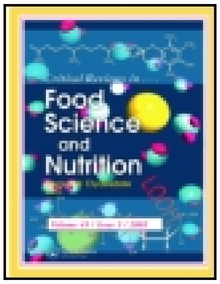

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ONION: NATURE PROTECTION AGAINST PHYSIOLOGICAL THREATS

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ABSTRACT

Onion (Allium cepa L.*) is found in various regions of Europe, North America, Asia, and Africa. It is one of the classic examples of allium species used not only for culinary preparations but also for medicinal purposes. Onion with a variety of purpose, often used as a raw material in many dishes and accepts almost all of the traditions and culture. Owing to its storage characteristics and durability of the shipping, Onions have been traded more widely than most vegetables. The pungent fractions of the garlic are mostly sulfur containing moieties while its two chemical groups have marked effect on human health. These are flavonoids and ALK (EN)-based cysteine sulphoxides (ACSOs). Compounds in onions have been reported with a range of health benefits, including anti-cancer properties, anti-platelet activity, antithrombotic activity, antiasthmatic and antibiotic effects.*

KEYWORDS: *Allium cepa, Physcio-chemical characteristics, nutritional benefits, functional benefits, health promoting potentials*

BACKGROUND

Medicinal spices are used to enhance flavor and aroma in many parts of the world. The economy from spices, accounting for about $ 2 billion tons (Srinivasan, 2005). Possible medical benefits of spices include the risk of atherosclerosis, cardiovascular disease, cancer and diabetes

(Ali et al., 2000; Ashraf et al., 2005; Banerjee et al., 2003; Cazzola et al., 2011; Lai and Roy, 2004). Herbs are nature's gift to mankind and an herbal revitalization is blooming across the world. Medicinal herbs contain substances that are well known to modern and ancient civilizations for their healing properties. They have been important to mankind, both socially and economically, for thousands of years (Butt et al. 2009).

Over the centuries, species in the genus *Allium* have attained reputations and special attention in the tradition of many cultures as formidable prophylactic and therapeutic medicinal agents (Kendler, 1987). It is cited in the Egyptian Codex Ebers, a 35 century old document, useful in the treatment of heart disorders, tumors, worms, bites, and other ailments (Fenwick and Hanley, 1985). Hippocrates and Pliny the Elder were promoters of *Allium's* medicinal virtues, Charak, the father of Ayurvedic medicine, claimed that garlic and onion maintains the fluidity of blood and strengthens the heart (Chutani and Bordia, 1981).

World onion production is increased by at least 25%, than in the past 10 years, the current output of about 44 million tons, making it the second most important horticultural crop after tomatoes (FAO Statistics, 2011). Onion has also been utilized as a medicinal agent according to sources dating from ancient times. Mixed with honey, it was used to treat such disparate conditions as visual disorders and dog bites (Fenwick and Hanley, 1985). According to Corzo-Martinez et al. (2007) garlic and onion intake offer protection against cancer development, and its utilization as therapeutic agents seems to be very safe. Onions contain a flavonoid called quercetin, which delays oxidative damage in cells and other bodily tissues (National Onion Association, 2011). Quercetin is the most abundant flavonoid in the human diet, and is mainly found in onions (Duthie and Dobson, 1998). Studies done at Wageningen Agricultural

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University, the Netherlands, showed twice absorption of quercetin from onion relative to tea, and thrice as compare to apple (National Onion Association, 2011).

In this global village, health claims regarding the potential benefits of onion or its various preparations has been approved and are now available in the market as dietary supplement, herbal products and getting a wide range of popularity now a days in many cultures for their hypolipidemic and procirculatory effects. Onion and its various preparations are imperative functional foods with diverse health benefits. Evidence also ensures its possible applications in cancer therapy, reactive oxygen species (ROS) associated diseases and certainly in immunonutrition (Butt et al., 2009; Butt et al., 2007). This review is also an effort to clarify the importance of onion and its constituents as nature's gift to fight against various physiological threats.

CLASSIFICATION AND CHEMISTRY

There are about 660 species in the genus *Allium* that are mostly found in Asia but with some species in Africa, Central and South America. Onions are believed to have originated from Afghanistan/Iran/USSR region and are now grown in over 175 countries worldwide. Onions (*Allium cepa*) belong to the family Liliaceae (Butt et al., 2009), although they are listed by some authors in different families like Alliaceae. Onions are perennial crop, which may be red, white or yellow in color, and consumed in its tender state, raw, ripe, and pickled or in form of powder (FAO, 2011). The plants bear small flowers that are usually white or purple. Onions are highly valued for their flavor and nutritional value and preserved in the form of pickles. Its leaves are also used in salads and soups.

Insert Figure 1 here

Chemical composition of Allium cepa

Onion has an approximately 90% water with high content of dietary fibre and sugars. In terms of vitamins and minerals content onion has low sodium content and a high content of vitamin B_6, folic acid, calcium, magnesium, phosphorus and potassium. By difference, onion has low content of lipids and among the amino acid content only arginine and glutamic acid are extraordinary.

Insert Table 1 and 2 here

Flavonoids, Quercetin and quercetin glucosides

Onion is the richest source of dietary flavonoids and contributes to a large extent to the overall intake of flavonoids. Two flavonoid subgroups are found in onion, the anthocyanins, which impart a red to purple color to some varieties and the flavonols such as quercetin and its derivatives responsible for the yellow and brown skins of different varieties (Griffiths et al., 2002). Flavonols are the predominant pigments of onions. Only compounds belonging to the flavonols, the anthocyanins, and the dihydroflavonols have been reported to occur in onion bulbs. At least 25 different flavonols have been characterized, and quercetin derivatives are the most important ones in all onion cultivars. Their glycosyl moieties are almost exclusively glucose, which is mainly attached to the 4', 3, and/or 7-positions of the aglycones. Analogous derivatives of kaempferol and isorhamnetin have been identified as minor onion pigments (Slimestad et al., 2007).

Quercetin 3, 4'-diglucoside (QDG) and quercetin 4'-glucoside (QMG) are in most cases reported as the main onion flavonols in literature (Caridi et al., 2007). These glucosides of quercetin represent about the 90% of the overall contents in different *Allium* species (Bonaccorsi

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et al., 2008). Significant differences in the levels and ratios of the two compounds were identified among red (‘Redwing’ QDG 191 mg/100 g dry weight-dw and QMG 85 mg/100 g dw), brown (‘Cream Gold’ QDG 153 mg/100 g dw, QMG 58 mg/100 g dw), and white onion varieties (‘Spanish white’ QDG < 1 mg/100 g dw, QMG < 1 mg/100 g dw) (Caridi et al., 2007). Likewise, early studies showed the presence of predominantly cyanidin 3-glucoside, with lesser amounts of cyanidin 3-laminaribioside and other minor unidentified cyanidin, peonidin and pelargonidin glycosides. (Terahara et al., 1994) determined the anthocyanins in the Japanese cultivar Kurenai having cyanidin 3-glucoside, cyaniding 3-laminaribioside and their 6”-malonyl derivatives. Fossen et al. (1996) reported four major and six minor anthocyanins content in different cultivars like Red Baron, Tropea and Comred (grown in Norway) including the 3-malonylglucoside, 3 dimalonylglucoside and 3,5-diglucoside derivatives of cyanidin, peonidin 3,5-diglucosides and two 3-glycosylated derivatives of pelargonidin. In red onion, grown in Canada and the USA (Mambo, Red Jumbo, Red Bone and Red Granex), the main anthocyanins were cyanidin 3-glucoside, cyaniding 3-laminaribioside, cyanidin 3-(6”-malonylglucoside) and cyanidin 3-(6”- malonyllaminaribioside) (Donner et al., 1997). Minor anthocyanins were shown to be cyanidin 3 (3”-malonylglucoside), peonidin 3-glucoside, peonidin 3-malonylglucoside and cyaniding 3-dimalonyllaminaribioside. These differences in anthocyanin composition are probably due to genetic variations.

Insert Figure 2 here

Organosulfur compounds (OSCs)

Allium plants contain high concentrations of alk(en)yl cysteine sulfoxides (ACSOs) (Lee et al., 2011). Among them, onions, shallots, and leeks contain the methyl, propyl, and prop-1-

enyl cysteine sulfoxides. When the onion tissue is disrupted by cutting, crushing or chewing, the ACSOs are enzymatically degraded by the enzyme allinase to iminopropionic acid and alk(en)yl cysteine sulfenic acids. The iminopropionic acid spontaneously hydrolyses to form ammonia and pyruvic acid. The sulfenic acids decompose spontaneously afterwards, methyl and propyl sulfenic acids yield mainly thiosulfinates, while prop-1-enyl sulfenic acid forms both, the corresponding thiosulfinate and thiopropanal S-oxide, the onion lachrymatory factor (Block et al., 1993).

Onion pungency is caused by a wide range of sulfur compounds that causes burning sensation in the back of the mouth and throat. A convenient method to measure onion pungency is to analyze pyruvic acid, which is formed in stoichiometric amount to the thiosulfinates. Pyruvic acid has been shown to correlate well with flavour perception. The balance between level of pungency and level of sugars determines the perception of sweetness in an onion. High pungency can mask a high level of sugars so that the onion is not perceived as sweet. Also, onions with low pungency and low sugar content can be perceived as bland. Ideally, a sweet onion would have a high level of sugars and low pungency (Vagen and Slimestad, 2008).

Thiosulfinates are unstable, particularly on heating, and break down to a complex mixture of compounds, in which mono-, di-, tri- and tetra-sulfides predominate (Munday and Munday, 2004; Rose et al., 2005). Dipropyl disulfide, dipropyl trisulfide, and propenil disulfides are the major constituents of onion volatiles, although many others compounds have been identified, including dipropyl sulfide and dipropenyl sulfide (Munday and Munday, 2001).

Insert Figure 3 here

Recently Yamazaki et al. (2011) determined 11 sulfur containing flavor precursors in onion including S-alk(en)yl-L-cysteine derivatives, methiin, alliin, isoalliin, cycloalliin, deoxyalliin, N-(gamma-glutamyl)-S-methyl-L-cysteine, N-(gamma-glutamyl)-S-(2-propenyl)-L-cysteine, N-(gamma-glatamyl)-S-(E-1-propenyl)-L-cysteine(Glu-PEC), N-(gamma-glutamyl)-S-(2-propenyl)-L-cysteine sulfoxide, N-(gamma-glutamyl)-S-(E-1-propenyl)-L-cysteine sulfoxide (Glu-PECSO) and S-(2-carboxypropyl) glutathione.

Fructans and fructooligosaccharides (FOS)

Bulb dry matter content is an important quality parameter of onion, also significant in the onion dehydration industry as it directly relates to the energy needed for drying. About 65 to 80% of bulb dry matter consists of non-structural carbohydrates (Benkeblia, 2005; Kahane et al., 2001). Onion's predominant non-structural carbohydrates are glucose, fructose, sucrose and low-molecular-weight fructans, while starch and raffinose are absent. Fructans, also known as fructooligosaccharides (FOS), are polyfructosyl sucroses of varying molecular size that constitute the main carbohydrate reserve of onion. Fructans accumulate during bulbing followed by catabolism during growth and sprout development of the bulbs (Benkeblia, 2005).

It is generally accepted that FOS is a common name only for fructose oligomers that are mainly composed of kestose (GF2), nystose (GF3) and fructofuranosylnystose (GF4), in which fructosyl units (F) are bound by ß-linkage at the position of sucrose (glucose+fructose-GF) respectively. There is a clear predominance of kestose (GF2) in every onion tissue and no occurrence of highly polymerized fructans. The tissues richest in fructans are the fleshy layers,

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so that the outer two fleshy layers turn out to be the best onion by-product as a possible fructan source (Jaime et al., 2001a; Jaime et al., 2002).

The fructan degree of polymerization (DP) level in onion is mostly in between 3 and 15. Short chain fructans, with a degree of polymerization less than 5, are potentially used as natural low-calorie sweeteners. Onion bulbs with fructans of a high DP may be used for lipid replacement with consequential health benefits (Kahane et al., 2001). Onion showed a better soluble/insoluble dietary fibre (SDF:IDF) ratio than other vegetables that are connected with different metabolic and physiological effect. SDF increases the viscosity of the stomach contents, thereby allowing down-mixing and absorption of nutrients, whereas IDF reduces intestinal transit time and increases the bulk of the food mass (Jaime et al., 2002). Fructans could act as osmoregulators due to their solubility in water inside the vacuole. Fructans act stimulating the growth of specific microorganisms in the colon (*Bifidobacteria* and *Lactobacilli*) with a general positive health effect, including on colonic inflammation (Ernst and Feldheim, 2000; Roberfroid, 2007). Administration of FOS significantly lowered fasting glycemia and total cholesterol, increasing the intestinal absorption and bone density of calcium and magnesium.

Other onion bioactive compounds

Recent literature reported that several interesting novel compounds have been isolated from onion. Among them, saponins and peptides have been isolated and studied for their potentially beneficial health perspectives. A number of different saponins have been identified in *Allium species*, with processing give rise to different saponins again (Corea et al., 2005; Lanzotti, 2006). 5-hydroxy-3-methyl-4-propylsulfanyl-5H-furan-2-one, and four others compounds, were isolated and confirmed to be quinone reductase and glutathione *S*-transferase inducers *in vitro*

(Xiao and Parkin, 2007), therefore they could act as chemopreventive agents. Several research reported antifungal, antitumor, cytotoxicity, blood coagulability, antispasmodic and cholesterol-lowering effects of saponins isolated from onion and garlic (Lanzotti, 2006).

Four furostanol saponins, two of which were new compounds, named ceparoside A and ceparoside B were isolated from the seeds of *Allium cepa* L. (Yuan et al., 2008). Other new saponins were found by Corea et al. (2005) they were reported to possess antispasmodic activity in the guinea pig isolated ileum such an effect might contribute to explaining the traditional use of onion in the treatment of disturbances of the gastrointestinal tract. Recently, it was also reported that gamma-glutamyl peptide from onion (Wetli et al., 2004) inhibits the development and activity of osteoclasts *in vitro* (Langos et al., 2007).

HEALTH BENEFITS OF ONIONS

Allium vegetables health properties have been supported by numerous *in vitro*, *in vivo*, and *ex-vivo* studies. Particularly, onion has been described to have several health benefits related to its antioxidant, anticarcinogenic, hypolipidemic, hypoglycaemic, and antiaggreagatory effects. From medical and nutritionally point of view, it has to be considered that the onion used as a food or a food ingredient in many dishes also exerts a wide an array of medicinal effects that are very interesting for its human health potentials. It has been described that a diet rich in *Allium* vegetables, including onion, would lead to several health benefits that could be helpful in the prevention of two of the more relevant and prevalent diseases nowadays such as CVD and cancer insurgences.

Onion and cancer

Research has indicated that onions may have a role in the prevention of a wide range of different cancers, including colorectal, stomach, liver, renal, lung, bladder, breast, ovarian, brain and oesophagus cancer. A large and recent European study, published in 2006 in the American Journal of Clinical Nutrition, found that moderate frequency of onion consumption protected against colorectal, laryngeal and oesophageal cancers. More frequent consumption was even strongly protective and was also significant for oral cavity and oesophageal but not for prostate, breast or renal cell cancers (Galeone et al., 2006). Hsing et al. (2002) also showed the anti-tumour effects of onions, with men consuming 10 g of onions per day being 70% less likely to develop prostate cancer than those consuming less than 2 g of onions per day. The organosulfur compounds in onions proved to be strong anticarcinogens in cell experiments, animals and human trials (Chu et al., 2002; Fukushima et al., 1997; Hatono et al., 1996; Munday and Munday, 2001). This is thought to be partially because of their role in the activation of detoxifying enzymes, which remove potentially cancer-causing substances.

In last years, scientists have focused their research activities on the prevention of cancer by nutrition with a diet containing high proportion of vegetables and fruits. Reviews concerning the effects of the *Allium species* were published by (Block, 1996; Corzo-Martinez et al., 2007; Kendler, 1987; Krishnaswamy and Polasa, 1995; Steinmetz and Potter, 1996; Wargovich and Uda, 1996). Onions are rich in organoselenium compounds, which may help to prevent cancer. Selenium is usually fixed to sulphur-containing amino acid derivatives. Quercetin and its derivatives, which are also typical constituents of onions are of great interest, because of their anticarcinogenic properties (Formica and Regelson, 1995).

The association between consumption of *Allium* vegetables and risk for cancer has been assessed in several epidemiologic studies, mainly case-control (Bianchini and Vainio, 2001; Galeone et al., 2006). In general, these studies are more consistent in reporting a protective effect of onion in gastric cancer (Zhou et al., 2011). However, onion consumption has been also consistently related with a decreased colorectal cancer risk. In addition, onion consumption was reported to decrease the risk for the cancer of the lung (Sankaranarayanan et al., 1994) and of the brain (Hu et al., 1999) in case-control studies. Onion consumption was significantly inversely correlated with the risk of the stomach cancer. Recently, (Gonzalez et al., 2006; Gonzalez et al., 2011) observed in the European Prospective Investigation into Cancer and Nutrition (EPIC-EURGAST) a probable protective effect of total vegetables and *Allium* vegetables intake on the intestinal type of gastric cancer and cervical cancer. Most of the case-control studies concerning onion were conducted in China (Gao et al., 1999; You et al., 1989) and several of them in Asia and Europe (Boeing et al., 1991; Gonzalez et al., 1991; Hansson et al., 1993; Tuyns et al., 1992). A cohort study was conducted in The Netherlands (Dorant et al., 1996). The antimutagenic effect of ethanolic extracts of onion and garlic against the mutagenicity of *N*-nitrosamines was evaluated by the Ames test (Ikken et al., 1999). Onion showed a greater effect than garlic. Onion consumption reduced the risk of carcinoma in the non-cardial part of the stomach (Challier et al., 1998). Onions also provide protection against aorta and liver cancer recently identified by (Gorinstein et al., 2011). Similarly, it also provide protection against breast cancer (Viry et al., 2011).

Diets rich in fruit and deep-yellow vegetables, dark-green vegetables, onions and garlic are modestly associated with reduced risk of colorectal adenoma, a precursor of colorectal cancer

(Millen et al., 2007). Decreased risk for colorectal cancer with the consumption of onion was generally found in case-control studies. The effect was particularly significant for consumption of cooked onions and leeks in Belgium (Tuyns et al., 1988), for a combination of garlic, onions, and pepper in Argentina (Iscovich et al., 1992). In a case-control study in Australia (Steinmetz and Potter, 1993) it was reported a lower risk for both sexes, with a more pronounced decrease for women and also for cancer of the proximal compared with the distal colon. However, a cohort study in The Netherlands showed no significant effect of consumption of onions, leeks, and garlic supplements (Dorant et al., 1996).

Insert Table 4 here

In addition to organo-sulphur compounds, eruboside-B, a steroid saponin isolated from garlic bulb, and organo- Se compounds are largely responsible for the anticarcinogenic activity. Se-enriched garlic and onion have higher anticarcinogenic activity than the common plants (El-Bayoumy et al., 1996; Matsuura, 1997). This increased effect of cancer prevention is achieved at least partly by S substitution with Se. The pure Se-compounds have proved to be superior anticancer agents than their corresponding S-analogues. For example, diallyl selenide is at least 300 times more active than DAS in the reduction of tumors of mammal cancer (El-Bayoumy et al., 2006). The two major Se-compounds possessing anticancer activity in onion are g-glutamyl-Se-methyl selenocysteine and Se-methyl selenocysteine, being Se-methyl selenocysteine and Se-allyl selenocysteine the most chemopreventive Se-compounds (Block et al., 2001). Quercetin and kaempferol, from onion, possess anticarcinogenic properties. Particularly, they have antineoplastic effects by inhibiting bioactivating enzymes (Lautraite et al., 2002), by inducing detoxifying enzymes and apoptosis (Brisdelli et al., 2007), due to their antioxidant and anti-inflammatory activities (Raso et al., 2001).

Several epidemiological studies have found inverse associations between lung cancer risk and onion intake, probably due to its high content of flavonoids (Le Marchand et al., 2000). Quercetin enhances bioavailability of some anticancer drugs, as Tamoxifen, a non-steroidal antiestrogen for treating and preventing breast cancer, by promoting their intestinal absorption and reducing their metabolism (Shin et al., 2006; Wu et al., 2005). Large-scale gene expression analysis in combination with functional assays yields a considerable amount of information on anticarcinogenic potential of all these active components. Thus, for example, data from cDNA array studies revealed that the antiproliferative effects of DADS may be related to changes in gene expression of aggrecan 1, tenascin R, vitronectin and cadherin 5 (Knowles and Milner, 2003). A recent study (Van Erk et al., 2005) showed the broad range effects at gene expression level, elucidated that quercetin exerted effect on colon cancer cells *in vitro*. Likewise, it has been recently elucidated the response of garlic and its components depends on the consumer's genetic backgrounds (nutrigenetic effects), DNA methylation and histone regulation (nutritional epigenomic effects), ability to induce or repress gene expression patterns (nutritional transcriptomics effects), occurrence and activity of specific proteins (nutriproteomic effects), and/or dose and temporal changes in cellular small-molecularweight compounds (metabolomics effects).

Onion and cardiovascular disease (CVD) prevention

CVD include coronary heart disease (heart attacks), cerebrovascular disease, raised blood pressure (hypertension), peripheral artery disease, rheumatic heart disease, congenital heart disease and heart failure. If current trends are allowed to continue, by 2015 an estimated 20 million people will die from CVD (mainly from heart attacks and strokes). Therefore, CVD have a major impact on the mortality and quality of life on human populations across the world, despite improvements in lifestyle and innovations in the prevention and treatment of CVD in previous decades (Wensing et al., 2009). CVD risk factors are mainly determined by uncontrollable causes (heredity, gender and age) and lifestyle-related causes (smoking, physical inactivity, stress and unhealthy diet), which are possible to be modified.

The study by Galeone et al. (2009), the first from Mediterranean countries, suggested that a diet rich in onions may have a favorable effect on the risk of acute myocardial infarction; therefore these vegetables could be useful in a CVD preventive diet. Several biomarkers are measured to predict CVD events including blood lipids levels (LDL-cholesterol and triglycerides), fibrinogen (a marker of thrombosis and inflammation), D-dimer (a marker of thrombosis), plasminogen-activator inhibitor type 1 (a marker of fibrinolytic potential and endothelial function), high-sensitivity creactive protein (CRP) (inflammation marker), homocysteine (a marker of endothelial function and oxidant stress), B-type and N-terminal pro–atrial natriuretic peptides, serum aldosterone, plasma renin (markers of neurohormonal activity), and urinary albumin-to-creatinine ratio (a marker of glomerular endothelial function) (Kannel, 2005; Wang et al., 2006). Alterations in lipid profiles, diabetes, hypertension, and obesity are risk factors conventionally associated to the early appearance of CVD. Onion has been described to have hypolipidemic, hypoglycaemic, and antithrombotic effects and therefore could be useful in the CVD prevention. Focusing on onion lipid lowering effects, this vegetable has been reported to exert moderately hypolipidemic effects in experimental animal such as healthy pigs fed a high fat diet and consequently reduction of CVD and obesity (Gabler et al., 2006; Ostrowska et al., 2004).

Among bioactive compounds involved in onion hypolipidemic effects, quercetin has shown to have the ability to reduce serum cholesterol levels and arteriosclerosis severity (Glasser et al., 2002). A recent study by Kumari and Augusti (2007) also proclaimed for the lipid lowering action of the S-methyl cysteine sulfoxide (SMCS) isolated from *Allium cepa* L. Onion has also been reported to have hypoglycaemic effects (Srinivasan, 2005). It was inferred that beneficial ameliorating influence of dietary onion on diabetic nephropathy may be mediated through onion's ability to lower blood cholesterol levels and to reduce lipid peroxidation, dietary onion caused significant beneficial modulation of the progression of renal lesions in diabetic rats (Babu and Srinivasan, 1999). Other rat studies have assessed onion hypoglycaemic effects (El-Demerdash et al., 2005).

Recently, Lee et al. (2008) showed that onion skin was effective in controlling hyperglycemia in animal models of type 2 diabetes mellitus, at least in part by inhibiting alpha-glucosidase activity. Thrombosis complications play a major role in CVD. Blood clot formation depends on an intricate series of events involving platelets, other cells, and the activation of specific blood proteins, known as coagulation factors. A thrombus is a blood clot formed when there is an imbalance in the blood coagulation system that can block the flow of blood through a vein or artery, and can detach from the vessel wall to become a life-threatening embolus when it lodges in the lungs or other vital organs. Blood clots in coronary arteries cause acute coronary syndrome and blood clots that form in the heart are the major cause of stroke in people with atrial fibrillation. Onion inhibits platelet aggregation *in vitro* and *in vivo* (Ali et al., 1999; Ali et al., 2000; Briggs et al., 2001; Hubbard et al., 2006; Jung et al., 2002). The mechanism by which onion exerts its antithrombotic effect has been shown to involve the inhibition of thromboxane A2 formation, potent inducer of platelet aggregation (Moon et al., 2000).

The antiplatelet activity observed in onion is influenced by genotype, environmental factors and genotypically determined sulfur content of the bulb (Goldman et al., 1996; Sance et al., 2008) having onion α-sulfinil-disulfides (cepaenes) a demonstrated antithrombotic activity (Block et al., 1997). Another recent study by Sakakibara et al. (2008) suggested that onion exerted antidepressant-like activity in a behavioural model that acted independently of the hypothalamic-pituitary-adrenal axis. Similarly, Brankovic et al. (2011) studied the acute effect of ethanol extracts ginkgo (*Ginkgo biloba L.*), garlic (*Allium sativum L.*), and onion on arterial blood pressure (BP), and heart rate (HR) in anesthetized normotensive rats. They concluded that the most effective in reducing arterial BP and HR is extract of garlic and onion.

Antiplatelet or antithrombotic effect

The main focus of recent research is on antiplatelet activity of onion extracts. Reducing platelet aggregation has a preventive effect on some cardiovascular disorders, such as atherosclerosis. In addition, onion extracts have some lipid-lowering effects. The antithrombotic potential of aqueous extracts from onion and garlic was evaluated firstly by Bordia et al. (1996). Extracts were administered orally and intraperitoneally to rats. A relatively low dose of the aqueous garlic extract (50 mg kg^{-1} body weight) decreased thromboxane-B2 levels significantly, regardless of the mode of administration. Onion extracts were effective at higher concentrations (500 mg kg^{-1} body weight). Boiling the extracts before application resulted in an almost complete loss of activity. Cooking may therefore cause the decomposition of the potent antithrombotic components in alliums.

The effects of aqueous extracts of raw and boiled onion and garlic on collagen induced platelet aggregation were studied *in vitro* (Ali et al., 1999; Ali et al., 2000). The concentrations of onion and garlic required for a 50% inhibition of the platelet aggregation were calculated to be 90 and 7 mg/ml plasma (rabbit), respectively. Boiled extracts showed a reduced inhibitory effect. Goldman et al. (1996) investigated the antiplatelet activity of extracts of four bulbonion cultivars (mild cvs 'Exhibition' and 'MSU8155B' and pungent cvs 'W434B' and 'W420B'), grown at two different locations in the USA. The highest antiplatelet activity was observed in the two pungent cultivars, i.e. onion bulbs with high sulphur content exhibited a significantly greater antiplatelet activity than those containing low levels of sulphur. Significantly greater activity was determined for three out of four cultivars grown in Oregon compared with those from Wisconsin. During postharvest cold storage at 4°C, antiplatelet activity was increased by about 60% across all cultivars, reaching a maximum at 90 days of storage. However, changes in pungency were not correlated with changes in antiplatelet activity (Debaene et al., 1999). Juice prepared from a flowering umbel of the onion genotype 'W420B' had antiplatelet activity 336% higher than that of juice obtained from onion bulbs (Goldman et al., 1996).

The active principle of onion and related species in terms of inhibition of platelet aggregation is not yet identified but previous studies showed that antithrombotic action of onion aqueous extracts was because of inhibition of thromboxane formation, potent inducers of platelet aggregation (Moon et al., 2000). However, some studies have been carried out with isolated compounds (Makheja and Bailey, 1990). Allicin, which occurs more abundantly in garlic than in onion, and adenosine, both inhibited platelet aggregation without affecting cyclo-oxygenase and lipoxygenase metabolites of arachidonic acid. The trisulphides investigated inhibited platelet aggregation, as well as thromboxane synthesis, along with the induction of lipoxygenase metabolites. The observed *in vivo* antiplatelet effects appear to be more attributable to adenosine than to allicin and alk(en)yl polysulphides of onion. Several epidemiologic studies have reported that antiplatelet activity of onion is considered to be a property of organo-sulphur compounds. In particular, a class of a-sulphinyl-disulphides (cepaenes) found in onion extracts has demonstrated antithrombotic activity (Block et al., 1997). These compounds have structural similarity to ajoene, considered the major antiplatelet compound in garlic extracts. In addition, other non-sulphur compounds, such as b-chlorogenin and quercetin, have also been shown to inhibit platelet aggregation (Rahman and Lowe, 2006).

Antiplatelet activity is substantially affected by genotype, environment and storage duration of vegetable. It has been reported that onions and garlic’s antiplatelet activity was determined by the native concentration of organo-sulphur compounds and genotypically (Goldman et al., 1996), being garlic 13 folds more potent than onion (Effendy et al., 1997).

Bone strengthening Properties

Onion consumption has also been reported to be involved in the bone metabolism and in the behaviour as a possible antidepressant agent. A recent study by Matheson et al. (2009) reported that onion consumption seems to have a beneficial effect on bone density in perimenopausal and postmenopausal women. Furthermore, older women who consume onions most frequently may decrease their risk of hip fracture by more than 20% *versus* those who never consume onions. Prevention of low bone mass is important to reduce the incidence of osteoporotic fractures. Onion retains its bone resorption inhibitory activity in the rat when added to a vegetarian diet (Muhlbauer et al., 2002).

Antimicrobial and Antifungal Properties

Onions have been shown to possess antibacterial and antifungal properties (Kyung, 2011; Mohamed, 2010; Santas et al., 2010). Volatile oil of onion has been shown to be highly effective against Gram positive bacteria, dermatophytic fungi, growth and aflatoxin production of *Aspergillu*s fungi genera including *Aspergillus niger, Brettanomyces anomalus, Candida albicans, C. lipolytica, Cladosporium werneckii, Fusarium oxysporium, Geotribum candidum and Saccharomyces cerevisiae.* Onion oils and aqueous extracts were almost ineffective against Gram-negative bacteria (Griffiths et al., 2002). Onion extracts inhibit oral bacteria causing dental caries (Kim, 1997). In contrast, comparable garlic preparations were active against Gram-negative bacteria (Dankert et al., 1979; Elnima et al., 1983; Yoshida et al., 1999a; Yoshida et al., 1999b). Aqueous extract or the juice of onion has been reported to inhibit *in vitro* growth of *Escherichia coli, Serratia marcescens*, *Steptococcus species*, *Acetobacillus odontolyticus*, *Pseudomonas aeruginosa and Salmonella Typhosa, Streptococcus mutans*, *Streptococcus sobrinus*, *Porphyromonas gingivalis* and *Prevotella intermedia* (Bakri and Douglas, 2005). A petroleum ether extract of onion inhibited the *in vitro* growth of *Clotridium paraputrificum* and *Staphylococcus aureus.*

Similarly, Onion extracts are effective against many yeast species and their essential oil inhibits the dermatophytic fungi (Kunicka-Styczynska, 2011; Zohri et al., 1995). The active compounds of onion destroy fungal cells decreasing the oxygen uptake, reducing cellular growth, inhibiting the synthesis of lipids, proteins and nucleic acids, changing the lipid profile of the cell membrane and inhibiting the synthesis of the fungal cell wall (Gupta and Porter, 2001).

The main active antifungal agents from onion extracts are the breakdown products of allicin, including diallyl trisulphide (DATS, DADS, DAS) and ajoene, which have a greater antifungal effect than allicin (Tansey and Appleton, 1975). An antifungal compound, fistulosin (octadecyl 3-hydroxyindole), has been isolated from welsh onion (*A. fistulosum*), which showed a high activity towards *Fusarium oxysporum* inhibiting primarily the protein synthesis (Phay et al., 1999). In addition to sulphur compounds, a great variety of antifungal proteins and peptides have been isolated from several Allium species (Lam et al., 2000; Wang and Ng, 2001) such as allicepin, a novel isolated antifungal peptide from onion bulbs (Wang and Ng, 2004). Finally, it is necessary to consider certain steroid saponins, such as eruboside-B, isolated from the garlic bulb that also exhibit antifungal activity for *Candida albicans* (Matsuura et al., 1988).

Welsh onion extracts have been reported to exert more inhibitory activity towards aflatoxin production than the preservatives sorbate and propionate at pH values near 6.5, even at concentrations 3-10 folds higher than maximum level used in foods. In addition to inhibitory effects against pathogenic bacteria, onions have been found to promote beneficial microorganisms. Onions contain fructo-oligosaccharide (FOS), probiotics which are non-digestible ingredients fermented by bifido bacteria in the body that help to maintain the health of the gut and colon. Onions contain 2.8% FOS as compared to 1.0% FOS in garlic, 0.7% in rye, and 0.3% in bananas.

Insert Table 5 here

Chemical characterization of sulphur compounds has proven the main active ingredient for antimicrobial activity (Rose et al., 2005). In addition some proteins, saponins and phenolic compounds can also contribute to this activity (Griffiths et al., 2002). Recently it was found that onion peel could be a good source of functional biomaterial for pharmaceutical industries if prepared by sub critical water extraction (SWE) because onions have strong antimicrobial activity against *Bacillus cereus* (Kim et al., 2011).

Antiparasitic activity

Onion extracts are effective against *Opalina ranarum*, *Opalina dimidicita*, *Balantidium entozoon, Entamoeba histolytica, Tripanosoma brucei, Leishmania, Leptomonas and Crithidia* (Reuter et al., 1996). In China, DATS, an allicin breakdown product, easily synthesized and more stable than the extremely volatile allicin, is commercially available as a preparation, called Dasuansu, prescribed for the treatment of giardiasis and infections by *E. histolytica* and *Trichomonas vaginalis* (Lun et al., 1994). Allicin, ajoene and other organo-sulphur compounds from garlic and onion are also effective antiprotozoals. Antiparasitic properties of onion extracts towards different strains of *Leishmania* and *T. vaginalis* have been reported as well (Saleheen et al., 2004). Similarly administration of onion was beneficial in protecting susceptible hosts against opportunistic zoonotic parasites such as *Cryptosporidium parvum* (Nadia et al., 2011). Onion and garlic intake can significantly cause reduction of worm burden, hepatic and intestinal eggs and oogram count in mice infected with *Schistosoma mansoni* recently reported by (Mantawy et al., 2011).

Antiviral activity

Quercetin, the major onion flavonoid, possesses antiviral activity and enhances the bioavailability of some antiviral drugs (Wu et al., 2005). Lectins are heterogeneous group of glycoproteins with the ability to recognize and bind specifically to carbohydrate ligands. Chen et al. (2011) studied the antiviral activity of extract of five *Allium* plants (shallots, garlic, onions, leeks, and green onions) in comparison with compounds of quercetin, zalcitabine (ddC), allicin, and ribavirin against adenovirus. With regard to the antiviral activity of ddC, both the MU and PRD (Plaque reduction) methods showed a high correlation with no significant difference. Most of the Allium plants tested were non-toxic to human lung carcinoma (A549) cells, and shallots exhibited the highest level of antiviral activity for both ADV41 and ADV3, followed by garlic and onions.

Antioxidant activity

Oxidation of DNA, proteins and lipids by reactive oxygen species (ROS) plays an important role in a wide range of common diseases, including cancer and cardiovascular, inflammatory and neurodegenerative diseases, such as Alzheimer's disease and other age-related degenerative conditions (Borek, 1997; Richardson, 1993).

Flavonoids, ubiquitous in the plant kingdom, have been widely studied for their antioxidative effects (Hertog and Katan, 1998; Rice-Evans et al., 1995). Onions are known to contain anthocyanins and the flavonols quercetin and kaempferol (Bilyk et al., 1984; Rhodes and Price, 1996) and both have antioxidant activity. Onion is one of the major sources of dietary flavonoids in many countries, which are present either as sugar conjugates or as aglycones. The antioxidative effects of consumption of onions have been associated with a reduced risk of neurodegenerative disorders (Shutenko et al., 1999), many forms of cancer (Hertog and Katan, 1998; Kawaii et al., 1999), cataract formation (Sanderson et al., 1999) and ulcer development (Suzuki et al., 1998). Data from a range of *in vitro* testing methods suggested onions have moderate levels of antioxidant activity in comparison with other vegetables (Halvorsen et al., 2002; Pellegrini et al., 2003; Wu et al., 2004).

The major flavonoid found in onion is quercetin, present in conjugated form, as quercetin 40-O-β-glycopyranoside, quercetin 3,40-O-β-diglycopyranoside, and quercetin 3,7,40-O-β-triglycopyranoside (Koncic and Jug, 2011; Sellappan and Akoh, 2002). The dry outer layers of onion, which are wasted before food processing such as cooking, contain large amounts of quercetin, quercetin glycoside and their oxidative products (Gu¨ lsen et al., 2007), which are effective antioxidants against non enzymatic lipid peroxidation and oxidation of low density lipoproteins (LDL). Quercetin and its dimerized compound showed the highest antioxidative activity, which is comparable to that of α-tocopherol (Ly et al., 2005). It has been confirmed that its absorption is low in contrast to other dietary antioxidants such as vitamins C and E, limiting its capability to act as antioxidant in plasma *in vivo* (Lotito and Frei, 2006).

Onions and Eye health

The carotenoids in spring onions may protect against macular degeneration. Some epidemiologic evidence does suggested that lutein and zeaxanthin protect against age-related eye disease (Mares-Perlman et al., 2002; Sies and Stahl, 2003). Lower risk of eye disease has been found in conjunction with consumption of foods rich in lutein and zeaxanthin (Mares-Perlman et al., 2002), higher levels of lutein and zeaxanthin in the blood and higher levels of lutein and zeaxanthin in the retina (Beatty et al., 2001; Bone et al., 2000). However, these relationships were not observed in other studies, or were only observed in subgroups of the study population (Mares-Perlman et al., 2002). Mares-Perlman et al. (2002) described findings with respect to the relationship between lutein and zeaxanthin and reducing cataract risk as “somewhat consistent”. Two studies showed a higher incidence of cataracts in those in the lowest quintile of lutein and zeaxanthin intake compared with the highest, and three prospective studies found that those in the highest quintiles had a 20–50% lower risk of experiencing cataract problems. Although concentrations are generally highest in ocular tissue, a number of studies have established the presence of lutein and zeaxanthin in serum and body tissues. Their antioxidant activity has led to speculation that higher consumption of these chemicals lead to higher levels in body tissues, and that this may lower the risk of chronic disease. Lutein is more widely dispersed in the body than zeaxanthin and it is possible that, along with other carotenoids with antioxidant activity, it may confer protection against diseases such as cancer and cardiovascular disease as well as positively affecting immune function.

Daily consumption of more than 500 ml of tea, a large source of quercetin, was associated with decreased risk of cataracts (Robertson et al., 1991). It has been reported that the percentage of quercetin absorbed from onions is approximately twice that from tea (de Vries et al., 1998). Therefore, high daily intake of onions may provide some protection against the risk of cataract formation.

Anti-inflammatory effects

Quercetin's anti-inflammatory effect on prostaglandins, leukotrienes, histamine release and subsequent anti-asthmatic activity has been investigated (Wagner et al., 1990). Inflammation is part of the body's natural immune response to trauma. Thiosulfinates and capaenes responsible for the anti-inflammatory activities also cause inhibition of the immune response (Chisty et al., 1996; Dorsch and Wagner, 1991). The organosulfur compounds of onions also have been credited with anti-asthmatic effects (Augusti, 1996). Thiosulfinates formed from onion tissue degradation (i.e. chopping) have been credited with inhibition of arachidonic acid metabolic pathways and subsequent anti-inflammatory and anti-asthmatic effects (Wagner et al., 1990). Saponins have also been shown to have anti-inflammatory activity (Sparg et al., 2004).

Anti-diabetic effect

Significant research has been done on the effect of onion consumption on diabetic conditions. Two organosulfur compounds were linked to significant amelioration of weight loss, hyperglycemia, low liver protein and glycogen, and other characteristics of diabetes mellitus in rats. Similarly, Suresh Babu and Srinivasan (1997) found that 3% onion powder reduced hyperglycemia, circulating lipid peroxides and blood cholesterol (LDL-VLDL exclusively). Analysis of the effects of quercetin on human diabetic lymphocytes showed a significant increase in protection against DNA damage from hydrogen peroxide at the tissue level (Lean et al., 1999). Further human studies are needed to assess the ability of a high flavonoid diet to attenuate diabetic conditions. Similarly the antihyperglycaemic effect of 12 edible plants was studied on 27 healthy rabbits (Roman-Ramos et al., 1995). Apart from cauliflower, only onion and garlic decreased the hyperglycaemic peak, which was induced by the glucose tolerance test. In further studies, alloxan-diabetic rats were treated with S-methyl-L-cysteine sulphoxide (typical for many Allium species) and S-allyl-L-cysteine sulphoxide (typical for garlic) at a concentration of 200 mg kg^{-1} body weight per day (Kumari and Augusti, 2007; Kumari et al., 1995). Both compounds significantly lowered blood glucose levels. Medium levels of FOS (1-kestose (1-kestotriose; GF-2), nystose (1,1-kestotetraose; GF-3), and 1F-beta-fructofuranosylnystose (1,1,1-kestopentaose; GF-4) and sugars (glucose, fructose and sucrose) have been identified in red onions that have significant role in protection against diabetes (Judprasong et al., 2011).

Effect on memory

There has been recent interest in the effects of allium-derived compounds on memory impairment. An animal study showed onion extract and a compound found in onions, di-n-propyl trisulfide, improved memory function in a mouse model and demonstrated that its efficacy was due to antioxidant activity (Nishimura et al., 2006).

Effects on the respiratory system

Certain onion-derived compounds, in particular thiosulfinates and cepaenes, showed remarkable *in vitro* inhibitory effect of cyclooxygenase and lipoxygenase mediated reactions which initiated eicosanoid metabolism and lead to bronchial restriction. Therefore, these compounds have antiasthmatic activity (Wagner et al., 1990). It has been described that saturated thiosulphinates are less active than unsaturated ones and that cepaenes are more active than thiosulphinates. In further studies, guinea-pigs were chosen as the model for investigating the effect of organosulphur compounds on platelet activating factor (PAF)-induced bronchial constriction (Dorsch, 1996; Dorsch et al., 1987b). Furthermore, a chloroform extract (at 20 mg kg^{-1} body weight) was more active than the lyophilized onion juice (at 100 mg kg^{-1} body weight). Thiosulphinates and cepaenes were identified as the active compounds that has been investigated in a previous study by (Dorsch et al., 1987a).

In a human study, adult volunteers suffering from allergic bronchial asthma were treated with 100 ml of a 5% ethanol onion extract prepared from 100 g sliced onions 1 h prior to an allergen inhalation test (Dorsch et al., 1987a). Immediate and late bronchial reactions were markedly reduced after onion pretreatment.

ADVERSE EFFECTS AND TOXICITY

The adverse effects of *Allium* species in humans can be most common, less frequent and rare (Tattelman, 2005). The most common side effects, produced by intake of small amounts of onion, are bad breath and body odour. However, several studies have demonstrated that consumption of excessive amounts onion, especially when the stomach is empty, can cause other less frequent undesirable effects, such as gastrointestinal upsets (burning sensation and diarrhoea), flatulence and changes in the intestinal flora (Ackermann et al., 2001). Within the group of rare effects, dermatological problems in susceptible individuals (allergic dermatitis, burns and blisters), produced by the direct application on skin of fresh or crushed garlic and onion (Davis, 2005; Friedman et al., 2006).

Onion preparations used as complementary medicine with drugs are heavily scrutinized due to their ability to stimulate P450 enzymes in the liver, which are responsible for metabolising exogenous chemical compounds. Several recent studies have reported that concurrent intake of onion, with a high quercetin content, markedly decreases the oral bioavailability of cyclosporin, with subsequent organ transplant rejection (Yang et al., 2006). Studies to determine the influence of quercetin coadministration on plasma concentrations of the protease inhibitor saquinavir (antiviral HIV drug) have also been carried out. However, more studies are needed to determine if saquinavir intracellular concentrations are altered by coadministration of quercetin, because of substantial interand intrasubject variability (DiCenzo et al., 2006).

The intake of onion and their derivatives should be controlled, including ingested dose, long-term medication and safety and effectiveness of chosen preparation, with the purpose of minimizing the risk of adverse side effects (Davis, 2005). In spite of this, onion use as therapeutic agent seems to be very safe, since all adverse effects previously described appear with an excessive and prolonged consumption.

FACTORS DECREASING HEALTH BENEFITS OF ONIONS

Tannins and anthocyanins from the skin of red onion have been reported to have antioxidant activity (Augusti, 1996), but in one study no appreciable amounts remained in the edible portion once the outer skin had been removed (Rhodes and Price, 1996). However, this is not true for all varieties, with some still containing appreciable amounts. In peeled Tropea Red onions the edible portion contained only 27% of the anthocyanins, although 79% of the flavonols. Quercetin content is highest in the dry skin and decreases from the outer to inner rings (Patil and Pike, 1995). Thus, peeling may significantly reduce the flavonoid content (especially anthocyanins and to a lesser extent flavonols) and hence some of the health benefits of onions.

In contrast, fructans are richest in the fleshy layers (Jaime et al., 2001b), as are sulfur compounds. Chopping may also affect the phytochemical content. As mentioned above, many of the sulfur compounds that have health benefits are not formed until the onion tissue is chopped.

However, if left too long these compounds can be changed further and loose activity. Rhodes and Price, (1997)(Rhodes and Price, 1996) showed that quercetin 3,4'-diglucoside was rapidly degraded in macerated tissues (50% decline after 5 hours), being converted to the quercetin monoglycoside and free quercetin. All these compounds have antioxidant activity so this feature of onions might not be affected by chopping. In a different study (Makris and Rossiter, 2001), chopping was shown to have no significant effect on flavonol content or antioxidant activity. Ewald et al. (1999) showed the greatest loss of flavonoids in onion occurred during the pre-processing step when the onion was peeled, trimmed and chopped before blanching.

Ioku et al. (2001) measured the effects of various cooking methods on the flavonoid content in onion. Microwave cooking without water retained both flavonoids and ascorbic acid. Frying did not affect flavonoid intake while boiling of onions lead to about a 30% loss of quercetin glycosides, which transfers to the boiling water (flavonoids are water-soluble). (Crozier et al., 1997) also examined the effects of cooking on onions and found boiling reduced flavonoid content significantly, while microwaving had slightly less of an effect and frying resulted in the lowest loss. Makris and Rossiter (2001) showed a flavonol loss of 20% on boiling and antioxidant activity also decreased.

Adam et al. (2000) and Benítez et al. (2011) examined quality changes in onion during drying. The results showed that drying temperatures above 65°C exerted a pronounced influence on colour. The pyruvate content decreased with increasing temperature and slice thickness. The sugar content was also significantly influenced by the drying temperature. The rate of ascorbic acid degradation decreased with increasing temperature and slice thickness. Because carotenoids present in spring onions are fat-soluble, they are best absorbed in the body if accompanied by some form of oil or fat in the meal. Chopping and cooking assists in releasing carotenoids from the food matrix and this also increases their bioavailability.

CONSULSION

Many health benefits have been reported for onion. Extract of this spice exhibited a significant antibiotic activity. That could be a replacer of modern antibiotics. Antiasthmatic, antidiabetic and a weak antiplatelet activity were proved for *A. cepa*. Cardiovascular benefit of this excellent medicinal plant is well known since old days. 40 to 100g of *Allium cepa* is the recommended intake and it must be incorporated in daily diet in order to compete with onset of different diseases.

PICTURE CAPTION

Figure 1: Classification of *Allium cepa*

Figure 2: Flavonoids, Quercetin and quercetin glucosides structures present in Allium cepa

Figure 3: Formation of different organo-sulphur compounds in processed onions

TABLE CAPION

Table 1: Proximate analysis, vitamin contents and minerals present in 100g of raw onion

Table 2: Lipids and amino acids present in 100 g of raw onions

Table 3: Major functions of Onion *(Allium cepa)* in human body

Table 4: Overview of cancer prevention by *Allium cepa*

Table 5: Overview of antibacterial, antifungal and antiparasitic activity of onions

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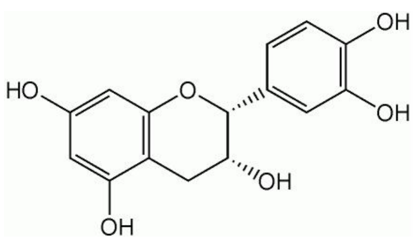
Kingdom	Plantae
Clade	Angiosperms
Clase	Monocots
Order	Asparagales
Family	Amaryllidaceae
Subfamily	Allioieae
Genus	*Allium*
Species	*A.cepa*

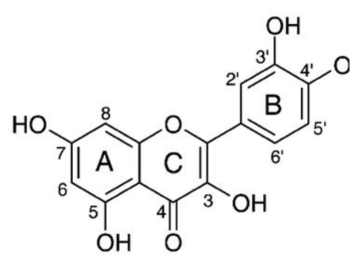
Scientific Classification

***Allium cepa* L. var.**

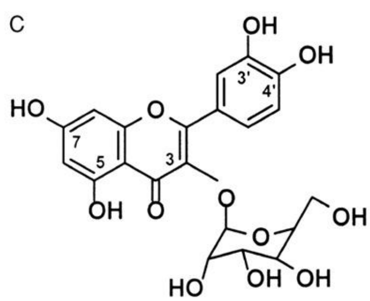
Figure 1: Classification of *Allium cepa*



flavonoids structure



qurecetin structure



qurecetin-3-glucoside

Figure 2: ***Flavonoids, Quercetin and quercetin glucosides structures present in Allium cepa***

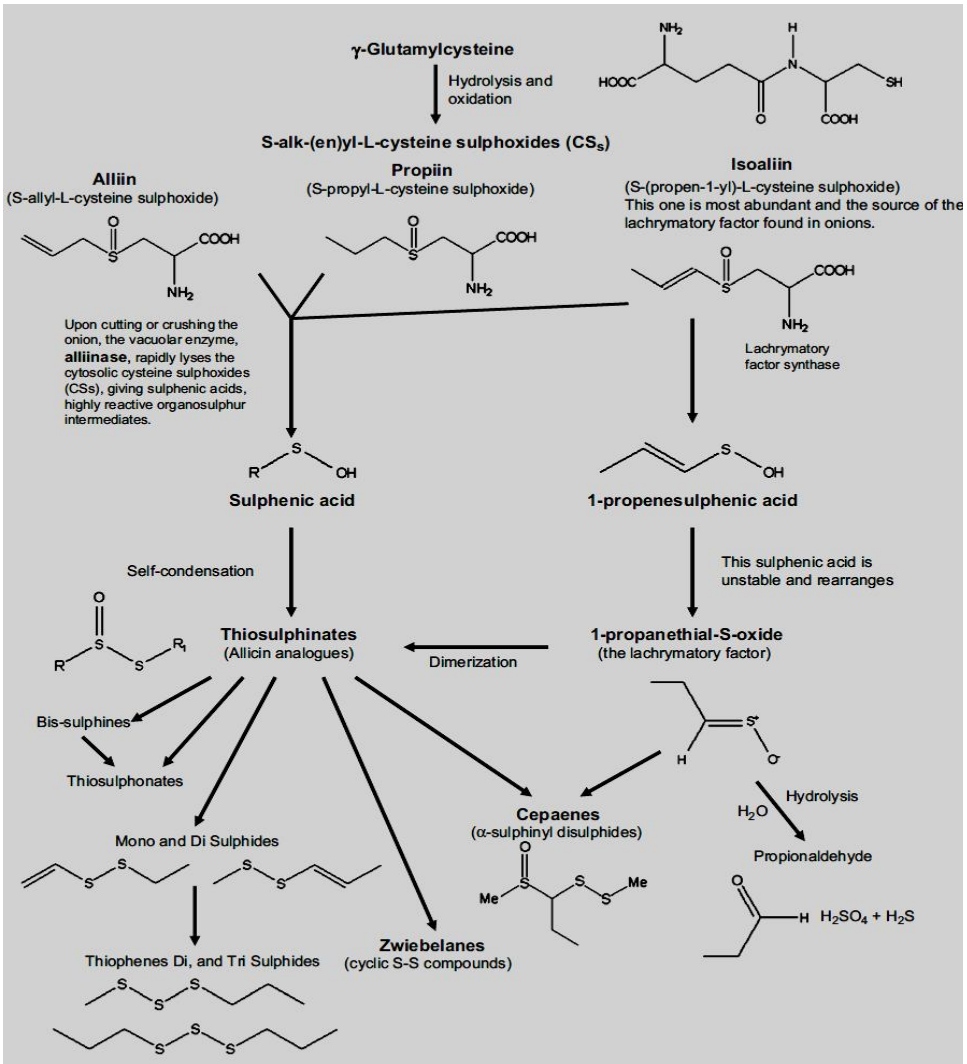


Figure 3: Formation of different organo-sulphur compounds in processed onions (Corzo-Martinez et al., 2007)

PROXIMATES	MEAN (g)	VITAMINS	MEAN (mg)	MINERALS	MEAN (mg)
Water	**89.11**	Vitamin C	**7.4**	Calcium	**23**
Protein	**1.1**	Thiamin	**0.046**	Iron	**0.21**
Total lipids	**0.1**	Riboflavin	**0.027**	Magnesium	**10**
Ash	**0.35**	Niacin	**0.116**	Phosphorus	**29**
Carbohydrates	**0.34**	Pantothenic acid	**0.123**	Potassium	**146**
Fibre	**1.7**	Vitamin B-6	**0.12**	Sodium	**4**
Sugar total	**4.24**	Folate	**19 mcg**	Zinc	**0.17**
Sucrose	**0.99**	Choline	**6.1**	Copper	**0.039**
Dextrose	**1.97**	Betaine	**0.1**	Manganese	**0.129**
Fructose	**1.29**	β-Carotene	**1 μg**	Selenium	**0.5 μg**
Energy	**40 Kcal**	Vitamin A	**2 IU**	-	-
-	-	Lutein+zeaxanthin	**4 μg**	-	-
-	-	Vitamin E	**0.02**	-	-
-	-	Vitamin K	**0.4 μg**	-	-

Table 1: Proximate analysis, vitamin contents and minerals present in 100g of raw onion (USDA, 2008)

LIPIDS	MEAN (g)	AMINO ACIDS	MEAN (g)
Myristic acid	**0.004**	Tryptophan	**0.014**
Palmitic acid	**0.034**	Threonine	**0.021**
Stearic acid	**0.004**	Isoleucine	**0.014**
Total Saturated acids	**0.042**	Leucine	**0.025**
Oleic acid	**0.013**	Lysine	**0.039**
Linoleic acid	**0.013**	Methionine	**0.002**
Linolenic acid	**0.004**	Cystine	**0.004**
Total monounsaturated acids	**0.013**	Phenylalanine	**0.025**
Total polyunsaturated acids	**0.017**	Tyrosine	**0.014**
Phytosterols	**15 mg**	Valine	**0.021**

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-	-	Arginine	**0.104**
-	-	Histidine	**0.014**
-	-	Alanine	**0.021**
-	-	Aspartic acid	**0.091**
-	-	Glutamic acid	**0.258**
-	-	Glycine	**0.025**
-	-	Proline	**0.012**
-	-	Serine	**0.021**

Table 2: Lipids and amino acids present in 100 g of raw onions (USDA, 2008)

NAME	FUNCTION
Vitamin A	Important for normal vision and eye health
Retinol (animal origin)	Involved in gene expression, embryonic development
Some carotenoids (plant origin,	and growth and health of new cells
converted to retinol in the body)	Assists in immune function
	May protect against cancers and atherosclerosis
Vitamin C	Necessary for healthy connective tissues – tendons,
Ascorbic acid	ligaments, cartilage, wound healing and healthy teeth
	Assists in iron absorption
	A protective antioxidant - may protect against some
	cancers
	Involved in hormone and neurotransmitter synthesis
Vitamin E	Non-specific chain-breaking antioxidant
alpha-tocopherols and tocotrienols	Reduces peroxidation of fatty acids
	May protect against atherosclerosis
Thiamin	Coenzyme in the metabolism of carbohydrates and
Vitamin B1	branched-chain amino acids
	Needed for nerve transmission
	Involved in formation of blood cells
Riboflavin	Important for skin and eye health
Vitamin B2	Coenzyme in numerous cellular redox reactions
	involved in energy metabolism, especially from fat
	and protein
Niacin	Coenzyme or cosubstrate in many biological
Vitamin B3	reduction and oxidation reactions required for energy
Nicotinic acid, nicotinamide	metabolism and fat synthesis and breakdown
	Reduces LDL cholesterol and increases HDL
	cholesterol

Vitamin B6	Coenzyme in nucleic acid metabolism,
Pyridoxine, pyridoxal, pyridoxamine	neurotransmitter synthesis, haemoglobin synthesis.
	Involved in neuronal excitation
	Reduces blood homocysteine levels
	Prevents megaloblastic anaemia
Folate	Coenzyme in DNA synthesis and amino acid
Generic term for large group of	synthesis. Important for preventing neural tube
compounds including folic acid and	defects
pterylpolyglutamates	Key role in preventing stroke and heart disease,
	including reducing blood homocysteine levels with
	vitamin B12
	May protect against colonic and rectal cancer
Calcium	Structural component of bones and teeth
	Role in cellular processes, muscle contraction, blood
	clotting, enzyme activation, nerve function
Copper	Aids in utilization of iron stores, lipid, collagen,
	pigment
	Role in neurotransmitters synthesis
Iron	Component of haemoglobin and myoglobin in blood,
	needed for oxygen transport
	Role in cellular function and respiration
Magnesium	Component of bones
	Role in enzyme, nerve, heart functions, and protein
	synthesis
Manganese	Aids in brain function, collagen formation, bone
	structure, growth, urea synthesis, glucose and lipid
	metabolism and central nervous system functioning
Potassium	Major ion of intracellular fluid
	Maintains water, electrolyte and pH balances
	Role in cell membrane transfer and nerve impulse
	transmission
Phosphorus	Structural component of bone, teeth, cell membranes,
	phospholipids, nucleic acids, nucleotide enzymes,
	cellular energy metabolism
	pH regulation
	Major ion of intracellular fluid and constituent of many
	essential compounds in body and processes

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Zinc	Major role in immune system
	Required for numerous enzymes involved in growth and repair
	Involved in sexual maturation
	Role in taste, smell functions

Table 3: Major functions of Onion *(Allium cepa)* in human body (BUPA, 2006; FAO, 2009)

EFFECT	AUTHOR	MODEL
Antimutagenic effects	Ikken et al., 1999	Ames test
Antimutagenic effects	Kato et al., 1998	Salmonella strain
Protective effects	Gao et al., 1999	Human case-referent study
Stomach-carcinoma protection	Darant et al., 1996	Human case- control study
Breast- cancer protection	Challier et al., 1998	Human case-control study
Induction of Phase II enzymes	Guyinnet et al., 1999	Wistar rats
Chemopreventive activity	Siess et al.,1997	Rats
Chemopreventive activity	Takada et al., 1997	Ito rat-liver test
Lung cancer protection	Sankaranarayanan et al., 1994	Human case-control study
Brain tumor protection	Hu et al., 1999	Human case-control study
Gastric cancer protection	González et al., 2006	Human case-control study
colorectal cancer protection	Millen et al., 2007	Human case-control study
Prostate cancer protection	Hsing et al., 2002	Human case-control study
Tumors protection	Shrivastava and Ganesh, 2010	Rats

Table 4: Overview of cancer prevention by *Allium cepa*

EFFECT	AUTHOR	MODEL
Antifungal activity	Yin and Tsao, 1999	Aspergillus species
Antifungal activity	Mahmoudabadi et al., 2009	Scopulariopsis sp.
Antifungal activity	Abdel-Gawad and Saber, 1995	dermatophytic fungi

Antibacterial activity	Kim, 1997	Oral Pathogenic bacteria
Antibacterial activity	Zohri et al., 1995	Bacterial sps
Antibacterial activity	Elnima et al., 1983	several bacterial sps
Antibacterial activity	Abubakar, 2009	Mycobacterium tuberculosis
Antiparasitic activity	Reuter et al., 1996	various parasites
Antiparasitic activity	Nadia et al, 2011	*Cryptosporidium parvum*

Table 5: Overview of antibacterial, antifungal and antiparasitic activity of onions