Phytochemistry of *Allium cepa* L. (Onion): Its Nutritional and Pharmacological Importance

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Abstract

The present studies were conducted to review the phytochemical composition, nutritional and pharmacological values of onion. Attempts have been made to compile the findings of 75 articles into a single manuscript. Onion is cultivated all over the world. The onion bulbs are comprised of polysaccharides including peptides, fructans, flavonoids (mostly quercetin), saccharose and organosulfur compounds having salutary effects on human health. The onion in the diet gives us a positive response in nutritional manner. The nutritional contents of onion bulb are crude oil, vitamin E, sodium, potassium, and zinc. The onion bulb has the potential to reduce the problem of stomach cancer, osteoporosis, and brain cancer in human beings. In addition, onion is antidiabetic, anti-inflammatory, anti-scar, antispasmodic, antiseptic, anti-genotoxic, anti-mutagenic, diuretic, anti-parasitic, antimicrobial, antipyretic, and Analgesic.

Key words: Onion, Phytochemicals, Nutrients, Disease treatment,

1. Introduction
Onion is cultivated commercially almost everywhere in the world [1]. Out of fifteen vegetables reported by Food & Agriculture Organization of United Nations, onion falls second solely to tomato in terms of total annual world production [2]. It is an agricultural crop of short intervals [3] grown at low liberties [4]. Onion is used throughout the year in medicines, salads and is cooked with many vegetables. It also finds applications in various types of processed foods such as pickles. The human use of onions is as old as the Neolithic period [5]. China and India are the first and second largest producers of onions, respectively. The United States harvests about 125,000 acres, producing 6.75 billion pounds each year. The four largest onion producing regions of United States are Washington, Idaho-Eastern Oregon, California, and West-Central Oregon. In Pakistan, onion is commercially grown on an area of 131.4 thousand hectares and the annual production is around 1.8 million tones. The top ten onion producing districts of Pakistan are Chaghi, Hyderabad, Sanghar, Swat, Kharan, Kalat, Mirpurkhas, Nawabshah, Nasirabad, and Dir contributing more than 59% of the total production [6].

The onion was reported to be grown during the rainy seasons in the river Afram basin of the Eastern region of Ghana because of the availability of irrigation water and rainfall. However due to prevalence of onion thrips and fungal diseases during those days, onion was mainly grown after mid-June to mid-July. About 94.6% of the farmers grew Malavi (a local onion cultivar) only which was susceptible to the onion thrips as well as basal fusarium rot [7]. Onion comprises of more than 780 morphologically described species with great diversity. Onion’s chromosome number is 16 (2n). It (Allium cepa L.) belongs to Genus Allium, Order Liliaceae, Subclass Liliales, Division Liliopodia, Super division Spermatophyta, Subkingdom Tracheobionta and Kingdom Plantae [8]. China is the world's leading producer of onion (contributing 31.43 percent to the total production), according to FAO reports based on the 2000-2004 average production. Other eight major onion producing countries are India (10.22%), Turkey (3.83%), Pakistan (2.97%), Russia (2.84%), Iran (2.80%), Japan (2.35%), Brazil (2.22%), and Spain (1.95%) [9-12].
Keeping in view the great nutritional and medicinal value of this plant, this paper overviews phytochemical composition, nutritional and pharmacological value of onion.

2. Phytochemical Composition

Onion is an important source of nutritional contents e.g., flavonoids. It is especially rich in three important phytochemicals (flavonoids, organosulfur compounds and fructans). Such substances are known for their positive health effects. Onions are the main suppliers of flavonoids and organosulfur compounds which are potent antioxidants. As regards the antioxidant property contributing parameters, the concentration of ascorbic acid was found in the range of 1.18 to 3.89 mg/100 g of fresh weight. Across all cultures, ascorbic acid concentration has been greatly decreased. In the wild onion varieties, ascorbic acid content was usually between 5.0 and 10.0 mg/100 g fresh weight [13]. Organosulfur constituents of onions are mainly comprised of four diallyl sulfides: diallyltetrasulfide (DTTS), diallylmonosulfide (DMS), diallyltrisulfide (DTS) and diallyldisulfide (DDS). Di- and trisulfides were the principal compounds extracted by steam distillation of volatile fraction of onion. The primary sulfur-containing components in onions are Salk(en)yl-L-cysteine sulfoxides (ACSOs) e.g., alliin; they act as biosynthetic intermediates for ACSOs and also have a role as storage peptides. Volatile compounds including allicin and lipid-soluble sulfur compounds e.g. diallyl disulfide (DADS) and diallyl sulfide (DAS) originate from these metabolic pathways in the vegetables [14]. The specific smell and taste characteristics of the onion oil are owed to the presence of these compounds [15]. In addition to these sulfur containing compounds and flavonoids in onion, there are several other ingredients including lectins (highly abundant), prostaglandins, pectin, fructan, adenosine, biotin, phospholipids, fatty acids, glycolipids, nicotinic acid and vitamins B1, B2, B6, C & E. Its biological effects have been studied for a number of decades [16]. Besides, the presence of some steroidal sapogenins and saponins has also been reported; these components play an important role in pharmacological and biological activities i.e., antibacterial, antithrombotic, anti-inflammatory, antitumor, antifungal and hypocholesterolemic properties [16]. The presence of volatile S-
compounds owes the pungent flavor to the onion. Onions are known as an excellent source of flavonoids which are the part of Flavonolis family of polyphenols. A flavonoid subclass which includes quercetin (Figure 1) is considered as a leading and prominent nutritional flavonoid of onions. Other flavonols like quercetin, such as isorhamnetin and kaempferol, were also found in onions [15, 17, 18]. The secondary metabolites (phenolics) present in onions have an antioxidant effect and consist of aromatic hydroxylated rings [19]. The phenolics are very important antioxidant contents of plants [20].

![Figure 1: Structure of Quercetin](image)

Other sources of phytochemicals in onion bulbs are the fructans. The fructans mainly contain fructooligosaccharides. Mainly, they are nystose, inulin, fructofuranosynystose and kestose. The health benefits of these carbohydrates have been recorded extensively in recent years because of their prebiotic effect [21].

It has been reported that onion samples exhibit the presence of 10 various organic acids. The results were in agreement with those found in cv Recas onions (Table 1) [22].

### Table 1: Ten organic acids identified in onion

| No | Acid            | Quantity | No  | Acid            | Quantity |
|----|-----------------|----------|-----|-----------------|----------|
| 1  | Myristic acid   | 0.004 g  | 6   | Linoleic acid   | 0.013 g  |
| 2  | Palmitic acid   | 0.034 g  | 7   | Linolenic acid  | 0.004 g  |
| 3  | Stearic acid    | 0.004 g  | 8   | Monounsaturated acids | 0.013 g |
|    |                 |          |     |                 |          |
|   | Saturated acids | 0.043 g |  | Polyunsaturated acids | 0.017 g |
|---|----------------|---------|---|-----------------------|---------|
| 5 | Oleic acid     | 0.013 g | 10| Glutamic acid         | 0.258 g |

Landraces of the onions were also analyzed for their unique composition of phenols. The most abundant phenol for all landraces was gallic acid, whose amount varies in Febbrarese and Giugnese from 55.66 to 64.90μg/g dw respectively. From a nutritional standpoint, quercetin has an important role among identified phenols. Quercetin is the aglycone component of many other flavonoid glycosides e.g. quercitrin and rutin present in citrus fruits, buckwheat and onions [23] are bases of proteins and sugars. The fructo-oligosaccharides, fructose, sucrose and glucose are the principal non-structural sugars in onion bulb tissue. Onions bulbs contain remarkable mineral composition, particularly potassium and phosphorus [24, 25]. Richest minerals which are present in the ‘Red Amposta’ are phosphorus (107.33 mg/100g DW), potassium (136.82 mg/100g DW), soluble protein (3.78%), water (86%), sodium (9.11 mg/100g DW), magnesium (3.17 mg/100g DW), calcium (60.47 mg/100g DW), and soluble sugar (4.72%) [26].

3. Nutritional Value

In fact, onion plants have many health benefits due to their nutritious content. Crude fiber in the food products is increasingly recognized as a useful implement for controlling oxidative processes and as a functional ingredient in the food. The availability of crude fiber in the diet is required for digestion and waste disposal [27]. The contraction of the digestive tract's muscle walls is caused by fiber, which counteracts constipation [28].

*Allium cepa* L has high moisture content. Varieties show the need for adequate protection, as they are susceptible to deterioration. It renders them susceptible to microorganism infection. High content of water allows the body to absorb them, because the body does not need to use any of its own liquids. That means the body needs lesser time and resources to eat, and can assimilate all the nutrients much more easily. So, it places less pressure on the digestive system [29].”
The composition of the mineral elements revealed that calcium and iron are essential for bone development and hemoglobin production respectively. In addition to this, many important health benefits are associated with onion when consumed in raw form in salad or when it is used in the raw form by the direct ingestion of phytochemicals. Onion finds an immense significance in the food industry due to the presence of a number of rich nutritional contents. However, further investigations are needed, ranging from the farmer's field to the treating center, it is necessary to preserve valuable nutritional contents (for human health) by the use of appropriate technologies [30]. In both varieties of *Allium cepa L.*, sodium was also found to be substantially lower than potassium. It has been stated that low sodium diet is helpful in the prevention of high blood pressure and that high potassium has a protective result against excessive intake of sodium. Zinc present in onion plays a significant role in the appropriate functioning of nucleic acid metabolism and reproductive system [31].

Onion bulbs are enriched with vitamin C, dietary fiber and folic acid. Anti-oxidant compounds present in the onion help to fight inflammation. They are enriched with high soluble fibers called fructans. Onion contains low quantity of calcium, iron, folate, magnesium, phosphorus and potassium. These minerals have major effect on human health [32]. Raw onion contain following nutrients:

**Carbs:** In onion there are about 9-10% carbohydrates in the form of glucose fructose [33].

**Fibers:** They contain 0.9-2.6% fibers of the total weight of onion. Fructans fibers present in the onion help to feed friendly bacteria in the gut [34].

**Proteins:** They contain small amount of protein (less than 1 gram).

**Vitamins and minerals:** Onion contains following vitamins and minerals:

- **Vitamin C:** It is required for our immune function necessary for good health of skin and hairs.
- **Vitamin B(water soluble):** It is necessary for growth and metabolic activities especially during pregnancy.
- **Vitamin B6:** This vitamin help in the formation of RBCs.
- **Potassium & calcium**: This mineral is necessary for proper functioning of heart because it helps in the lowering of blood pressure. Calcium is also present in the onion which helps to strengthen bones [35].

According to the recommended daily allowance (RDA) and adequate intake (AI) values, vitamin C is required 13.11% for males and 15.73% for females, vitamin B-6 is required 11 to 15% (depending on age). Manganese is required 9% for males and 11.5% for females. In different regions of the world onion has different varieties which vary from each other with respect to their contents in terms of vitamins, carbs, fibers present in them [36].

4. **Pharmaceutical Importance**

Onion is rich in many nutritional and pharmaceutical ingredients which are used in treatment of a large number of diseases (Figure 1). Onion can be used in raw form, juice, poultice, powder, liquid extract, syrup and capsules (Table 2).

Table 2: Medicinal applications of onion

| Benefit           | Action                              | Component responsible                        |
|-------------------|-------------------------------------|----------------------------------------------|
| anti-inflammatory agents | reduce the swelling, pain and symptoms associated with severity | vitamin C and quercetin                      |
| Heart issues      | Reduce heart disease risk            | vitamin B6                                   |
| diabetes          | Reduce the fasting blood glucose levels | Allyl propyl disulfide and chromium         |
| osteoporosis      | inhibits the osteoclasts            | gamma-L-glutamyl-trans-S-1-propenyl-L-cysteine sulfoxide |
**Antioxidant effect:** This is the most well-studied and defined onion flavonoid action for protecting cells and tissues from reactive oxygen species (ROS). ROS generates free radicals, which destroy cells in various organs exogenously [37-39]. Flavonoids like kaempferol and quercetin have also been shown to stabilize free electrons generated by ROS in vitro [40, 41]. The flavonoid hydroxyl structure contributes hydrogen and an electron to peroxyl and hydroxyl to stabilize it, which helps to scavenge ROS [42]. Flavonoids' heterocycles initiate conjugation between a free 3-hydroxyl and aromatic bands, resulting in antioxidant activity [43]. Furthermore, reports show that the number, location, and number of sugar rests all affect antioxidant activity [44]. The antioxidant function of quercetin and its dimerized derivatives is similar to that of -tocopherol. As a result, the onion extract's outer layer is assumed to be a source of nutritional constituents [45]. Flavonoids also have metal chelating properties, which prevent the formation of free radicals [46]. Iron stabilization and iron chelation are properties of quercetin [47]. Kaempferol is a powerful antioxidant since its high concentration promotes the synthesis of antioxidant enzymes including superoxide dismutase, catalase, and others. It also inhibits atherosclerosis by preventing the oxidation of low-density lipid protein (LDLP) [48].

**Anti-diabetic:** Onion is used for treating diabetes and its complications [49]. In Zucker diabetic fatty rats, it shows effects of anti-obesity. The use of raw red onion on a regular basis dissolves fat and helps obese women lose weight [50]. Type 2 diabetes and other lifestyle conditions are treated with onion soup [51]. The extract recovers the $\alpha$-glucosidase function of the intestines, regulates spikes in the Sprague-Dawley rat model of postprandial blood glucose levels and protects mice from diabetic
neuropathy. In diabetic rats, it increases hyperglycemia and insulin resistance caused by a high-fat diet and streptozotocin. The *A. Cepa* (red onion) exhibits hypoglycemic symptoms in Types 1 and 2 diabetic patients [52]. In a high fat diet streptozotocin diabetes rodent model, dietary *A. Cepa* bulbs showed anti-diabetic properties [53]. The onion is a healthy medicinal plant that is used to treat diabetes patients. All anti-diabetic ingredients, including onions, can be used to treat diabetes mellitus [53]. In alloxane-induced diabetic rats, *A. Cepa* has hypoglycemic impact. Onions have an anti-hyperglycemic effect and reduce metabolic defects in rats with streptozotocin-induced diabetes [54].

**Wound Healing and Anti-scar:** Onion is widely used in the preparation of ayurvedic wound healing formulations [55]. This also indicates biological efficacy in preventing median sternotomy wounds in paediatric patients [56]. The extract has a beneficial effect on a human skin fibroblast cell line and is used to treat keloids. Onion peel abstract shows biological efficiency for hypertrophic scar prevention and keloid. Onion extract gel also demonstrate hypertrophic parasternal scar defense [57]. This is also used in topical diagnosis and prevention of postoperative hypertrophic wounds, and in keloid surgery [58]. Likewise, *A. Cepa*-allanto in pentaglycan gel is used to treat hypertrophic skin wounds and to enhance the cosmetic appearance of postoperative scars and burn scars [59].

**Anticancer Activity:** Organosulfur compounds produced by *A. Cepa* inhibit the proliferation of six different tumor cells [60]. Allium contains the flavonoid quercetin, which has been shown to have anti-cancer properties. It has the ability to stop the development of various cancer cells. Consumption of allium vegetables, especially garlic, is linked to a lower risk of prostate cancer [61].

**Anti-genotoxic and Anti-mutagenic Effects:** By inhibiting FAS, onions (*A. Cepa* L.) have inhibitory effects on cancer cells and adipocyte proliferation [62]. Allium vegetables inhibit the proliferation of MCF-7 breast cancer cells and reduce the risk of prostate cancer [53]. It is healthy food for human beings to avoid cancer. *A. Cepa* displays anti-mutagenic andantigenotoxic activity against carcinoma in the gut. Zidovudine or nevirapine causes cytogenotoxic changes in *A. cepa* root.
Onions contain the flavonoid quercetin, which has anticancer properties at particular sites. Isolated polyphenols from *A. Cepa* induce apoptosis in human leukaemia cells by inhibiting PI3K/Akt signaling pathways and suppressing apoptosis protein-1 inhibitors [64].

**Antimicrobial:** Green extract of onion dissolved in ozonated water inactivates the typhimurium Salmonella enterica. It also inactivates internalized and infected enteric viruses on the surface and prevents the development of Gram-positive, Gram-negative bacteria in vitro [66]. Internalized *S. Typhimurium* is inactivated with radiated UV-C and chemical sanitizers using green onions [67]. To decontaminate *Escherichia coli* O157:H7 water, green onions and pulsed light (PL) and PL-surfactant-sanitizer are used. Varieties of cepa red and white displayed chemical differences from each other and showed good antimicrobial and antioxidant activity [68].

**Antiparasitic:** Onion oils were found to be successful against *Schistosoma mansoni* cryptosporidium parvum infection in mice in an experiment [69]. *A. Cepa* oil has been shown to be extremely effective in the treatment of worm infections. The onion is successful against the eelworm (*Ditylenchus dipsaci*), a small soothing parasitic nematode that causes swollen, twisted leaves [70].

**Antihyperlipidemic:** Onion derivative sulfur-compounds, including S-methyl cysteine sulfoxide and allylpropyl disulfide [71] exhibited hypolipidemic effect. These compounds have been found to reduce the effects of diet-induced atherosclerosis, maintain hypolipidemic action, and inhibit platelet production in rats and rabbits. These compounds are abundant in raw onion, which has antithrombotic effects [63].

**Analgesic:** Onions are used as antidepressants [72] for they suppress synthase of the lachrymatory factor (LFS). In a rat depression model, onion powder has an antidepressant-like effect. Fresh onion juice can reduce pain and inflammation in both acute and chronic conditions, with a stronger anti-inflammatory effect [73].

**Antipyretic:** Fresh, *A. Cepa* liquid bulb extract on paracetamol and carbon tetrachloride [74]. Usage of alliums reduces genotoxicity caused by series of synthetic
pharmaceutical compounds. It also decreases toxicity, genotoxicity and cytotoxicity of the metamizole sodium and acetylsalicylic acid [75].

5. Conclusions
The onion bulbs are comprised of polysaccharides including peptides, fructans, flavonoids (mostly quercetin), saccharose and organosulfur compounds with salutary effects on human health. The onion in the diet gives us a positive response in nutritional manner. The nutritional contents in onion bulb include crude oil, vitamin E, sodium, potassium and zinc. The onion bulb has the ability to reduce the problem of stomach cancer, osteoporosis and brain cancer in human being. It is also anti-diabetic, anti-inflammatory, anti-scar, antispasmodic, antiseptic, anti-genotoxic, anti-mutagenic, diuretic, anti-parasitic, antimicrobial, antipyretic and analgesic.

Conflict of Interest
The authors declare no conflict of interest.

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