The Pharma Innovation Journal 2022; 11(6): 1148-1153

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(6): 1148-1153

www.thepharmajournal.com
Received: 13-02-2022
Accepted: 22-05-2022

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Bioactive composition of onion (*Allium cepa*) and its health benefits: A review

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Abstract
The common onion (*Allium cepa)* is one of the world's oldest cultivated plants, used as a vegetable and flavoring all over the world. Sulphur amino acids, as well as a variety of vitamins and minerals, have been found in this species. Flavonoids, phytosterols, and saponins are among the secondary metabolites that have been discovered. Despite its primary usage as a food source, this plant has been shown to provide a wide range of health benefits. A variety of biological activities have been described, including antioxidant, antibacterial, and antidiabetic effects. Onion and its bioactive components have been shown to have antioxidant, antibacterial, anti-inflammatory, anticancer, cardiovascular protective, neuroprotective, and immunomodulatory activities in several studies. I believe that by publishing this review, more people will become aware of onion and its bioactive components, which have the potential to be used in the creation of functional foods and nutraceuticals for the prevention and treatment of certain chronic illnesses.

Keywords: *Allium cepa*, flavonoids, quercetin, saponin, nutrients and disease treatment

Introduction
The onion is one of the oldest vegetables, and it has been employed in folk medicine and culinary preparations since ancient times. It is now one of the most significant crops, ranking third in importance behind potato and tomato as food crops (Teshika *et al*., 2019) [36]. Onions are cultivated in a range of shapes, colors, sizes, dry matter content, and pungency to fulfil specific culinary and nutritional needs, and have therefore become an almost ubiquitous element in food preparation across the world. Onion production is divided into three categories: fresh market bulbs, dried onions for food processing, and green, salad onions for fresh consumption (Griffiths *et al*., 2002) [16]. In 2018, the global output of onion bulbs (dry onions) was predicted to be 96.7 million tonnes (FAO, 2020). Asian nations, especially China and India, are the largest producers, accounting for 67.5 percent of global output. European nations account for 9.3% of global output, with Spain and the Netherlands leading the way (FAO, 2020). Onions may be preserved for up to 9 months provided refrigeration or controlled environment storage is available, which is a key benefit (Griffiths *et al*., 2002) [16]. Even yet, long-term storage of onions in bulk can result in significant losses of up to 25%-30%. (Lewande, 2012). As a result, onion processing maintains product stability while preserving its unique sensory character. Dehydrated goods, such as flakes, rings, granules, powder, and processed onions, such as frozen or canned onions, or onions in vinegar and brine, are becoming increasingly popular on the international market (Lewande, 2012*).*

The health advantages of onion consumption in everyday life have received a lot of attention because two chemical groups found in onions, flavonoids and alk (en)yl cysteine sulfoxides, are thought to have a variety of biological roles that promote human health. The primary flavonoids found in onion bulb are quercetin 4' -O-glucoside (Q4'G) and quercetin 3,'4 -O-di glucoside (Q3, 4'diG), while the onion peel contains quercetin aglycone (QA) and Q4'G. (Tsushida and Suzuki 1995) [37]. Although other vitamins are present in onion, the most important component it contains is vitamin C. *Allium cepa* (onion) provides several health advantages to consumers due to its strong therapeutic characteristics, nutritional value, and energy value (B. Shovon., *et al*., 2013) [31]. Onion has been shown to have anticarcinogenic qualities in oesophageal, stomach, lungs, prostate, and developing brain carcinomas. Antileishmanial action was also observed in its aqueous extract against Leishmanial promastigotes. Antifungal, antibacterial, cardiovascular health, lowering high blood pressure, and insulin resistance are some of the additional actions of *Allium cepa*.

Bioactive composition of onion

Flavonoids

Catechins (flavan-3-ols), leucoanthocyanidins (flavan-3, 4-diols), flavanons, flavanonols, flavonols, and anthocyanidins are the fundamental groups of flavonoids (Velíšek, 2002) [40]. The flavonol quercetin is the most abundant in onions. it contains both free and bound forms of quercetin (Rhodes & Price, 1996) [28]. The quercetin diglycosides and monoglycosides account for 93 percent of the total flavonol content in onions (Lombard *et al*., 2005) [22]. (Ioku and colleagues (2001) discovered two quercetin glycosides: quercetin 4-O-ß-glucoside and quercetin 3, 4-O-ß-diglucoside, both of which are regarded as bioactive compounds having good effects on human health. (Gulsen *et al*., 2007; Prakash *et al*., 2007) [17] discovered that quercetin, its glycosides, and oxidative derivatives are powerful antioxidants involved in oxidative stress-related activities. Quercetin has a wide range of beneficial properties. A particularly useful flavonoid found in onions is an antioxidant that may help prevent cancer. "It may also have heart health advantages," said Angela Lemond, a registered dietitian nutritionist in Plano, Texas, and a spokesman for the Academy of Nutrition and Dietetics. According to the University of Maryland Medical Center, quercetin has several other benefits, including reducing the symptoms of bladder infections, promoting prostate health, and decreasing blood pressure. Disulfides, trisulfides, cepaene, and vinyl dithiins are some of the other phytochemicals found in onions. It inhibits allergy symptoms by reducing the release of histamine from cells. It is one of the most potent anti-carcinogenic chemicals because it prevents the formation of malignant cells (Yoshida *et al*., 1990; Neuhouser, 2004) [45]. It helps to prevent diseases such as stomach cancer, intestinal cancer, and lung cancer, among others. According to O'Reilly *et al*. (2001) [24], quercetin is the most effective inhibitor of membrane lipid peroxidation and hence has the potential to impact atherosclerosis. Increased quercetin consumption has been linked to a lower risk of cardiovascular and other degenerative illnesses. Onions also contain flavones such luteolin and kaempferol, in addition to quercetin (Lanzotti, 2006). When compared to other vegetables and fruits, onions have 5 to 10-times higher quercetin (300 mg kg–1) than broccoli (100 mg kg–1), apples (50 mg kg–1), and blueberries (40 mg kg–1).

The red onion types have the largest flavonol content, as well as red anthocyans in the form of cyanidin, peonidin, and pelargonidin glycosides.

Sulphur

Onion is high in organic chemicals, including sulphur. Sulphur is a prevalent mineral in our bodies that aids in protein synthesis and cell structure formation," Lemond explained. "I prefer onions because they provide flavour without the use of salt or sugar," Jarzabkowski added. These molecules are responsible for a variety of health and therapeutic benefits, as well as the onion's disagreeable odor. Interactions of these sulphur compounds with thiol molecules in biological systems can explain their bactericidal, allergenic, antifungal, anticancer, and larvicidal activities (Brewster & Rabinowith, 1990) [7]. S-alk(en)yl cysteine sulphoxides are onion aroma precursors. Sulphur-containing chemicals present in fresh and/or cooked onion have recently been shown to prevent the development of white adipose cells. Cycloalliin, S-methyl-L-cysteine, S-propyl-L-cysteine sulfoxide, dimethyl trisulfide, and S-methyl-L-cysteine sulfoxide have all been shown to prevent adipogenesis. These findings suggest that the anti-obesity action of onion extract may be due in part to these chemicals. Sulphur compounds are produced as a result of the enzyme alinase's action as well as a chemical breakdown of precursors. In onions, propenyl-L-cysteine sulphoxide is the precursor of the main onion flavor and lachrymatory component, which is unpleasant and repulsive to some animals (Block *et al*., 1992) [5]. The onion is a useful vegetable in our kitchen. It may be eaten in a variety of ways, including cooked, fried, and roasted. Despite the fact that technological arrangements reduce the concentration of helpful chemoprotective compounds in onions, regular, frequent daily consumption contributes to the normal functioning of the antioxidant system in the human organism. In the human diet, onions should be consumed fresh, such as in salads, and we advocate utilizing red onion cultivars when choosing a variety.

Anthocyanin

Organic molecules called anthocyanins are present in the epidermal layer of plant cells. They have a complicated structure that includes an aromatic three ring molecular region with one or more sugar molecules attached. Anthocyanin is made up of a flavylium cation (2-phenylbenzopyrilium) that connects hydroxyl (–OH) and/or methoxyl (–OCH3) to one or more sugars. The sugar-free anthocyanidin aglycones and the anthocyanin glycosides are two types of anthocyanins that are usually 3 glucosides of the anthocyanidins (Williams and Grayer, 2004) [43].

Saponin

Saponins are amphipathic glycosides that have a foaming property. In their structure, one or more hydrophilic glycoside moieties are connected to a lipophilic triterpene derivative. (Hostettmann and Marsden, 1995) [18]. Polycyclic (C27) aglycones (C30) are connected to one or more sugar side chains, and the aglycone might be steroidal or triterpene.

Carbohydrates

Carbohydrates constitute 9–10% of raw and cooked onions, respectively. Simple sugars like glucose, fructose, and sucrose, as well as fiber, make up the majority of their constitution. A 3.5-ounce (100-gram) piece has a total digestible carb value of 7.6 grams, which includes 9.3 grams of carbs and 1.7 grams of fiber.

Fibers

Onions are a good source of fiber, with 0.9–2.6 percent of the fresh weight depending on the onion variety. They're high in fructans, which are a type of beneficial soluble fiber. Onions are a major source of fructans in the diet. Prebiotic fibers like fructans nourish the good bacteria in your stomach. Short-chain fatty acids (SCFAs), such as butyrate, are formed as a result of this, which may enhance colon health, decrease inflammation, and lower the risk of colon cancer. FODMAPs, on the other hand, are fructans, and they can induce unpleasant digestive symptoms in people who are sensitive to them, such as those who suffer from irritable bowel syndrome.

Vitamins

Vitamin C is a powerful antioxidant. This antioxidant is necessary for immunological function as well as skin and hair upkeep Folate is a B vitamin that is found in (B9). Folate is a water-soluble B vitamin that is crucial for cell development and metabolism, especially in pregnant women (Katalin Fekete., *et al*., 2012) [11] B6 is a B vitamin. This vitamin, which may be found in most meals, aids in the development of red blood cells. Potassium. This mineral is critical for heart health and can reduce blood pressure (Connie M Weaver., 2013) [42].

Potassium and calcium

These minerals are important for the correct functioning of the heart since they help to reduce blood pressure. The onion also contains calcium, which helps to build bones.

Health benefits

Antioxidant activity

The antioxidant activity of onion flavonoids is the most well-studied and characterized mechanism for protecting cells and tissues from reactive oxygen species (ROS). ROS produces free radicals, which exogenously kill cells in numerous organs. *In vitro*, flavonoids such as kaempferol and quercetin have been found to stabilize free electrons created by reactive oxygen species (ROS). Peroxyl and hydroxyl are stabilized by the flavonoid hydroxyl structure, which supplies hydrogen and an electron to help scavenge ROS. The heterocycles of flavonoids induce conjugation between a free 3-hydroxyl and aromatic bands, which results in antioxidant action (Bros W *et al*., 1990) [6]. Furthermore, data reveal that antioxidant activity is affected by the quantity, position, and the number of sugar rests. The antioxidant effects of quercetin and its dimerized derivatives are comparable to those of -tocopherol. As a result, the outer layer of the onion extract is thought to be a source of nutritious components. Metal chelating activities of flavonoids help to limit the production of free radicals. Quercetin's properties include iron stability and iron chelation (Van acker *et al*., 1996) [38]. Kaempferol is an effective antioxidant because its high concentration encourages the production of antioxidant enzymes such as superoxide dismutase, catalase, and others. It also prevents the oxidation of low-density lipid-protein, which prevents atherosclerosis (LDLP).

Antimicrobial activity

Flavonoids have high antibacterial effects, according to several research (Table 1). Onion fiber-based composite composites containing extracted flavonoids from onion skins have been shown to have antibacterial action against Staphylococcus aureus and *E. coli* (Cheng *et al*., 2015) [8] Furthermore, the antibacterial activities of gold nanoparticles, silver nanoparticles, graphene, and polymeric films containing onion extracts were proven against both gram-positive and gram-negative bacteria. Quorum sensing is critical for bacterial virulence coordinating during infection. In Pseudomonas aeruginosa and Serratia marcescens, onion organic extracts and quercetin interfered with quorum sensing-regulated violacein production and swarming motility, with quercetin aglycone reducing violacein production and quercetin aglycone and quercetin 3--D-glucoside inhibiting bacterial motility. The production of biofilms, which is another important component for antimicrobial resistance and is mediated by the quorum-sensing system, was unaffected by onion extracts or quercetin. In a prior study, it was shown that sitosterol-derived compounds from onion husk extract and quercetin 4′-O—D glucopyranoside from onion peel extract suppressed quorum sensing-mediated virulence factors in pathogens, such as biofilm formation. In addition, onion essential oil has been shown to have anti-biofilm action against Listeria monocytogenes (Somrani *et al*., 2020) [34].

Table 1: Antimicrobial Activity of Onion

Activity	Model	Reference
Antibacterial	*Helicobacter pylori, Staphylococcus aureus*	Ramos *et al*., 2006 [26]
Antibacteria	*Mycobacterium tuberculosis*	Abubakar and Ado, 2009 [3]
Antiviral	Human immune virus	Van Damme *et al*., 1993 [39]
Antiviral	Enhance bioavailability of antiviral drug	Wu *et al*., 2005 [44]
Antiparasitic	Various parasites	Reuter *et al*., 1996 [27]
Antiparasitic	*Leishmania sp., Trichomonas vaginalis*	Saleheen *et al*., 2004 [29]
Antiparasitic	*Cryptosporidium parvum*	Abu El Ezz *et al*., 2011 [2]

Wound Healing and Anti-scar

Onion is a common ingredient in ayurvedic wound healing treatments (Abdel maksound *et al*., 2012). This also demonstrates biological effectiveness in pediatric patients in avoiding median sternotomy lesions. The extract is utilized to treat keloids and has a positive effect on a human skin fibroblast cell line. An onion peel abstract demonstrates biological efficacy in the prevention of hypertrophic scars and keloid formation (Gangopadhyay *et al*., 2014) [13]. Hypertrophic parasternal scar protection was also demonstrated using onion extract gel. This is also employed in keloid surgery and topical diagnosis and prevention of postoperative hypertrophic wounds. A. Cepa-allanto in pentaglycan gel, on the other hand, is used to treat hypertrophic skin wounds and improve the aesthetic look of surgical scars and burn scars.

Blood sugar control

Type 2 diabetes is a widespread condition with elevated blood sugar levels as its primary symptom. Onions have been shown in animal experiments to reduce blood sugar levels. In humans, the same consequences have been observed. In one research, consuming 3.5 ounces (100 grams) of raw onions per day resulted in a considerable drop in blood sugar levels in persons with type 2 diabetes (Imad M Taj Eldin., *et al*., 2010) [10]. Raw onions may aid in the management of type 1 and type 2 diabetes, (Muhammad Sajid Hamid Akash., *et al*., 2014) [4].

Bone health

Osteoporosis is a prevalent health condition, particularly among women after menopause. One of the most important preventive strategies is to eat a healthy diet (Miriram F.

Delaney., 2006) [9]. Regular onion consumption has been related to enhanced bone density in women over the age of 50, (Eric M Matheson., *et al*., 2009) [23].

Cancer risk reduction

Onion phytochemicals are important in avoiding a variety of cancer-causing actions (Table 2) Cancer is a common disease characterized by excessive cell growth. It is one of the leading causes of death around the world. Increasing onion consumption has been related to a decreased risk of a range of cancers, including stomach, breast, colon, and prostate cancers in observational studies (Carlotta Galeone., *et al*., 2007) [12].

Table 2: Cancer Risk Reduction

Activity	Model	Reference
Lung cancer protection	Human case-control study	Sankaranarayanan *et al*., 1994 [30]
Brain tumor protection	Human case-control study	Hu *et al*., 1999 [20]
Gastric cancer protection	Human case-control study	González *et al*., 2006 [15]
Colorectal cancer protection	Human case-control study	Millen *et al*., 2007 [25]
Prostate cancer protection	Human case-control study	Hsing *et al*., 2002 [19]
Tumor protection	Rats	Shrivastava and Ganesh, 2010 [33]
Protective effects	Human case-referent study	Gao *et al*., 1999 [14]

Neuroprotective effect

Giving mice a methanolic extract of the outer scales and the edible region of the *Allium cepa* bulb before brain ischemia and reperfusion produced considerable benefits, according to a recent study. Neuroprotection by significantly reducing cerebral infarct size, significantly decreasing the increase in thiobarbituric acid reactive substances (TBARS) concentration in brain mitochondria and supernatant fractions, and preventing global cerebral ischemia (Shri, 2008) [32].

Immunosuppression

Inflammation is a normal immunological reaction to damage in the body. Thiosulfinates and capaenes, which have anti-inflammatory properties, also impair the immunological response. Quercetin also affects immunosuppression, and it has been found to help in kidney transplantation. Both immunological and nonimmune damage responses, which are significant risk factors in chronic graft loss, are suppressed by quercetin. Quercetin, on the other hand, has been found to protect mice against immunosuppression caused by UV radiation (Steerenderg, 1998) [35].

Conclusion

The onion is a widely grown and eaten vegetable that includes a variety of bioactive compounds. The primary bioactive ingredients of onion include sulfur-containing compounds like onions A and cysteine sulfoxide, as well as phenolic compounds like quercetin and quercetin glucosides, which contribute to its antioxidant, antibacterial, anti-inflammatory, and immunomodulatory effects. Furthermore, onion has the potential to be a valuable natural resource for the development of functional foods or nutraceuticals for the prevention and control of illnesses including obesity, diabetes, cancer, cardiovascular disease, and neurodegenerative disease.

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