- and diphenyl-thiosulfinate slow down thrombocyte biosynthesis. Onion extract and onion soup showed most inhibitory activity toward platelet aggregation.[166-169] Quercetin effects on platelet aggregation[170,171] and decreases blood pressure in hypertensive subjects,[172] and show cardiovascular benefits. Onion (*A. cepa*) leaves showed cardioprotective and antioxidant activity in doxorubicin-induced cardiotoxicity in rats.[173,174] It restores and control ambulatory blood pressure and endothelial function in overweight-to-obese patients affected with (pre-) hypertension [Table 3].[172]

Antipyretic

Fresh *A. cepa* liquid extract of bulbs on paracetamol and carbon tetrachloride induced hepatotoxicity.[175] *Allium* use cut down genotoxicity induced by series of pharmaceutical synthetic compounds.[176,177] It also cut down metamizole sodium and acetylsalicylic acid toxicity, genotoxicity and cytotoxicity [Table 3].[178]

Analgesic

Onions are used as anti-depressant[179] by suppression of lachrymatory factor synthase (LFS).[53,180] Onion powder shows antidepressant-like effect in a rat behavioral model of depression.[181] Fresh juice of onion is capable of inhibiting both acute and chronic pain as well as inflammation, with a more strong effect toward inflammation [Table 3].[182]

Hepatoprotective

The evaluation of cytogenotoxic effects of cold aqueous extract from achyrocline satureioides by *A. cepa* L. test.[183] Onion and garlic extracts showed hepatoprotective potential on cadmium-induced oxidative damage in rats.[184] Onion and garlic extracts significantly attenuated these adverse effects of cadmium. Onion extract proffered a dose-dependent hepatoprotection, prevent and protect cadmium-induced hepatotoxicity. Aqueous extract of *A. cepa* bulb has significant hepatoprotective activity against ethanol-induced hepatotoxicity.[185]

Antioxidant Activity

Onion is used in the traditional Indian spices that has a great health significance.[1] Aqueous extract of *A. cepa* antioxidant activity.[185] *A. cepa* red and white varieties showed antioxidant activities.[126] Quercetin-3'-O-beta-D-glucoside isolated from *A. cepa* antioxidant activities.[34] Onion flesh and onion peel enhance antioxidant status in aged rats.[39] Antidiabetic and antioxidant effects of S-methyl cysteine sulfoxide isolated from onions (*A. cepa* Linn.) as compared to standard drugs in alloxan diabetic rats.[186] Raw onion shows antithrombotic effect in streptozotocin-induced diabetic rat.[19] Dietary flavonols protect diabetic human lymphocytes against oxidative damage to DNA [Table 3].[187]

Insecticidal

Onion and garlic plant essential oils and its components were found effective against the Japanese termite (*Reticulitermes speratus* Kolbe) and *Lycoriella ingenua*.[188,189] These contain important sulfur compounds DATS, diallyl disulfide, eugenol, diallyl sulfide, and beta-caryophyllene among which DATS was found most toxic, but the presence of other compounds in essential oils showed potential fumigant activity and exhibited 100% mortality within 2 days of treatment against termites.[189] Crushed wild onion leaves significantly repel *Diaphorina citri* adults due to the presence of sulfur volatiles from *Allium* spp. These also affect Asian citrus psyllid,

D. citri Kuwayama (Hemiptera: Psyllidae), response to citrus volatiles**.** A blend of dimethyl trisulfide and dimethyl disulfide in 1:1 ratio showed an additive effect on inhibition of *D. citri* response to citrus volatiles.[190] Similarly, dried powder of *A. cepa* played a highly significant role in reducing egg deposition. It acts as a potent ovipositor deterrent to *Phthorimaea operculella.*[191] *Allium porrum* (L.), produce non-protein sulfur amino acids derived from cysteine, i.e., alk(en)yl-cysteine sulfoxides that are precursors of volatile thiosulfinates and disulfides. These defend most species including the specialist leek moth, *Acrolepiopsis assectella.* An increase in the sulfur precursor propyl-cysteine sulfoxide sulfur compounds cause an increase in the release of sulfur volatiles that makes an effective defense against the plant's main natural enemy [Table 3]. Onion essential oil based nanoformulations could be prepared by solvent evaporation from an oil-in-water volatile microemulsion. The efficacy of the formulated nanoformulations could be tested against agriculture, household, and medical pests. The formulated nanoformulations should be tested for toxicity to non-target organisms.

Phytochemistry

Onions contain 89% water, 1.5% protein, 4% sugar, 2% fiber, 0.1% fat, and vitamins B_1, B_2, and C, along with potassium and selenium [Table 2]. Onions also contain important dietary polysaccharides such as fructosans, saccharose, and peptides, flavonoids (mostly quercetin), and essential oil. Quercetin glycosides are heat-stable and show chemopreventive activity. Onion contains numerous sulfur compounds, including thiosulfinates and thiosulfonates; cepaenes; S-oxides; S, S-dioxides; mono-, di-, and tri-sulfides; and sulfoxides, which inhibit cell growth of cancer cells through induction of DNA damage mediated G2/M arrest and apoptosis [Table 3]. *Allium* scales and bulb on mincing or crushing releases cysteine sulfoxide from cellular compartments, after making contact with the enzyme alliinase from the adjacent vacuoles, its hydrolysis results with the release of reactive intermediate sulfenic acid compounds and various sulfur compounds. Similarly, chopping of onion bulbs causes damage to cells which allows enzymes called alliinases to break down amino acid sulfoxides and generate sulfenic acids. A specific sulfenic acid, 1-propenesulfenic acid, is rapidly acted on by a second enzyme, the LFS, giving syn-propanethial-S-oxide, a volatile gas known as the onion lachrymatory factor or LF that generates fast tears in exposed onion person [Figure 2].[192] Onions contain phytochemical compounds such as phenolics and flavonoids that basic research shows to have potential anti-inflammatory, anti-cholesterol, anticancer, and antioxidant properties.[34,193] These include quercetin[190] and its glycosides quercetin 3,4'-diglucoside and quercetin-4'-glucoside.[194,195] There are considerable differences between onion varieties in polyphenol content,[34,193] Yellow onions have the highest total flavonoid content, an amount 11 times higher than in white onions.[34] Red onions have considerable content of anthocyanin pigments with a high percentage of flavonoid content.[193] *A. cepa* red and white varieties showed antioxidant activities.[126] Quercetin-3'-O-beta-D-glucoside isolated from *A. cepa* antioxidant activities.[34] Onions flavonoids showed chemopreventive effect and are used in the treatment of cardiovascular diseases[166] and stop heartburn.[164] Certain onion genotypes containing higher contents of sulfur in the bulb showed greater antiplatelet activity. Thiosulfinates dimethyl- and diphenyl-thiosulfinate slow down thrombocyte biosynthesis. Similarly, S-methyl cysteine sulfoxide [Figure 2] isolated from onions (*A. cepa* Linn.) shows antioxidant effects in alloxan diabetic rats.[186] Dietary flavonols protect diabetic human lymphocytes against oxidative damage to DNA.[187]

CONCLUSION

Onion (*A. cepa* L.) is a well-known traditional medicinal plant that has been consumed for its putative nutritional and health benefits for centuries. This is highly usable vegetable that is used throughout the world. Potentially, it is an important chemo-preventive food item that improves dietary health and lower down cancer risks. Onions contain phenolics and flavonoids thathavepotential anti-inflammatory, anti-cholesterol, anticancer, and antioxidant properties. Nutritionally, indigenous variety of *Allium* is best because it contains ecologically favoring phytochemicals as it contains good percentage of water, sugar, protein, fiber, vitamins, and fats. Dietary use of onion stops heartburn and cardiovascular diseases. *Allium* is highly nutritional and its use lower down toxigenicity of oil. Consumption of large amounts of *Allium* vegetables reduces risk for gastric and prostate cancer. Onion is widely used in preparation of Ayurvedic formulations for wound healing and is used for treating cardiovascular diseases, hyperglycemia, and stomach cancer. It also shows antioxidant and hypoglycemic effects in Types 1 and 2 diabetic patients. *A. cepa* shows anti-genotoxic and anti-mutagenic effects in Swiss mice. Polyphenols found in raw *A. cepa* L. bulbs are chemopreventive for cancer. Onion peel extract shows biological efficacy for prevention of hypertrophic scar and keloid. Plant extract is prescribed to facilitate bowel movements and erections, and to relieve headaches, coughs, snake bites, and hair loss. Onions are also used to make syrups and dyes. The pungent juice of onions has been used as a moth repellent and can be rubbed on the skin to prevent insect bites. *A. cepa* (dry bulbs) showed antimicrobial activity against Gram-positive and Gram-negative bacteria and fungi *in vitro* tests. Hypolipidemic effects of onion sulfur-compounds, including S-methyl cysteine sulfoxide, and allylpropyl disulfide, compounds derived from onion have exerted anti-inflammatory and antihistamine effects *in vitro* and in animal models. *A. cepa* essential oil is a good fumigant to Japanese termite (*R. speratus* Kolbe). Green onions are used in ozonated water to inactivate *S. enterica typhimurium* infection. Onion shows adverse effects in the form of allergic reactions including contact dermatitis, intense itching, rhinoconjunctivitis, blurred vision, bronchial asthma, sweating, and anaphylaxis.

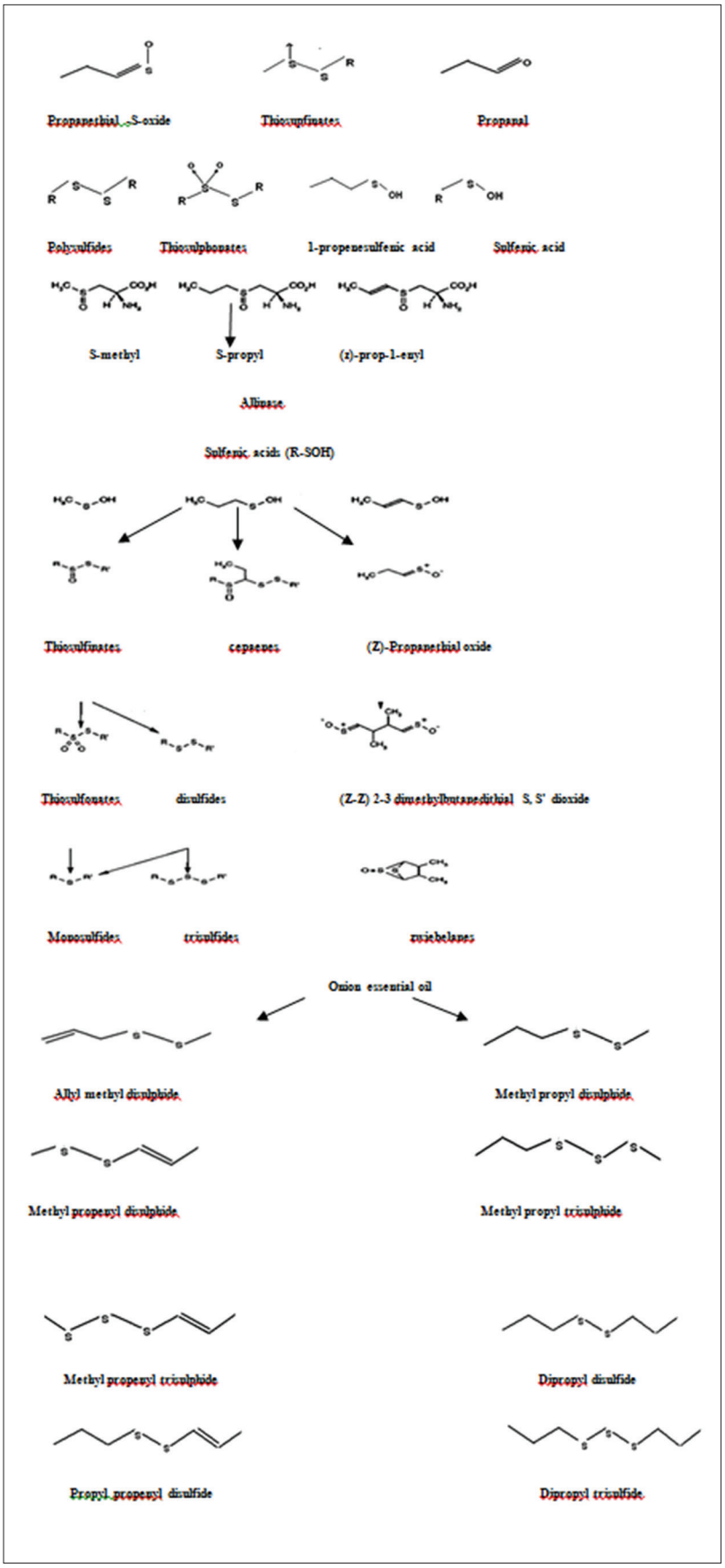

Figure 2: Various chemical compounds isolated from onion (*Allium cepa*)

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